National Argon Map: an AuScope initiative

Data Acquisition Project Proposal

This form should be completed and returned to Geoff Fraser (Geoff.Fraser@ga.gov.au) for consideration by the National Argon Map Oversight Panel

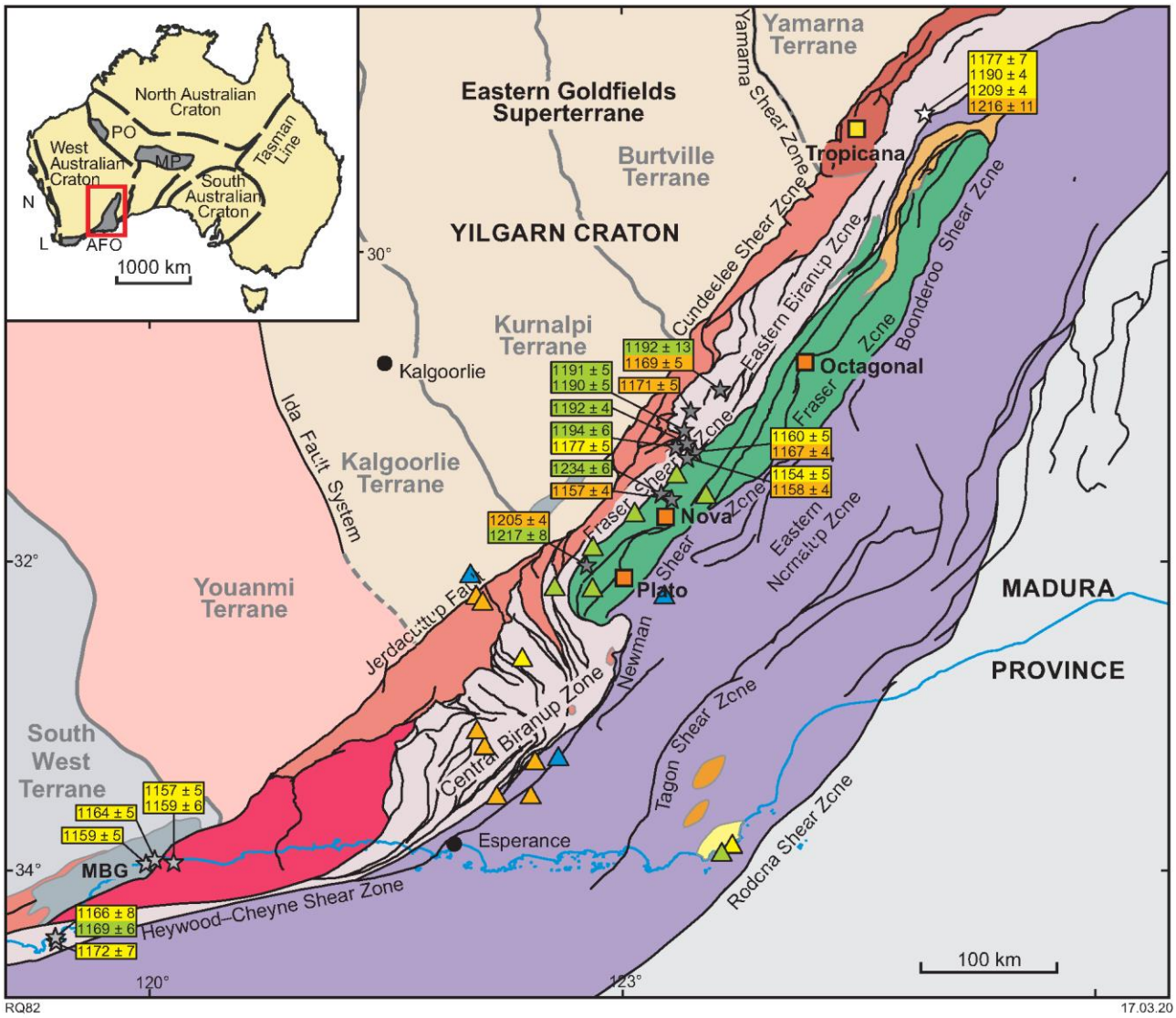
Project Proponent

Name: Raphael Quentin de Gromard
Affiliation and position: Geological Survey of Western Australia (GSWA), senior geologist
Collaborators: David Kelsey and Catherine Spaggiari (GSWA)
Project Title: Evolution of crustal structures in an inverted orogen, the east Albany–Fraser Orogen, Western Australia
Geographic Region: Fraser Range, Esperance, Point Malcolm, Western Australia
Geological Province or Tectonic Unit: east Albany–Fraser Orogen, Western Australia

