Timing and metamorphic character of intraplate deformation and rheological weakening

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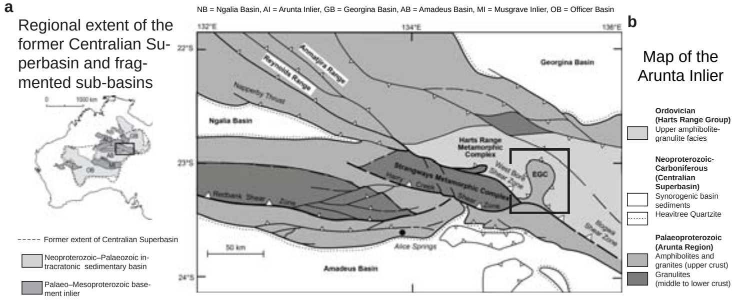
1. Abstract & methods

The Harts Range rift and basement complex is located in the continental interior of Australia. For the period 450–320 Ma, this tectonic domain is characterised by large-scale deformation of the Harts Range Group rift sequence and pervasive reworking of its underlying basement. The expression of intraplate deformation is manifest by the Entia Gneiss Complex (EGC), a domal structure that represents basement structurally underlying the Harts Range Group, and has evidence for associated deformation and fluid ingress between 390–320 Ma. The EGC also contains metapelites at various structural levels of the mid- to lower-crust, providing a means to constrain the thermobarometric record during a period of signifficant rheological weakening. Fluid–rock interaction is evidenced by extensive pegmatite intrusion and retrogresssion occuring episodically throughout this 130 Myr period, possibly coeval with prograde upper-amphibolite facies metamorphism.

Triangulating the Entia Gneiss Complex (section 2), a combination of petrographic observations (section 3) linked to *P*–*T* models (section 4) together with in situ geochronology (section 5) is vital in providing temporal constraints on the physical and thermal evolution of the reworking event. Phase equilibria forward modelling was calculated in THERMOCALC (v3.37) software. LA–ICP–MS in situ U–Pb monazite geochronology and trace element data were acquired using a Resonetics M-50-LR 193 nm excimer laser coupled to an Agilent 7700cx Quadrupole ICP–MS.

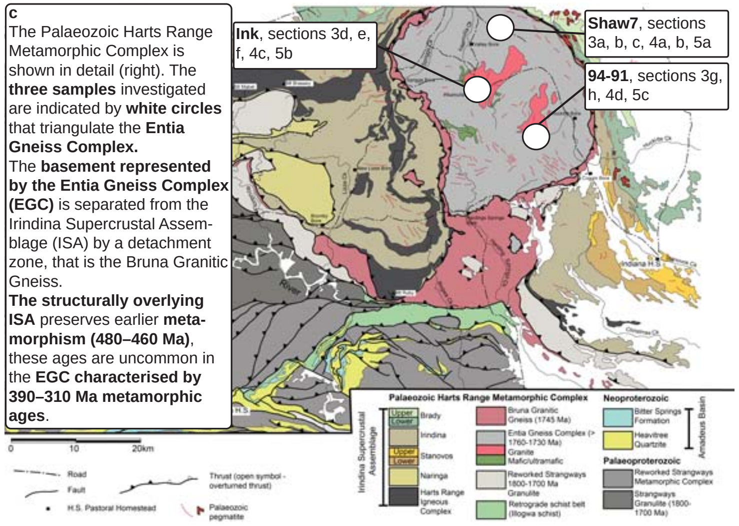
2. Geological setting



a Regional extent of the former Centralian Superbasin and fragmented sub-basins

b Map of the Arunta Inlier

NB = Ngalia Basin, AI = Arunta Inlier, GB = Georgina Basin, AB = Amadeus Basin, MI = Musgrave Inlier, OB = Officer Basin



c
The Palaeozoic Harts Range Metamorphic Complex is shown in detail (right). The **three samples** investigated are indicated by **white circles** that triangulate the **Entia Gneiss Complex.**
The **basement represented by the Entia Gneiss Complex (EGC)** is separated from the Irindina Supercrustal Assemblage (ISA) by a detachment zone, that is the Bruna Granitic Gneiss.
The structurally overlying ISA preserves earlier **metamorphism (480–460 Ma)**, these ages are uncommon in the **EGC characterised by 390–310 Ma metamorphic ages**.

