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: Catherine Spaggiari
Affiliation and position: Geological Survey of Western Australia (GSWA); Project Manager
Collaborators: David Kelsey and Raphael Quentin de Gromard (GSWA)
Project Title: Testing connections between the Lasseter and Mundrabilla Shear Zones
Geographic Region: Eastern WA, near the border with the NT and SA
Geological Province or Tectonic Unit: West Arunta Orogen and Kidson Craton; Madura and Coompana Provinces

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).

Located in northeastern Western Australia, the Lasseter Shear Zone is defined as a series of northeast-trending structures representing the boundary between unknown basement beneath the Canning Basin (Kidson Craton) and the western edge of the West Arunta and Tanami Orogens, and eastern edge of the Halls Creek Orogen (Fig. 1). To the south, the Mundrabilla Shear Zone is a north-trending, subvertical sinistral shear zone separating the Madura and Coompana Provinces beneath the Eucla and Bight Basins, with a possible extension or younger related fault in the Musgrave Province beneath the Officer Basin. Structural connections between the two shear zone systems have been speculated upon, but never tested. The aim of this study is to use the $^{40}Ar/^{39}Ar$ method to detect and date movement events on the two shear zone systems, and test for kinematic connections. If the connections prove positive, significant displacements over time will need to be taken into account to constrain models of the assembly of Proterozoic Australia. These large crustal-scale shear zone systems would also have provided significant magmatic and fluid pathways for mineralization, so understanding their evolution will help inform prospectivity analysis.

