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: Jack Muston
Affiliation and position: Research Assistant in the Structure Tectonics Team (ANU)
Collaborators: Brendan Hardwick (AGA), Sarah Dixon (AGA)
Project Title: $^{40}Ar/^{39}Ar$ thermochronology of the Coen Inlier
Geographic Region: Far North Queensland
Geological Province or Tectonic Unit: Coen Inlier

How will these samples benefit the National Argon Map?

Provide a succinct answer to this question, see the suggestions in the Guidelines and Criteria on the next page.

This proposal shares the same aim as the NAM AuScope 2020 Pilot Project. The Cape York region has had minimal coverage of $^{40}Ar/^{39}Ar$ geochronological data, as shown in Figure 1 below. We put forward 20 new $^{40}Ar/^{39}Ar$ samples, which aim to fill this significant geographic and knowledge gap, providing an N-S transect through structural boundaries and intrusive suites. The proposed samples were previously collected and dated using U-Pb SHRIMP geochronology by Geoscience Australia. This removes significant risk and uncertainty associated with fieldwork and sample collection due to the current COVID-19 pandemic. Furthermore, the samples can be collected and separated within the time frame of the National Argon Map initiative.

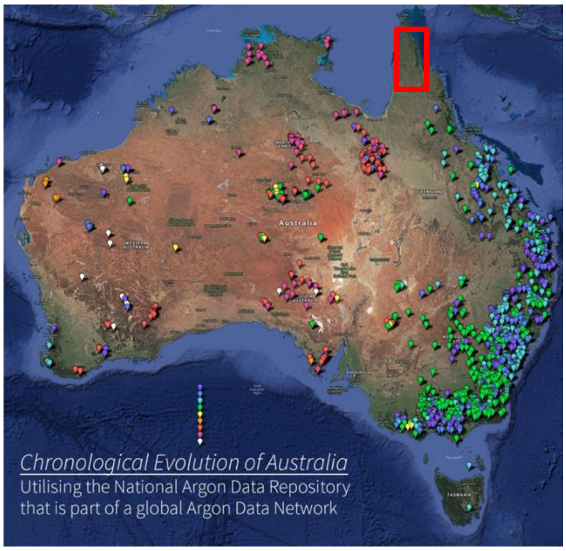

Figure 1. National Argon Map $^{40}Ar/^{39}Ar$ data coverage. Study region outlined in red. Map from http://tectonics.anu.edu.au/ArgonMap/

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).

This project involves collaboration between ANU and AngloGold Ashanti (AGA). The aims of this project are to contribute new $^{40}Ar/^{39}Ar$ geochronology data for intrusives within the Coen Inlier, which will enable forward modelling of the thermal history.

<u>Geological Background</u>

The Coen Inlier of far north Queensland consists Proterozoic crystalline metamorphic basement comprising the Etheridge, Savannah and Iron Range provinces, which is intruded by the Palaeozoic Cape York Batholith (Fig. 1). The Cape York Batholith outcrops over an area of 5,500 km^2 and is made up of the Pama Igneous Association (Silurian-Devonian) and the Kennedy Igneous Association (Early Carboniferous-Early Permian) (Blewett *et al*, 1998). The latter is associated with various groups of mineral deposits throughout north Queensland (e.g. Red Dome, Kidston and Mt Leyston). The Coen Inlier has had limited discussion in the literature, even though it has significant implications for the Rodinian and Gondwanan tectonic evolution (Brown *et al*, 2018). This project aims to address this gap in the literature, with new $^{40}Ar/^{39}Ar$ diffusion experiments giving an insight into the thermal history of the Palaeozoic granitic intrusions across the Coen Inlier. Each sample has existing zircon U–Pb geochronological data that will be used in conjunction with new $^{40}Ar/^{39}Ar$ geochronology data, to provide a unique insight into the thermal evolution of the region.

