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: David Kelsey
Affiliation and position: Geological Survey of Western Australia (GSWA); Project Manager
Collaborators: Heather Howard, Paul Duuring, Joshua Guilliamse, Raphael Quentin de Gromard, Weronika Gorczyk, Fariba Kohan Pour
Project Title: Tectonism and Exhumation of the Paterson Orogen and East Pilbara Craton margin
Geographic Region: Northern WA (far eastern Pilbara), south-western Canning Basin
Geological Province or Tectonic Unit: East Pilbara Craton, Capricorn Orogen, Paterson Orogen, Rudall Province, Yeneena Basin

Brief Project Description:

Approximately 500 word maximum. Include what geological process/problem will be addressed, and how new $^{40}Ar/^{39}Ar$ data from the specific samples to be dated will contribute. Please include reference to pre-existing geochronological constraints, if any exist. Please include a simple location map which showing the spatial distribution of samples in their geological context (with scale).

The Paterson Orogen is a highly prospective but comparatively poorly understood Neoproterozoic Orogen occurring on the northern margin of the West Australian Craton. The Paterson Orogen consists of a series of north-west trending structures that deform and rework rocks of the far-eastern and northeastern Archean Pilbara Craton, the Palaeoproterozoic Rudall Province and the Neoproterozoic Yeneena Basin. Basic but fundamental information such as the age of deformation, metamorphism and mineralisation events is sparse from the Paterson Orogen, greatly contributing to the lack of understanding of this orogen. To highlight this, the event for which the orogen is named – the approximately greenschist facies Paterson Orogeny – has poor age constraint and is currently documented as "c. 550 Ma ?" (Maidment, 2017). An older Neoproterozoic event, the Miles Orogeny ("c. 810–650 Ma?" in Maidment, 2017), is advocated as a compressional event but is also poorly age constrained. An additional, un-named Neoproterozoic event has been proposed (as "650–550 Ma ?" in Maidment, 2017), again with significant age uncertainty.

Uncertainties around the timing and duration of each of these events, including how many events there actually are, are further highlighted by the following. It is not clear whether hydrothermal mineralisation in the Yeneena Basin, with Sm–Nd, Pb–Pb and pitchblende ages spanning c. 841 to 791 Ma (Huston et al., 2010; Cross et al., 2011), dates the Miles Orogeny, or whether the Miles Orogeny instead correlates to the ages of felsic intrusive rocks of the O'Callaghans Supersuite (related to Telfer, for example) at c. 645–625 Ma (e.g. Dunphy and McNaughton, 1998; Bagas, 2004; Maidment et al., 2010; Maidment, 2017). Existing Ar–Ar age data from the Paterson Orogen are limited to 6 samples from the northwestern Rudall Province and immediately overlying Yeneena Basin that gave muscovite cooling ages of 671–646 Ma and a single K-feldspar cooling age of c. 554 Ma (Durocher et al., 2003, Australian J. Earth Sci., 50, 601–610), as well as single unpublished biotite age 717 ± 5 Ma from Cu mineralisation at the Maroochydore prospect (Reed, 1996). An Rb–Sr date of 595 ± 27 Ma from granitic gneiss (Chin and de Laeter, 1981) may date the Paterson Orogeny. All this existing data is difficult to interpret in a broad context since the samples

do not provide wide and systematic spatial coverage and so do not constrain potential lateral changes or hinterland-to-foreland patterns in the age of tectonic activity. Therefore, the aim of this study is to obtain $^{40}Ar/^{39}Ar$ age data from across the orogen, with the caveat of legacy sample availability and suitability, encompassing across the margin of the East Pilbara Craton and into the Yeneena Basin and across the Rudall Province – to provide a more systematic approach to understanding either/or: (a) the timing of movement (burial and/or exhumation/inversion) across major NW-trending structures of the Paterson Orogen; and (b) the timing of the Paterson and/or Miles Orogenies. The distribution of samples will enable lateral as well as foreland-to-hinterland understanding of basin evolution and inversion. As the Yeneena Basin (meta)sediments host economically important mineralization (e.g. Winu, Telfer, Nifty, Kintyre) a critically important aspect of the aim of this work is that the development of a coherent mineral systems understanding of the region requires underpinning fundamental data such as the age of geological activity and mineralisation.