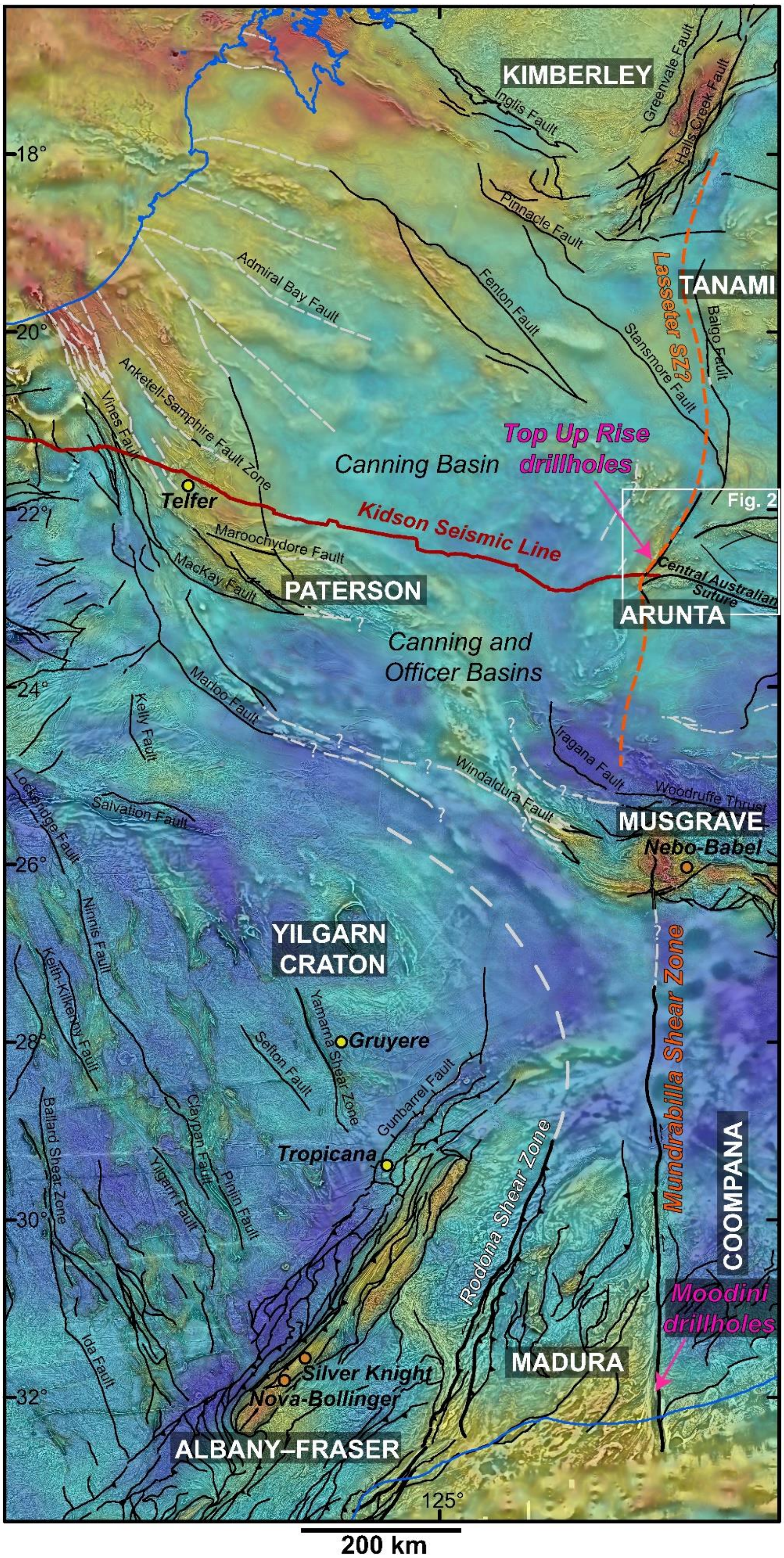

Figure 1. Gravity (colour) and first vertical derivative aeromagnetic (greyscale) image of Western Australia showing the inferred trace of the Lasseter Shear Zone, and major structures.

As yet there are no constraints on the timing of movement and kinematics of the Lasseter Shear Zone, although U–Pb zircon and monazite dating is in progress at GSWA on drillcore samples from the five Top Up Rise prospect drillcores (Fig. 2). These dates will help provide a stratigraphic and metamorphic framework for dating deformation events with the $^{40}Ar/^{39}Ar$ method. The Top Up Rise drillcores contain mylonitic rocks with muscovite-rich fabrics which we will target for dating, as well as other deformation fabrics. We will also investigate the possibility of dating deformed rocks from outcrops along the Central Australian Suture (thick black line in Fig. 2) in the vicinity of the Lasseter Shear Zone to investigate potential differences or links between movement events. The Central Australian Suture marks the boundary between the Aileron and Warumpi Provinces of the Arunta Orogen, formed during the c. 1640 Ma Liebig Orogeny (Scrimgeour et al., 2005, Precamb. Res. 142, 1–27).

