

$^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb dating in the eastern Pilbara, Australia; temporal constraints on structural and metamorphic events between 3.5 and 2.8 Ga (extended abstract)

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The Pilbara Craton in Western Australia consists of a mid to early Archean granitoid-greenstone terrain (2.8–3.6 Ga), characterized by bulbous granitoids surrounded by greenstone belts. The granitoid-greenstone terrain is unconformably covered by relatively undeformed Hamersley Group volcano-sediments. It provides unique opportunities to study 1) the structural and kinematic evolution in both greenstones and granitoids, and 2) their relation to magmatic and metamorphic events in early to mid Archean times. A better understanding of the evolution of the Pilbara Craton will provide insights into Archean geodynamics of the crust and may provide constraints to possible tectonic regimes in the Archean.

During the course of a structural and kinematic study in the Shaw Batholith area in the eastern Pilbara it became clear that precise dating of intrusive and metamorphic events was required to unravel the structural complexity of this area and eventually to be able to correlate structural and metamorphic events over the whole Pilbara granitoid-greenstone terrain.

In the Shaw Batholith and surrounding greenstone belts (Tambourah and Coongan Belt) three main phases of deformation had been recognized during the structural studies:

- 1) a WSW-directed extensional event, involving brittle listric faulting in the Coongan Belt and a ductile detachment in the Shaw Batholith (Split Rock Shear Zone),
- 2) an E-W directed compressional event, involving thrusting and folding in the Coongan Belt,
- 3) Craton-scale strike-slip deformation, localized in the north-trending Mulgandinnah Shear Zone in the western Shaw Batholith.

Although the relative timing of those structural events had been established, the precise timing was unknown. In addition, it was not clear what caused the greenschist to amphibolite-grade metamorphism in the greenstones. Was the metamorphism related to the intrusion of granitoids (contact metamorphism) or was it related to one or more of the deformation events (regional metamorphism)?

In this geochronological study two different dating methods were combined: $^{40}\text{Ar}/^{39}\text{Ar}$ dating of mineral separates (amphibole, biotite and muscovite) from both greenstones and granitoids, and U-Pb SHRIMP¹ dating of zircons from granitoids. The $^{40}\text{Ar}/^{39}\text{Ar}$ dating was performed at the laser argon laboratory at the Vrije Universiteit in Amsterdam, where the mineral separates were degassed stepwise. Because minerals have different closure temperatures for argon gas, the age recorded by this method is the time at which the mineral cooled below the closure temperature, i.e. the cooling age. For hornblende the closure temperature is between 450 and 550 °C. The analyses for the U-Pb zircon dating were done on the SHRIMP II at Curtin University in Perth (Australia). With the SHRIMP, circular domains with a diameter of ca. 20 μm can be analysed individually. In order to select areas for analysis in the zircons, cathodoluminescence images were made of all zircons prior to the SHRIMP analysis. Those cathodoluminescence images show various internal textures, with commonly occurring truncated cores with new overgrowth rims and occasionally recrystallized parts in the zircons. Because the U-Pb systematics remain undisturbed up to high temperatures (ca. 700 °C) in zircon crystals that have little radiation damage, the

¹ SHRIMP: Sensitive High Resolution Ion Microprobe

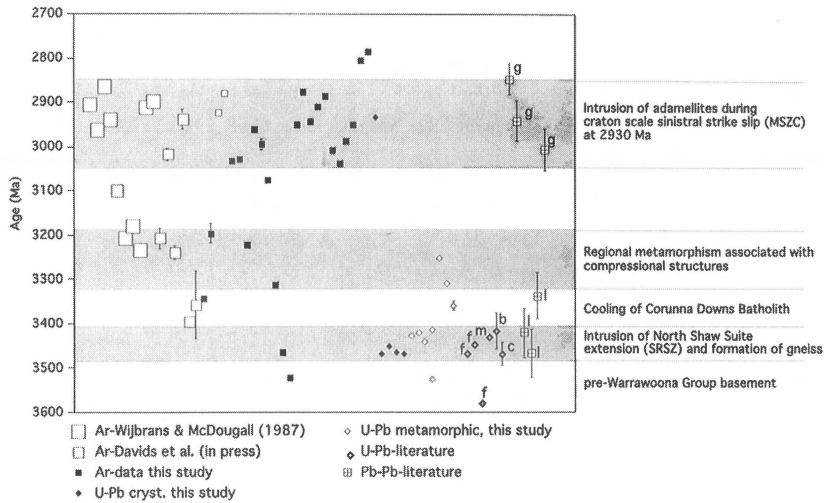


Figure 1. $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb SHRIMP data from this and previous studies, and related structural and metamorphic events in the Shaw area, based on this study and age data from: b = Pidgeon (1978), c = Williams et al. (1983), f = McNaughton et al. (1988), l = Bickle et al. (1993), m = McNaughton et al. (1993). SRSZ = Split Rock Shear Zone, MSZC = Mulgandinnah Shear Zone Complex.

U-Pb zircon age represents, under most crustal conditions, the time of growth of that particular part of the zircon grain. U-Pb zircon ages are usually interpreted as crystallization ages.

A number of geochronological studies had been made in the Shaw area prior to this study. Those data, summarized in Figure 1, show a major magmatic event at ca. 3450 Ma with intrusion of granodiorites and deposition of the Warrawoona Group greenstones, followed by the deposition of the Gorge Creek Group greenstones at ca. 3325 Ma. Pb-Pb whole-rock ages indicate another major intrusive event between 3050 and 2850 Ma.

The main objectives of this geochronological study were:

- 1) to date the three main structural events in the Shaw area (extension, compression and strike slip),
- 2) to determine the crystallization ages of the diorites and grey gneisses in the core of the Shaw Batholith, which could potentially represent a pre-Warrawoona Group basement,
- 3) to determine the thermal evolution by combining the results from previous $^{40}\text{Ar}/^{39}\text{Ar}$ studies in this area (Davids et al., in press; Wijbrans & McDougall 1987) to distinguish between contact-metamorphic effects and regional metamorphic effects.

The main results of the geochronological study are summarized in Figure 1:

- 1) The age of the extensional detachment zone in the Shaw Batholith, the Split Rock Shear Zone, is con-

strained to between 3470 and 3415 Ma by U-Pb zircon dating of deformed and intrusive granodiorites.

- 2) The age of a major compressional shear zone in the Coongan Belt, the Central Coongan Shear Zone, is constrained to between 3300 and 3200 Ma by $^{40}\text{Ar}/^{39}\text{Ar}$ dating of actinolites that grew over the mylonitic foliation.
- 3) The movement on the sinistral Mulgandinnah Shear Zone is constrained to 2934 Ma by the U-Pb crystallization age of a synkinematic granite dyke.
- 4) The crystallization ages of the diorites and grey gneisses are both within the range of the Warrawoona Group and do therefore not represent the basement to the greenstone sequence. There are indications for an older basement at ca. 3520 Ma, obtained from xenocrystic zircons.
- 5) Metamorphism is in most cases related to intrusion of granitoids. However, a number of cooling ages cannot be related to granitoid intrusions and are most likely related to regional metamorphism during the compressional event between 3300 and 3200 Ma.
- 6) Large areas of the Shaw Batholith have been thermally reset during post-tectonic intrusion of granitoids.

The combination of $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb SHRIMP dating is a powerful tool to unravel the complexities of the tectonothermal evolution of Archean terrains. The results show that the evolution of the eastern Pilbara

Craton consists of a number of tectonothermal phases, involving extension, compression and late-stage strike-slip deformation, separated by a relatively long period with little tectonic or magmatic activity.

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