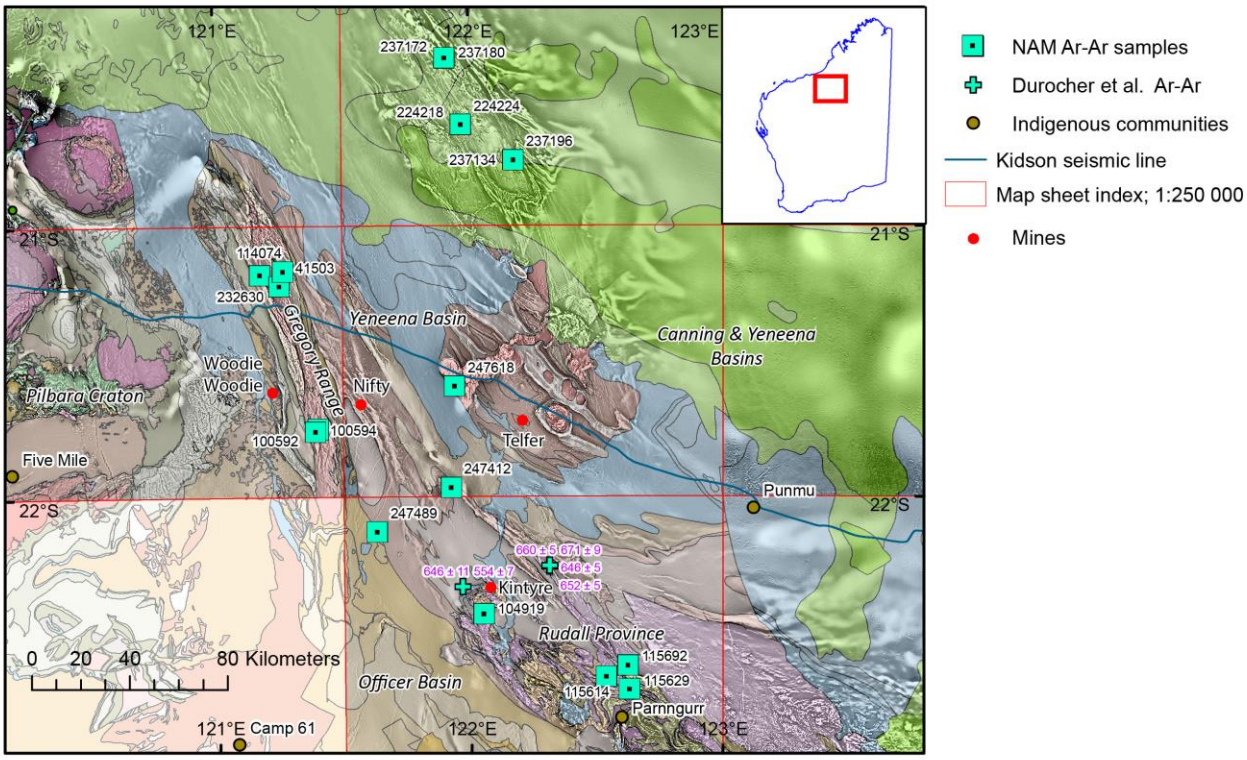

Figure 1. 1:500 000 interpreted bedrock geology map draped over greyscale RTP 1VD magnetic imagery of the part of the exposed Paterson Orogen (consisting of Rudall Province and Yeneena Basin) between the Pilbara Craton and Canning Basin. The Gregory Range forms the easternmost part of the Pilbara Craton. Sample locations for the present Ar–Ar study are shown as cyan squares. Existing Ar–Ar data sample locations and age information (Durocher et al., 2003) are shown as cyan crosses.