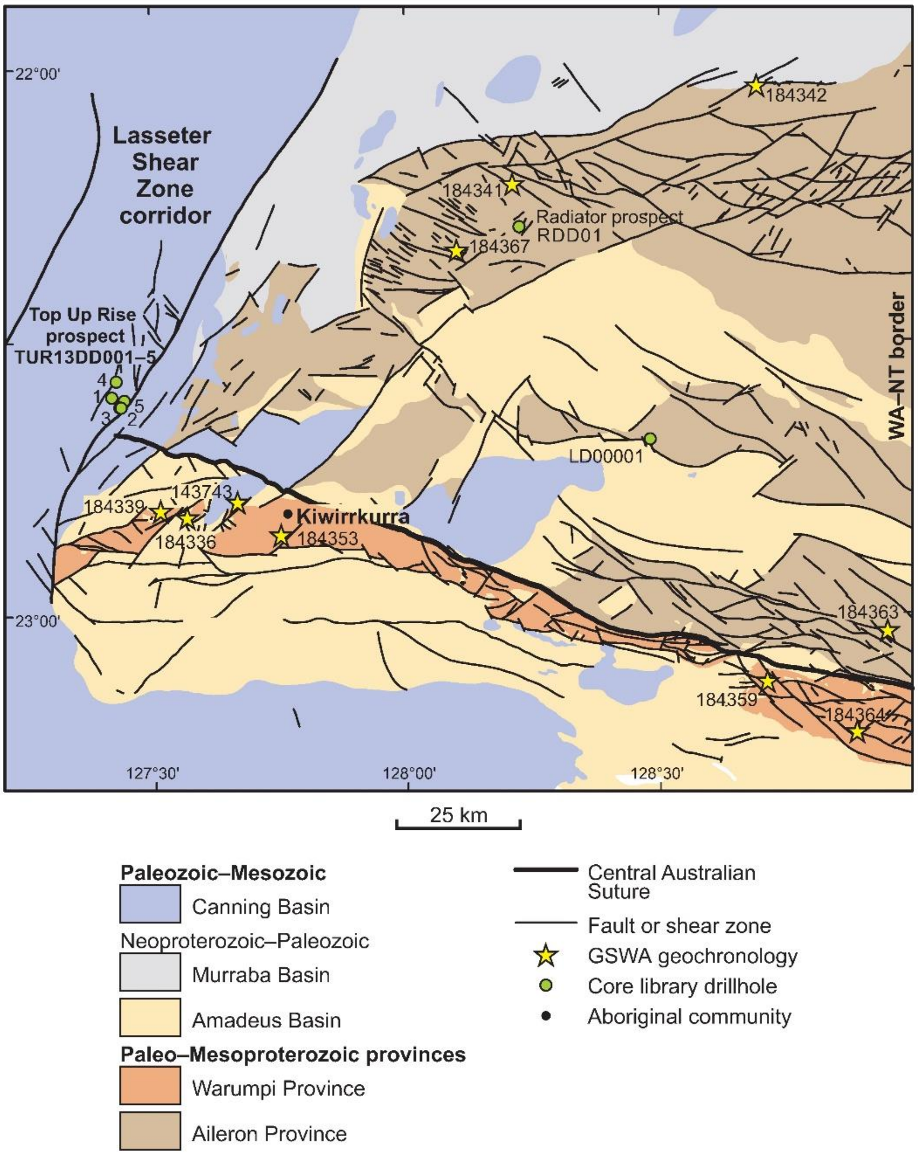

Figure 2. Interpreted solid geology map of the West Arunta showing dated U–Pb zircon geochronology samples and locations of drillholes.

Sinistral displacement on the Mundrabilla Shear Zone has been estimated at up to 300 km, based on matching magnetic and gravity features either side of the shear zone (Aitken et al., 2016, Gondwana Res., 29, 136–152). While the absolute amount of displacement is not well-constrained, the sinistral drag on the shear zone is clearly visible in aeromagnetic images, as are differences in gravity and seismic responses. Maximum ages of 1132 ± 9 and 1127 ± 7 Ma for this sinistral movement are provided by zircon crystallization dates from strongly magnetic Moodini Supersuite metamonzogranite from Moodini prospect drillcores that intersect high intensity magnetic anomalies within the Mundrabilla Shear Zone (Fig. 1; GSWA samples 192565 and 192566). However, it is feasible that this shear zone has a history that predates the intrusion of that monzogranite. A minimum age is provided by the 1090–1040 Ma Giles Event in the Musgrave Province, where voluminous intrusive and volcanic rocks crosscut the potential northward continuation of the Mundrabilla Shear Zone (Smithies et al., 2014, Gondwana Res., 27, 1419–1429).

Although it is tempting to make correlations between the two major shear zone systems based on their similar trends, younger events that may have modified or displaced the shear zones need to be considered. These include the possibility of block rotations (Li and Evans, 2011, Geology, 39, 39–42), dextral transpression recorded during the 670–510 Ma Paterson–Petermann–King Leopold Orogenies (Quentin de Gromard et al., 2019, Geoscience Frontiers, 10, 149–164), and crustal displacements during the formation of the Amadeus and Officer Basins. Taking such factors into account will help resolve whether both temporal and spatial connections between the two shear zone systems existed. For example, it is possible that the two shear zones could record similar movements, but without being spatially connected (e.g. from near or far-field stresses without being joined). This project will provide new $^{40}Ar/^{39}Ar$ datasets on two major shear zone systems to help resolve these issues by gaining an understanding of their evolution, and thereby provide insight into Proterozoic Australia assembly.

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

Six from the Mundrabilla Shear Zone drillcores, 10 from the Top Up Rise drillcores (Lasseter Shear Zone), 2 or 3 from outcrops from the Central Australian Suture (subject to access, but we have one sample of mylonite in archive). We can provide more samples if necessary, or if more drillcores become available.

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

Samples from the Mundrabilla Shear Zone typically contain biotite and K-feldspar within L-S fabrics. While sampling we will also look for muscovite and hornblende.

We have already sampled the Top Up Rise drillcores and have specifically targeted mylonitic zones for $^{40}Ar/^{39}Ar$ dating (5 samples). These have well-developed S-C fabrics and mica fish, dominated by muscovite. Some samples also contain K-feldspar and/or biotite. In addition to these samples we will choose additional samples to complement the U–Pb and monazite geochronology we are currently working on.

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)