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: Geoff Fraser
Affiliation and position: Geoscience Australia (GA), Director of Geochronology & Stratigraphy
Collaborators: Andrew Clark, Anthony Schofield (GA), Barry Reno (NTGS)
Project Title: Filling the gaps: thermotectonic evolution of the east Tennant region and eastern Pine Creek Orogen
Geographic Region: region east of Tennant Creek and eastern Pine Creek Orogen
Geological Province or Tectonic Unit: North Australian Craton

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 showing the spatial distribution of samples in their geological context (with scale).

The North Australian Craton (NAC) is one of the three major building blocks of Precambrian Australia, along with the West Australian Craton (WAC) and South Australian Craton (SAC) (e.g. Cawood and Korsch, 2008). The geological evolution of the NAC is known to extend from at least as old as ~2700 Ma (Hollis et al., 2009) through to Paleozoic reworking events as young as ~330 Ma (the Alice Springs Orogeny), with numerous magmatic, deformation and mineralising events punctuating that long history. The geochronological and isotopic evidence for this long and complex history has been recently summarised in a series of age and isotopic maps (Fraser et al. in press). While these maps provide a wealth of insight, they also highlight significant gaps in data coverage where new data acquisition is warranted. This proposal addresses two such gaps in the coverage of $^{40}Ar/^{39}Ar$ geochronology data in the NAC.

The east Tennant region

The region between Tennant Creek and Mount Isa has been a major focus of recent work by Geoscience Australia and collaborators, during the Exploring for the Future program. The basement geology of the region is extremely poorly understood, being entirely buried beneath overlying sedimentary rocks of the Georgina Basin, and the black soil plains of the Barkly Tablelands. From a mineral prospectivity perspective, the region is of interest because it is flanked on either side by outcropping provinces that are richly-endowed with economic mineral deposits. To the west, the Tennant Creek district hosts numerous Iron Oxide Copper Gold (IOCG) deposits, and to the east the Mount Isa district forms part of the world's richest Pb-Zn province, and also hosts IOCG-style mineralisation. Geophysical evidence from magnetic, gravity, seismic and magnetotelluric surveys (e.g. Schofield et al. in press) indicate the presence of an ENE-trending structural corridor east of Tennant Creek and extending towards the Paleoproterozoic Murphy Province to the north-east (Fig. 2). The age of the rocks, and the timing of structural and thermal events within this structural corridor are poorly constrained due to lack of basement samples. A small number of diamond drill-holes penetrate basement rocks in the east Tennant region. Zircon and monazite samples from these drill-holes have recently been analysed via the U-Pb SHRIMP method (Cross et al., in press), and results indicate a magmatic and metamorphic event at ~1850 Ma, contemporaneous with ~1850 Ma

magmatism and IOCG mineralisation at Tennant Creek. This raises the prospectivity of the east Tennant region for undiscovered IOCG mineralisation. No K-Ar or ^{40}Ar-^{39}Ar geochronology has been conducted in the east Tennant region (Fig. 1), hence the post-1850 Ma thermal and deformation history is unconstrained. In this study, we propose to analyse mica and feldspar from a selection of the same drill-holes and samples from which U-Pb ages have recently been acquired. The ^{40}Ar-^{39}Ar results will, therefore, complement the existing U-Pb constraints and provide evidence for timing of shearing, cooling and exhumation of the east Tennant region, allowing comparison with surrounding parts of the NAC, including the Tennant Creek and Mount Isa districts, as well as the Aileron Province to the south and Pine Creek Orogen region to the north. We note, also, that the east Tennant region is planned to be the location of the first stratigraphic drilling program to be conducted by the MinEx CRC. Timing of that drilling campaign is somewhat uncertain given constraints imposed by the current COVID-19 pandemic. Results from the small number of pre-existing drill-holes, as proposed here, will provide valuable context for any future geochronology studies to be conducted on samples from planned MinEx CRC drill-holes.

The eastern Pine Creek Orogen

The Pine Creek Orogen forms the northern part of the NAC, and has been divided into three major tectonic domains. The eastern-most of these domains, the Nimbuwah Domain, contains the oldest known rocks in the NAC, with magmatic crystallisation ages of ~2670 Ma and ~2640 Ma (Hollis et al., 2009). As shown on Fig.1, no K-Ar and ^{40}Ar-^{39}Ar ages are available for these oldest rocks of the NAC. To complement the work proposed above in the east Tennant region, we propose to analyse mica and feldspar from samples analysed by Hollis et al. (2009) to provide constraints on the timing of post-magmatic cooling, exhumation and juxtaposition with surrounding domains.