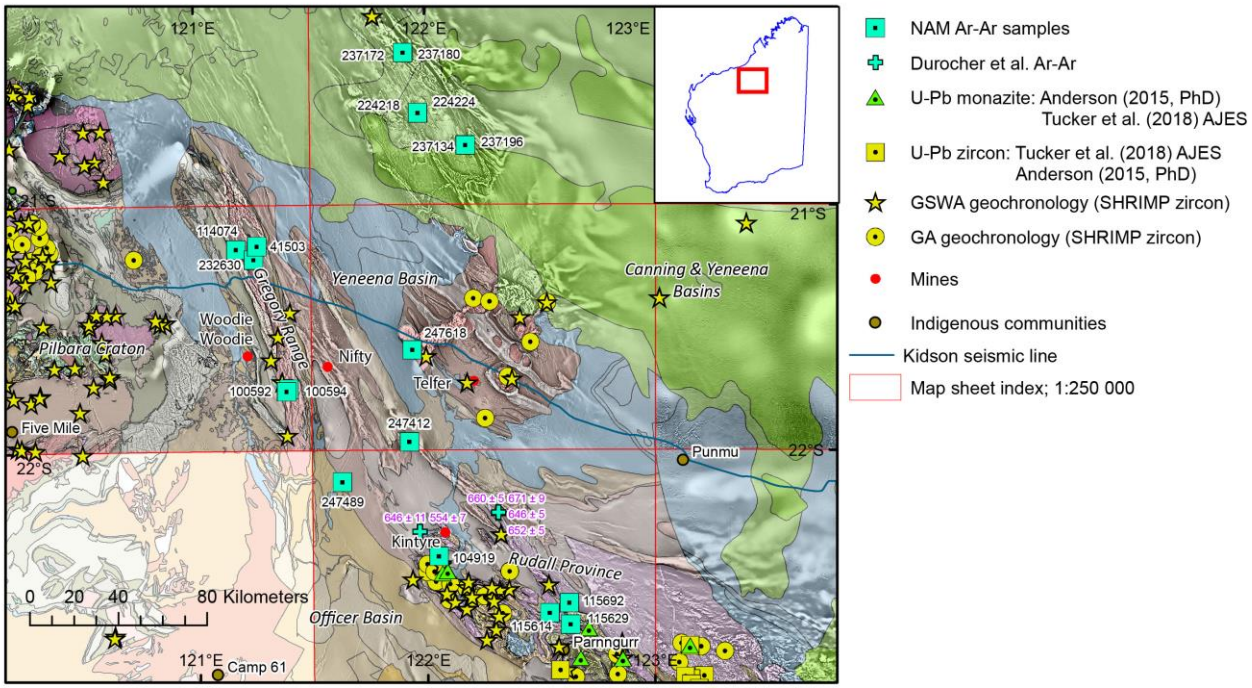

Figure 2. Same as for Figure 1 except instead showing locations of existing zircon and monazite U–Pb geochronology sample locations. These data mostly show Palaeo- and Mesoproterozoic magmatic and metamorphic ages. Only a small number of samples have Neoproterozoic ages, namely the magmatic ages of the Crofton and O'Callaghans granites and older gabbros (Duke, Hasties Retreat, Magnum) (14 magmatic in total) and a few detrital zircon samples with Neoproterozoic ages (6 in total).

Approximate number of samples proposed for $^{40}Ar/^{39}Ar$ analyses:

19, consisting of 5 from the Gregory Range, 5 from the Rudall Province and the remaining 9 from the Yeneena Basin. We can provide more samples if necessary. The list of samples is:

Object ID	GSWA Sample No.	Warox site ID or Researcher Sample ID	Hole/ Well Name/Site No	Tectonic or geographic location	Mineral for Ar-Ar analysis	To constrain
1	232630	HMHHAM000287		Pilbara Craton (Gregory Range)	hornblende	Cooling/exhumation
2	41503	GSD041503	26517	Pilbara Craton (Gregory Range)	hornblende	Cooling/exhumation
3	114074	IRW114074	Warroo Hill Trig point	Pilbara Craton (Gregory Range)	muscovite	Cooling/exhumation
4	100592	GSD100592	58706	Pilbara Craton (Gregory Range)	hornblende	Cooling/exhumation
5	100594	GSD100594	58708	Pilbara Craton (Gregory Range)	hornblende	Cooling/exhumation
6	104919	GSD104919		Rudall Province	muscovite	Cooling/exhumation, possibly metamorphism
7	115614	RHS115614		Rudall Province	muscovite	Cooling/exhumation, possibly deformation & metamorphism
8	115629	RHS115629		Rudall Province	muscovite	Cooling/exhumation, possibly metamorphism

9	115692	RHS115692		Rudall Province	muscovite	Cooling/exhumation, possibly deformation & metamorphism
10	46920	GSDSJW46920		Rudall Province	muscovite	Cooling/exhumation, possibly deformation & metamorphism
11	224218	PZDOBL000001	PND004, Obelisk	Yeneena Basin	biotite	Mineralisation/alteration
12	224224	PZDOBL000001	PND004, Obelisk	Yeneena Basin	muscovite	Cooling/exhumation, possibly deformation & metamorphism
13	237134	JNGXXX000031	EIS Antipa Citadel 12AMD00015	Yeneena Basin	biotite. Musc instead?	<- muscovite instead?
14	237196	JNGXXX000033	EIS Antipa Corker 14AMD0043	Yeneena Basin	biotite	Mineralisation/alteration
15	237172	JNGXXX000032	EIS Venus Citadel C8	Yeneena Basin	biotite	Cooling/exhumation, possibly deformation & metamorphism
16	237180	JNGXXX000032	EIS Venus Citadel C8	Yeneena Basin	biotite	Mineralisation/alteration
17	247412	EPT1702_Geo4	EIS Encounter BM2 EPT1702	Yeneena Basin	biotite?	Deformation
18	247489	EPT2193_Geo2	EIS Encounter Yeneena EPT2193	Yeneena Basin	biotite?	Deformation
19	247618	ETG0007_Geo2	EIS Encounter Telfer West ETG0007	Yeneena Basin	biotite?	Cooling/exhumation, possibly deformation & metamorphism

Lithologies and minerals proposed for $^{40}Ar/^{39}Ar$ analyses:

Muscovite, biotite, hornblende.

Where possible we have tried to choose samples that are located within shear zones or within known major fault panels. The only exceptions to this are samples with alteration and mineralisation, which were not targeted for structural features.

Do you have a preferred ^{40}Ar-^{39}Ar laboratory? (ANU, Curtin, UQ, UMelb):

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)