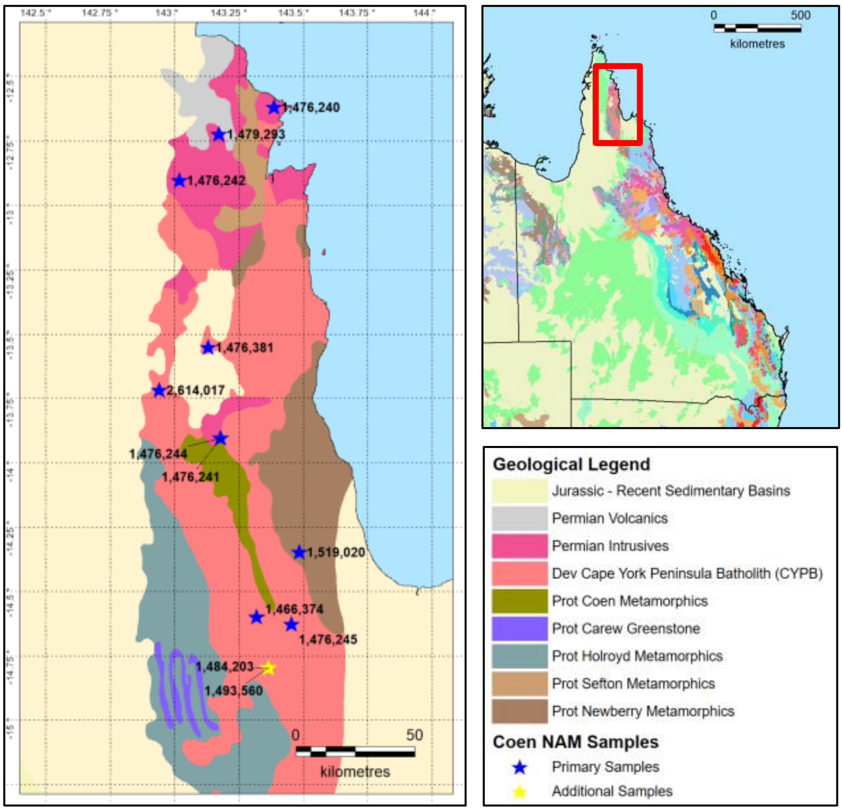

Figure 1. Geological Map of the Coen Inlier. 10 Primary samples are represented by blue stars and the two additional samples are represented by yellow stars.

Sample Selection

The 10 chosen locations cover a broad transect N-S through the Coen Inlier (blue stars in Fig. 1). At each location (both, if possible) pristine K-feldspar and mica (either white mica or biotite) will be separated for analysis. The age and temperature data provided by the proposed $^{40}Ar/^{39}Ar$ step-heating experiments will be used in conjunction with the existing U-Pb ages. This has been shown to be an effective method in unravelling tectonothermal events (Forster *et al*, 2015, 2019, 2020; Li *et al*, 2007). Using mica and K-feldspar pairs will allow distinction of any younger metasomatic events from magmatic crystallisation ages, thus building a comprehensive history for the intrusions. Furthermore, research has increasingly found micas to be a resourceful mineral for dating deformation using $^{40}Ar/^{39}Ar$ geochronology. We have suggested two additional samples (yellow star in Fig. 1) that broaden the scope of the transect further southward (Fig. 1). This would allow for thermal modelling of the southern extent of the Ebagoola Granite (Sample #: 1493560) and data for a younger metasomatic event/s (Sample #: 1484203).