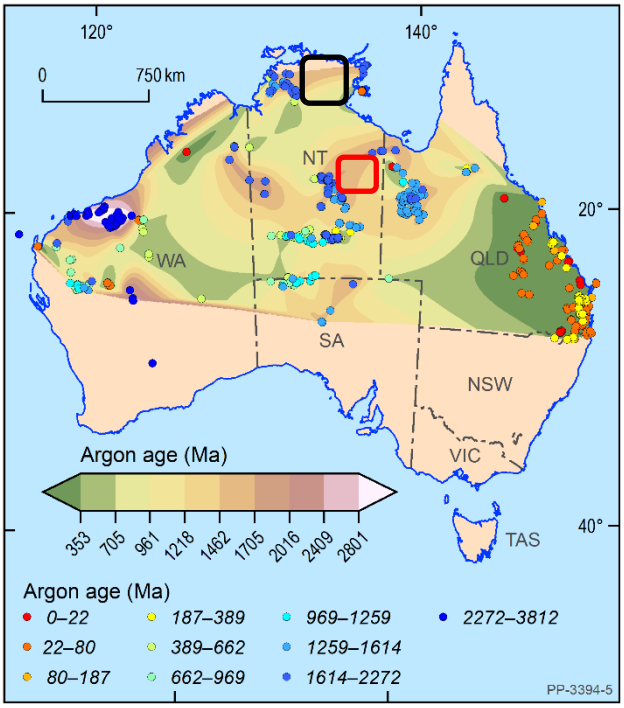

Figure 1: K-Ar and ^{40}Ar/^{39}Ar age map of northern Australia, from Fraser et al, in press. Geographic gaps in data coverage, (i) between Tennant Creek and Mt Isa and (ii) in the eastern Pine Creek Orogen, which will be addressed by this proposal, are shown by the red and black ellipses, respectively.