Brief Project Description:

The Albany–Fraser Orogen (AFO) is a Paleoproterozoic to Mesoproterozoic belt exposed along the southern and southeastern margin of the Archean Yilgarn Craton in Western Australia (Fig. 1). The orogen comprises reworked continental crust and is a highly prospective region for mineralization. During the Paleoproterozoic the continental margin was rifted and the resulting extensional structures were inverted during the Mesoproterozoic Albany–Fraser Orogeny. Understanding the evolution of these structures is paramount for understanding mineralization processes as they form major fluid pathways. These structures have a thrust and exhumation history that encompasses both Stage I (1330–1260 Ma) and Stage II (1225–1140 Ma) of the Albany–Fraser Orogeny, two long-lived and multi-phased tectonic events, but the polyphase history within each event is poorly known. Currently, the timing of deformation and high-temperature metamorphism within these major shear zones is known primarily from high-temperature methods including U–Pb zircon, U–Pb titanite and sparse U–Pb monazite data (Spaggiari et al., 2014, GSWA Record 2014/6, p 12–27; Kirkland et al., 2016, Precamb. Res. V. 278, p. 283–302). $^{40}Ar/^{39}Ar$ data exist for the west AFO and for the Fraser Zone and Biranup Zone in the east AFO and indicate cooling related to Stage II of the Albany–Fraser Orogeny (Fig. 1; Scibiorski et al., 2015, Precamb. Res. V. 265, p. 232–248; Scibiorski et al., 2016, Lithosphere, v. 8, p. 551–563). However, these data are not well integrated with the deformation history, PT modelling, and high- and low-temperature geochronology methods.

The proposed samples for new $^{40}Ar/^{39}Ar$ analyses were collected from outcrops from a variety of lithologies and tectonic units and minerals with different closure temperatures (hornblende, biotite and muscovite) were targeted. The metamorphic fabrics of these samples are constrained within an established structural framework. New $^{40}Ar/^{39}Ar$ data will be integrated with existing, new and upcoming U–Pb zircon, titanite and monazite data, and new and upcoming PT modelling of successive tectonic fabrics, to help produce robust reconstructions of the Albany–Fraser Orogeny, which together will provide critical constraints for tectonic reconstructions of the orogen and its role in the development of Proterozoic Australia. The locations of the proposed samples form a transect across the orogen, from the non-reworked Yilgarn Craton margin in the west, to the easternmost AFO and edge of the Madura Province, where the only exposure is the Malcolm Metamorphics. These datasets will fill a data gap between existing $^{40}Ar/^{39}Ar$ datasets (Fig. 1).



ALBANY–FRASER OROGEN

- Mount Ragged Formation
- Fraser Zone (1305–1290 Ma)
- Arid Basin
  - Gwynne Creek Gneiss
  - Malcolm Metamorphics
- Nornalup Zone (1800–1650 Ma); Recherche (1330–1280 Ma) and Esperance (1200–1140 Ma) Supersuites (undivided)
- Biranup Zone (1800–1650 Ma) and Archean remnants
- Barren Basin (undivided)
- Tropicana Zone (2720–1650 Ma)
- Munglinup Gneiss (2800–2660 Ma)
- Northern Foreland, undivided

Existing $^{40}Ar/^{39}Ar$ ages (Ma)

- Scibiorski et al, 2015
- Scibiorski et al, 2016
- Unpublished
- 1177 ± 5 Muscovite
- 1158 ± 4 Biotite
- 1192 ± 4 Hornblende

Proposed samples

- Muscovite
- Biotite
- Hornblende
- Hornblende + biotite

- Major faults
- Terrane boundary
- Geological boundary
- Coastline
- Town
- Au
- Ni

Approximate number of samples proposed for $^{40}Ar/^{39}Ar$ analyses:
20 samples encompassing 1 from the Yilgarn Craton, 2 from the Northern Foreland, 4 from the Biranup Zone, 3 from the Fraser Shear Zone, 2 from the Fraser Zone, 5 from the Nornalup Zone, and 3 from the Malcolm Metamorphics.