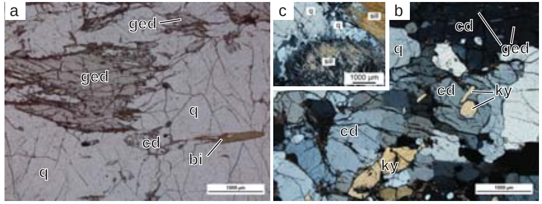
Ink, sections 3d, e, f, 4c, 5b

Shaw7, sections 3a, b, c, 4a, b, 5a

94-91, sections 3g, h, 4d, 5c

3. Petrography

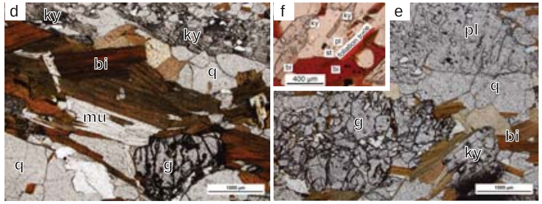
Sample Shaw7



Peak assemblage:
gedrite + cordierite + kyanite + biotite + plagioclase + quartz

Sillimanite after kyanite (c)

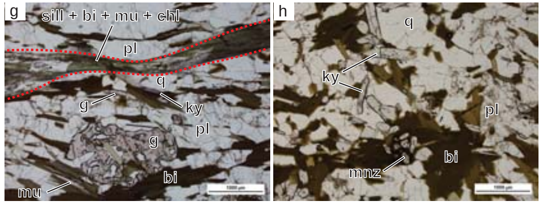
Sample Ink



Peak assemblage:
kyanite + garnet + biotite + muscovite + quartz + plagioclase ± staurolite

Remnant staurolite in matrix preserved within plagioclase (f)

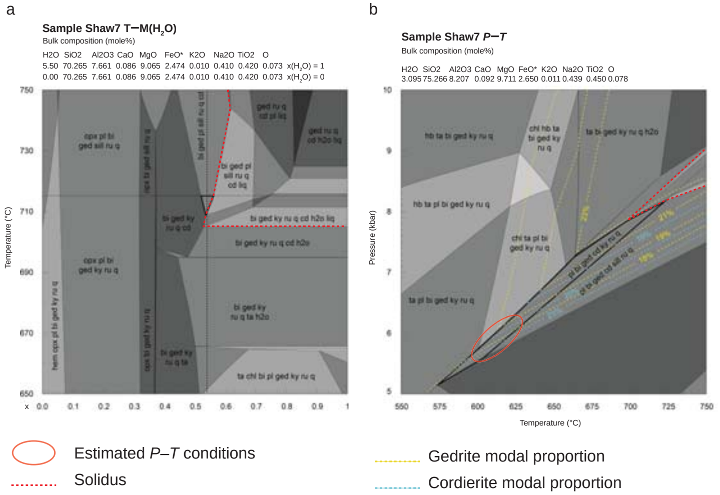
Sample 94-91



Peak assemblage:
kyanite + garnet + biotite + plagioclase + quartz

Retrograde:
sillimanite + biotite + muscovite + chlorite (localised to mm scale seams, dashed red outline)