Table 1: Sample list

	Results from zircon U-Pb dating								
GA Sample ID	**Magmatic Age (Ma)**	**Inherited Age (Ma)**	**Metamorphic Age (Ma)**	**Lat**	**Long**	**Rock Description**	**Stratigraphic Unit**	**Target Mineral/s**	
1466374	405	447		-14.599	143.318	Biotite granodiorite	Glen Garland Granite	White Mica/Biotite	K-Feldspar
1476245	405	2340		-14.627	143.454	Muscovite granite	Kintore Granite	White Mica/Biotite	K-Feldspar
1476242	284			-12.904	143.019	Granite	Weymouth Granite	White Mica/Biotite	K-Feldspar
1479293	287			-12.725	143.173	Granite	Weymouth Granite	White Mica/Biotite	K-Feldspar
1519020	1564	1619	416	-14.349	143.485	Felsic gneiss	Kitja Gneiss	White Mica/Biotite	K-Feldspar
2614017	407.7			-13.72	142.94	Monzodiorite	Rokeby Quartz Monzodiorite	White Mica/Biotite	K-Feldspar
1476244	285			-13.905	143.179	Adamellite	Twin Humps Granite	White Mica/Biotite	K-Feldspar
1476241	405			-13.905	143.179	Muscovite granite	Twin Humps Granite	White Mica/Biotite	K-Feldspar
1476381	409	436		-13.553	143.131	Muscovite granite	Blue Mountains Monzogranite	White Mica/Biotite	K-Feldspar
1476240	409	465		-12.619	143.386	Granite	Little Round Back Granite	White Mica/Biotite	K-Feldspar
1484203*	357	1559		-14.798	143.364	Propylitic altered andesite	Ebagoola Granite	White Mica/Biotite	
1493560*	1430			-14.795	143.364	Gneiss	Ebagoola Granite	White Mica/Biotite	K-Feldspar

Previous zircon U–Pb geochronological data exists for all the samples in this proposal, which are outlined in Table 1. These results record only a temperature-time point, in high temperature regimes. In contrast $^{40}Ar/^{39}Ar$ thermochronology method provides a continuous temperature-time history that includes both high and low temperatures. K-feldspar has been shown to retain argon at higher temperatures (~500-700°C) (Forster *et al*, 2015), and can therefore, enable a detailed thermal history model of the igneous intrusions within the Coen Inlier. Within the upper crustal environment, temperature can often be used as a proxy for depth, so that reconstructed thermal histories, may reveal a record of rock movement towards the surface, often reflecting tectonic and landscape evolution processes. The thermal history provides fills the gap in the data to answer significant questions around emplacement depth, timing and duration of metasomatic activity and any tectonothermal events in the region.

References:

Blewett, R.S. & Black, L.P., 1998. Structural and temporal framework of the Coen Region, north Queensland: implications for major tectonothermal events in east and north Australia. *Australian Journal of Earth Sciences*. 45, 597–609.

Brown, D.D. & Purdy, D.J., 2018. Updates to the geology of the northern Coen Inlier region, Cape York. *Queensland Geological Record.*

Forster, M. A., Armstrong, R., Kohn, B., Lister, G. S., Cottam, M. A., and Suggate, S., 2015. Highly retentive core domains in K-feldspar and their implications for 40Ar/39Ar thermochronology illustrated by determining the cooling curve for the Capoas Granite, Palawan, The Philippines. *Australian Journal of Earth Sciences*. 62:7, 883-902.

Forster, M. A., and Goswami, N., 2019. Characterisation of the post-Delamerian deformation and exhumation histories using 40Ar/39Ar thermochronology age data. *MinEx CRC Annual Research Conference: Frontier Exploration 2019. Project 8: Geological architecture and evolution.*

Forster, M. A., Koudashev, O., Nie, R., Yeung, S., Lister, G., 2020. 40Ar/39Ar thermochronology in the Ios basement terrane resolves the tectonic significance of the South Cyclades Shear Zone. *Geological Society, London, Special Publications*. 487, 291-313.

Li, Z. X., Wartho, J., Occhipinti, S., Zhang, C., Li, X., Wang, J., Bao, C., 2007. Early history of the eastern Sibao Orogen (South China) during the assembly of Rodinia: New mica 40Ar/39Ar dating and SHRIMP U–Pb detrital zircon provenance constraints. *Precambrian Research*. 159:1/2. 79-94.

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

We propose 20 samples from 10 locations transecting the Coen region. Each location will have a K-feldspar and mica pair. As outlined above we suggested two additional samples that broaden the scope of the transect further southward (bringing the total to 23). This would allow for thermal modelling of the southern extent of the Ebagoola Granite (1493560) in conjunction with younger metasomatic event/s (1484203).

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

Table 1: Sample List

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**Additional samples*

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 is required for $^{40}Ar/^{39}Ar$ laboratory due to the ongoing relationship and the detailed nature of the step-heating analysis needed for temperature-time forward modelling.

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)