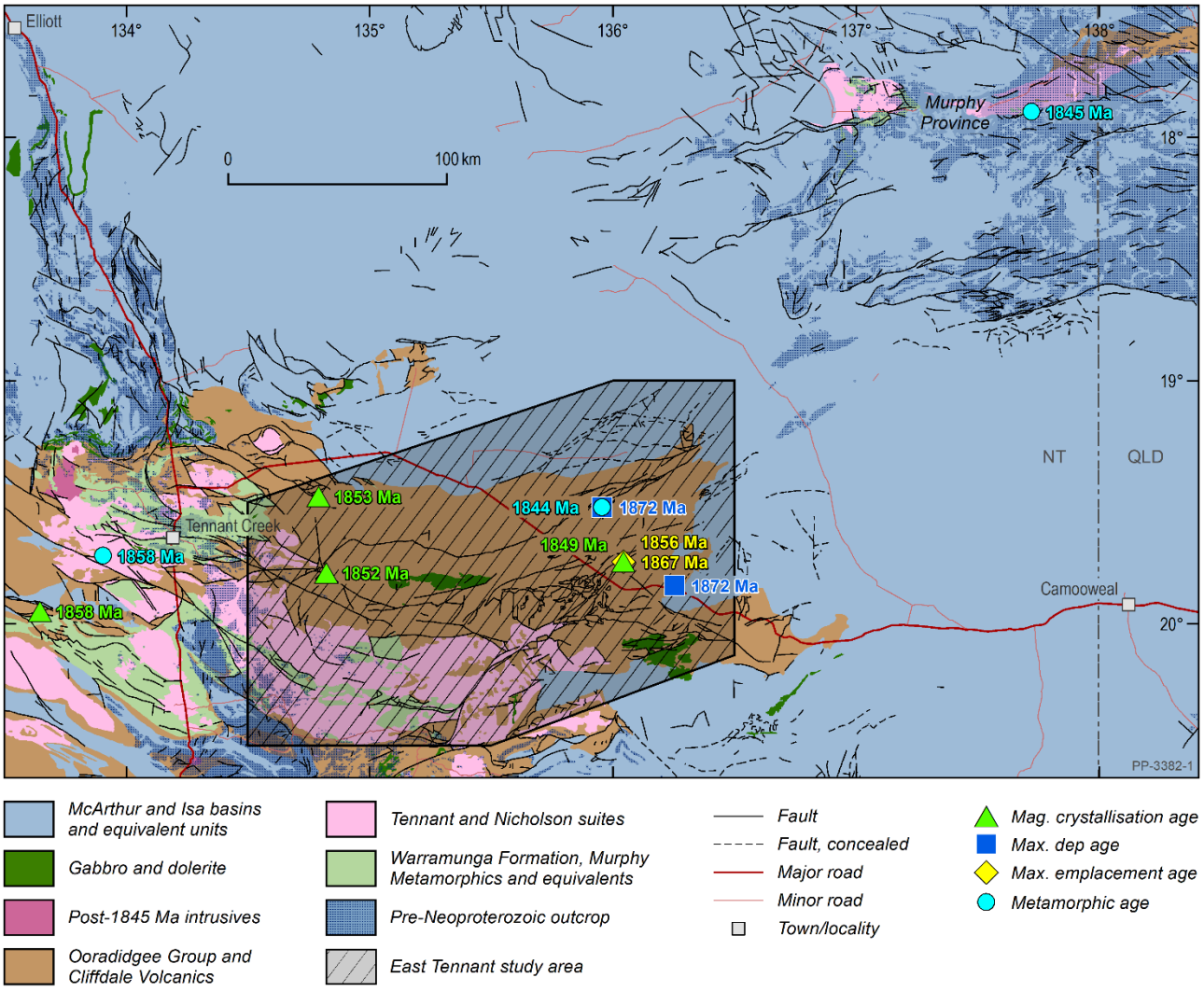

Figure 2: Pre-Neoproterozoic solid geology of the east Tennant region (Stewart, 2018). Coloured symbols show the locations of sparse drill-holes that intersect crystalline basement rocks. Ages against symbols indicate recently-acquired U-Pb SHRIMP zircon and monazite ages from magmatic and metasedimentary basement rocks (Cross et al., in press). Samples proposed to be analysed by the ^{40}Ar-^{39}Ar method in this study come from the same drill-holes as shown here.