4. Phase equilibria modelling (pseudosections)

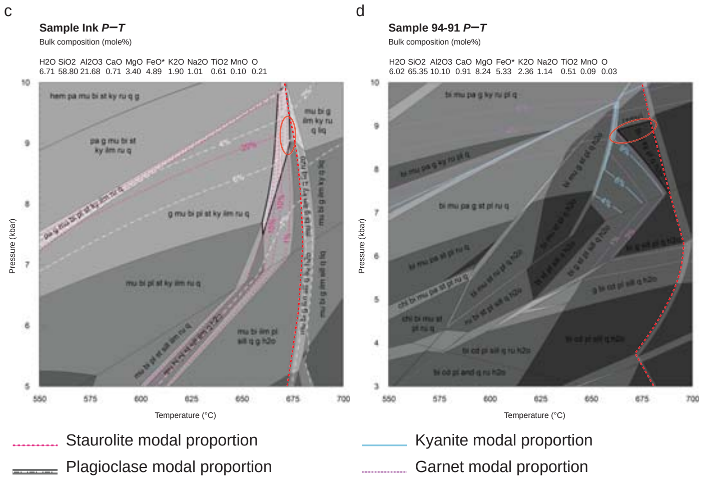


To accurately model the cordierite-orthoamphibole assemblage preserved in Shaw7, dataset ‘ds55’ was used, modelled in the geologically realistic system of NCKFMASHTO

Calculation of the T–M(H_2O) diagram allowed evaluation of mineral assemblage stability with varying H_2O (x). Modelled from no water (x = 0) to the value of loss on ignition (x = 1, or 5.50 mole % H_2O) obtained from XRF analysis. Using a composition from x = 0.54 (within the peak field, identified by a bold black outline) a *P*–*T* diagram was calculated (Fig. b)

Interpretation of the peak field (bold black outline) suggests a *P*–*T* range 5.5–6.4 kbar and 605–640 °C

pseudosections continued...

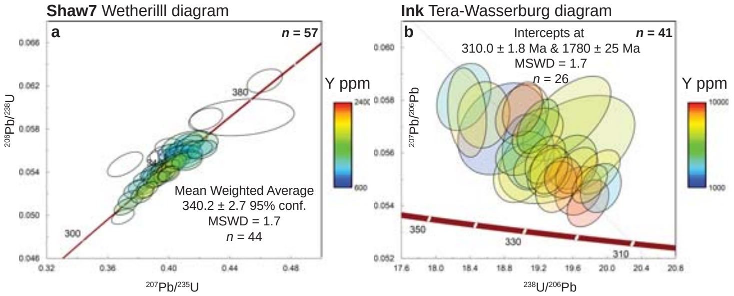


Both Ink and 94-91 were modelled with dataset ‘ds62’. Using the geologically realistic system MnNCKFMASHTO

Sample Ink is interpreted to indicate *P*–*T* conditions between 8.9–9.6 kbar and ~670 °C

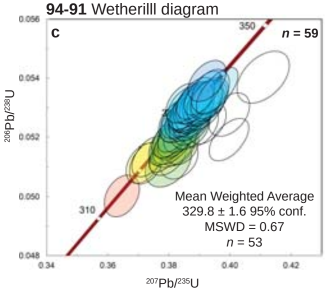
For sample 94-91 modal proportions of peak minerals could not be used to further constrain the peak field, corresponding to a *P*–*T* range 7.5–9.1 kbar and 660–690 °C

5. In situ U–Pb monazite geochronology



Shaw7 Wetherilll diagram

Ink Tera-Wasserburg diagram



94-91 Wetherilll diagram

Shaw7 displays an increase in yttrium towards younger analyses, however the significance of concordant analyses between 360–310 Ma with respect to peak metamorphic silicate minerals is ambiguous

Ink is anchored to protolith formation age, a lower intercept age is in agreement with youngest concordant analyses in Shaw7 (313.8±3.5) and 94-91 (314.7±3.5)

94-91 is consistent with garnet breakdown and liberation of yttrium, increasing towards younger analyses

6. Conclusions & ongoing research

Preliminary data show that the timing of metamorphism coincides with pegmatite crystallisation ages (390–320 Ma). Phase equilibria modelling suggests an increase in pressure towards the centre of the dome, consistent with exhumation of deeper structural levels. Aims for ongoing research include determining the geochemical character (F, Cl, Br, I using apatite as a probe) and potential sources of fluid constrained by stable isotope analyses ($\delta^{18}O$ and δD).