Lithologies and minerals proposed for $^{40}Ar/^{39}Ar$ analyses: The lithologies of the proposed samples include psammo-pelitic gneiss, amphibolite, metagranite and granitic gneiss and contain muscovite or biotite or hornblende, with three samples containing both biotite and hornblende. More material is available if substitutive material is required due to unforeseen reasons.

Do you have a preferred ^{40}Ar-^{39}Ar laboratory? (ANU, Curtin, UQ, UMelb):
If so, why you prefer this laboratory (e.g. student affiliation, ongoing relationship, sample type etc):

ANU, because of the expertise and specialization in dating deformation events.

Guidelines and Criteria

Project Proposals for funding support as part of the AuScope National Argon Map initiative will be assessed on the following criteria.

Australian: Samples must come from Australia (this may include Australian offshore regions)

Non-confidential: $^{40}Ar/^{39}Ar$ data must be made publicly-available (ie non-confidential)

Impact: to what extent new $^{40}Ar/^{39}Ar$ data from the proposed samples will contribute to geographic data coverage, or address key geological questions

Feasibility: whether the nature of the work is tractable via $^{40}Ar/^{39}Ar$ geochronology and the scale of the proposal is realistic within the time frame of the National Argon Map initiative (January 2020 – June 2021)?

Appropriate sample material: whether the proposed samples are (i) appropriate for $^{40}Ar/^{39}Ar$ analyses, and (ii) available within the time-frames of the National Argon Map initiative?

Oversight Panel

Dr Geoff Fraser, Geoscience Australia
Professor Zheng-Xiang Li,
Dr Anthony Reid, Geological Survey of South Australia
Peter Rea, MIM/Glencore
Dr Catherine Spaggiari, Geological Survey of Western Australia
Dr David Giles, MinEx CRC
Dr Marnie Forster (observer role as Project Coordinator)

Expectations

AuScope funding will cover the costs of sample irradiation and isotopic analyses.

Project Proponents will be responsible for:

- Provision of appropriate sample material. This includes mineral separation, which can be arranged at the relevant $^{40}Ar/^{39}Ar$ laboratories (in many cases this is preferred), but costs of mineral separation will be borne by the project proponent. The relevant laboratory reserves the right not to analyse material if it is deemed unsuitable for $^{40}Ar/^{39}Ar$ analysis.
- Provision of appropriate sample information. A sample submission template will be provided. Information in these sample submission sheets will form the basis of data delivery/publication, and the oversight committee or relevant laboratory reserves the right not to proceed with analyses unless and until appropriate sample details are provided. This includes description and geological context for each sample.
- Leading the preparation of reports and/or publications to deliver $^{40}Ar/^{39}Ar$ results into the public domain within the duration of the National Argon Map initiative (January 2020 – June 2021).
- Project Proponents will be expected to communicate directly with the relevant $^{40}Ar/^{39}Ar$ laboratory once a project has been accepted by the Oversight Committee, in order to clarify project expectations, arrange sample delivery, discuss results, collaborate on reporting and data delivery etc.

Participating Ar Laboratories will be responsible for:

- Providing advice to project proponents regarding suitable sample material and feasibility of proposed work
- Irradiation of sample material
- $^{40}Ar/^{39}Ar$ isotopic analyses
- Delivery of data tables, and analytical metadata to project proponents

Queries regarding possible projects as part of the National Argon Map initiative can be directed to Marnie Forster (Marnie.Forster@anu.edu.au) or Geoff Fraser (Geoff.Fraser@ga.gov.au)