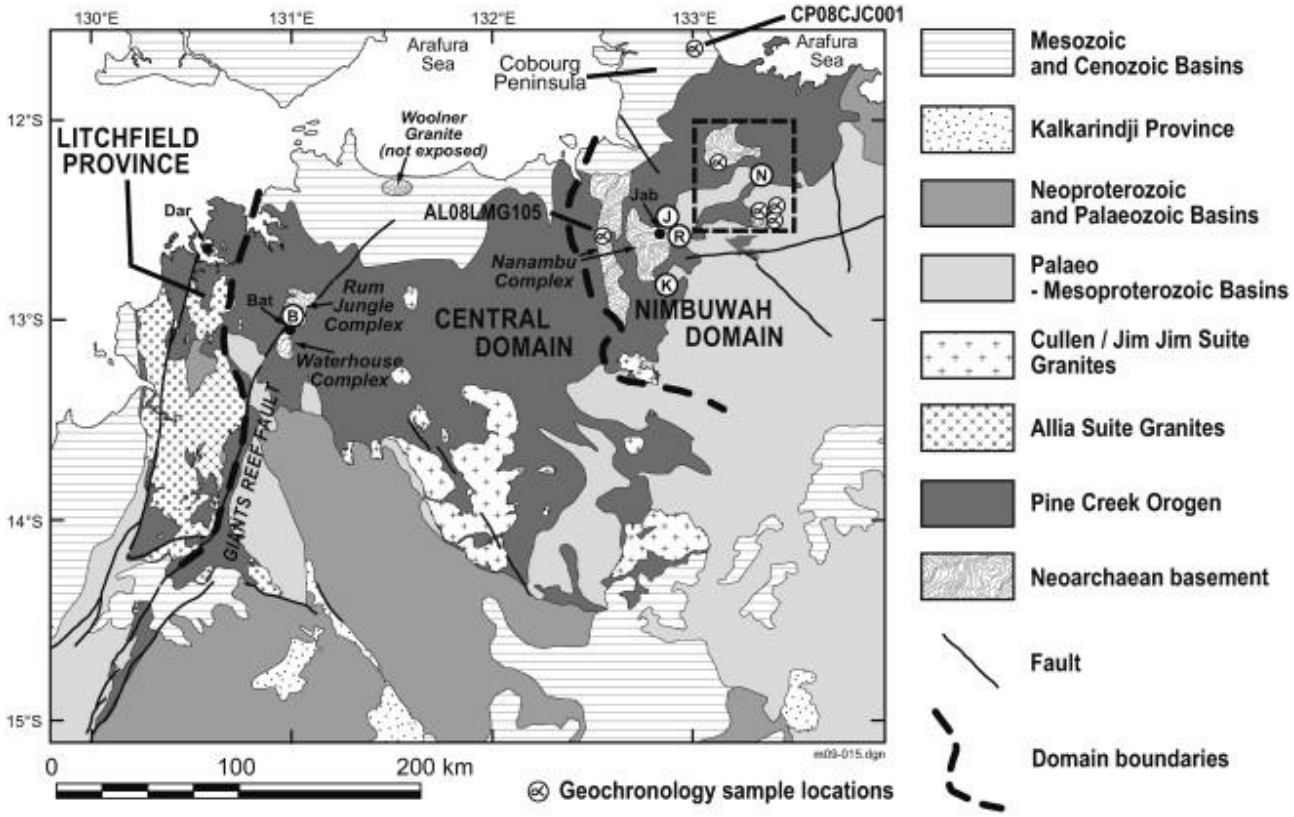

Figure 3: map of the Pine Creek Orogen showing the subdivision into the Litchfield Province, Central Domain and Nimbuwah Domain, each with contrasting geological histories (from Hollis et al. 2009). Samples proposed to be analysed in this study come from the Nimbuwah Domain, with locations marked by the α symbols.

References

Cawood, P. A. and Korsch, R. J., 2008. Assembling Australia: Proterozoic building of a continent. Precambrian Research 166, 1-4, 1-35.

Cross, A. J., Clark, A. D., Schofield, A. and Kositcin, N., in press. SHRIMP U-Pb zircon and monazite geochronology of the East Tennant region: a possible undercover extension of the Warramunga Province, Tennant Creek. In: Czarnota et al. (eds), Exploring for the Future: extended abstracts, Geoscience Australia, Canberra.

Fraser, G. L., Waltenberg, K., Jones, S. L., Champion, D. C., Huston, D. L., Lewis, C. J., Bodorkos, S. Forster, M., Vasegh, D., Ware, B. and Tessalina, S. in press. An Isotopic Atlas of Australia. In: Czarnota et al. (eds), Exploring for the Future: extended abstracts, Geoscience Australia, Canberra.

Hollis, J. A., Carson, C. J. and Glass, L. M., 2009. SHRIMP U-Pb zircon geochronological evidence for Neoarchean basement in western Arnhem Land, northern Australia. Precambrian Research, 174, 3-4, 364-380.

Schofield et al, in press. Data integration for greenfields exploration: an example from the East Tennant region, Northern Territory. In: Czarnota et al. (eds), Exploring for the Future: extended abstracts, Geoscience Australia, Canberra.

Stewart, A. J., 2018. Solid geology of the Tennant Creek-Mt Isa area, 1:2 500 000 scale, 1st edn digital dataset, Geoscience Australia, Canberra.

Approximate number of samples proposed for $^{40}Ar/^{39}Ar$ analyses: 12
We propose to analyse ~8 samples from the east Tennant region, We propose to analyse ~4 samples from the Nimbuwah Domain of the Pine Creek Orogen.

Lithologies and minerals proposed for $^{40}Ar/^{39}Ar$ analyses:
Samples from the east Tennant region include amphibolite-facies pelitic schists, and we propose analysing muscovite and biotite from tectonic fabrics in rocks from which U-Pb zircon and monazite ages have recently been obtained.
Samples from the Nimbuwah Domain, Pine Creek Orogen, are granitic gneisses as reported by Hollis et al. (2009), and we propose to analyse mica and K-feldspar from these 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, due to ongoing working relationship, and collaborative interests in the tectonic and thermal evolution of the North Australian Craton.

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, Curtin University
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)