

# 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](mailto:Geoff.Fraser@ga.gov.au)) for consideration by the National Argon Map Oversight Panel

### Project Proponent

Name: Bryant Ware
Affiliation and position: John de Leater Centre, Research Associate
Collaborators: Martin Wells, Mark Aylmore, Mike Wingate, Fred Jourdan
Project Title: Spodumene $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology: Implications for Li-Deposits
Geographic Region: Western Australia (Various state-wide Li ore locations)
Geological Province or Tectonic Unit: Pilbara and Yilgarn Cratons

### Brief Project Description:

Multi-collector noble gas instruments such as the ThermoFisher ARGUS VI have been revolutionary in the available capabilities within the realm of  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology applications. Recently the  $^{40}\text{Ar}/^{39}\text{Ar}$  technique with the mineral pyroxene has been shown to be a viable technique to obtain geologically meaningful crystallization ages for mafic igneous material (Ware and Jourdan, 2018).

This project proposes to continue the development of pyroxene  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology with a sample set of well characterised spodumene samples from across Western Australia (WA). The resulting data would represent the first potential direct dating of the mineral spodumene as well as be the most highly characterized data set yet of any pyroxene  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology project. This work would enable the geochronological data to be related directly to the petrology, which has never been done before. In addition,  $^{40}\text{Ar}/^{39}\text{Ar}$  analysis of spodumene can potentially be used as a signature method to certify ore bodies as ethically sourced battery material from Australia. Industries such as EV car manufactures are looking to impose strict compliance on its suppliers from lithium battery production down to raw material source.

The proposed spodumene sample set to be submitted for  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronological analysis is part of the current 2-year, MRIWA M532 project, *Geology, Mineralogy and Metallurgy of eMaterials Deposits in WA*. The overarching goal of the project is to develop a geo-metallurgical framework for WA, lithium pegmatite deposits, leading to improved efficiencies in exploration, mineral beneficiation and processing techniques. Representative examples of spodumene-bearing, Li-pegmatite have been collected from the main pegmatite fields in WA (Figure 1) and include examples from Li deposits, such as Greenbushes, Mt Cattlin, Bald Hill and Pilgangoora. Spodumene from these deposits has undergone detailed physico-chemical characterization including: (Q)XRD, SEM-based mineral-mapping, electron probe microanalysis (EPMA), laser ablation inductively coupled mass spectrometry (LA-ICP-MS), thermal analysis, Raman spectroscopy and laser induced breakdown spectroscopy (LIBS). To our knowledge only the Greenbushes and Pilgangoora deposits have been dated; Greenbushes - potentially two mineralising events over 2527–2430 Ma (zircon, U-Pb); Pilgangoora – at 2879 Ma (dating of columbite-tantalite).

Results of a pilot study of a spodumene from the Mt Cattlin mine site produced compelling results for the utilization of the  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology to date spodumene and pyroxene variants as a whole (Figure 2). Considering the  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology data only, these results provide two main fascinating considerations; 1) the high radiogenic argon component within the spodumene displays a high potential for high quality  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology results and, 2) the lack of two apparent domains within the argon results alone strengthens and further enlightens the argon systematic/degassing behaviour in pyroxene interpretations from the dolerite data.

The outcomes of this project will have two implications: 1) on a macro scale these results of well characterized samples will expand the understanding of the argon system in pyroxene as a whole, such as what the dates and/or age constraints obtained from pyroxene  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology truly represent in a geologic context (primary or alteration ages of pyroxene or a different auxiliary K rich phase, such as orthoclase, micas, fluid or melt inclusions); and, 2) on a micro scale applying direct dates to the mineralizing system which can be constrained through both potential outcomes of the geochronology results (i.e. can establish the crystallization age of the spodumene or if determined to be an alteration age, the age of fluid flow through the system).

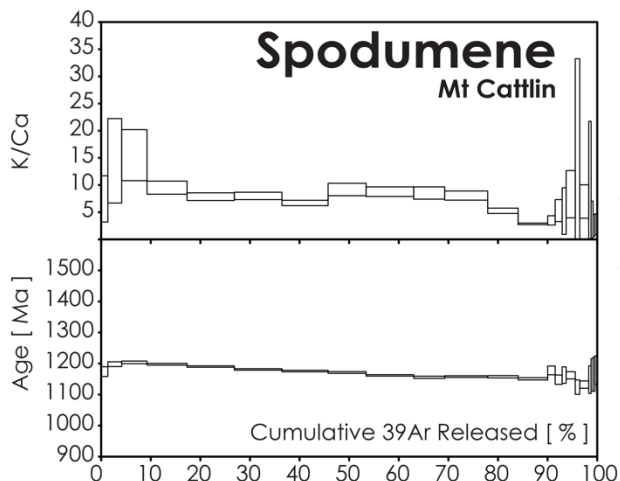


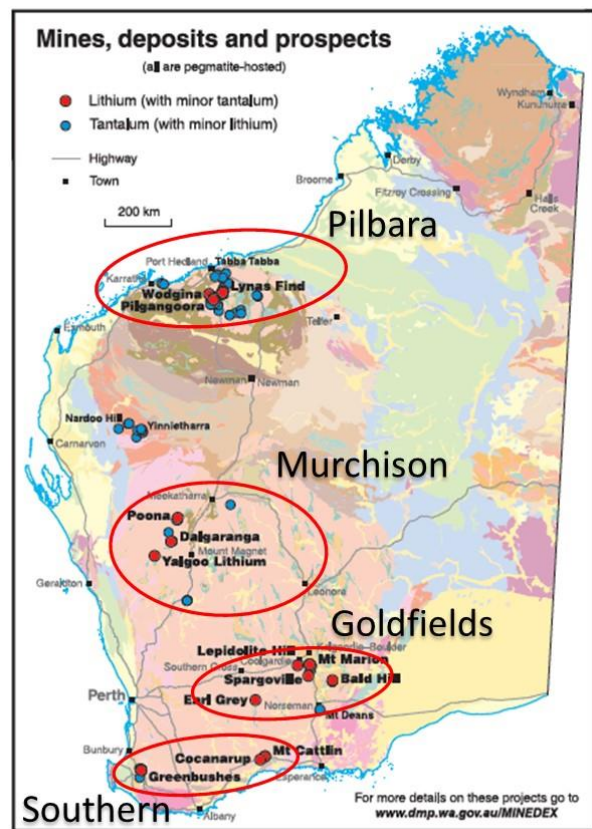
Figure 2:  $^{40}\text{Ar}/^{39}\text{Ar}$  results for spodumene from the Mt Cattlin mine site.

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

We would like to submit up to 10 samples of spodumene from four sites: Greenbushes (2 samples), Mt Cattlin (2 samples), Bald Hill (2 samples) and Pilgangoora (4 samples).

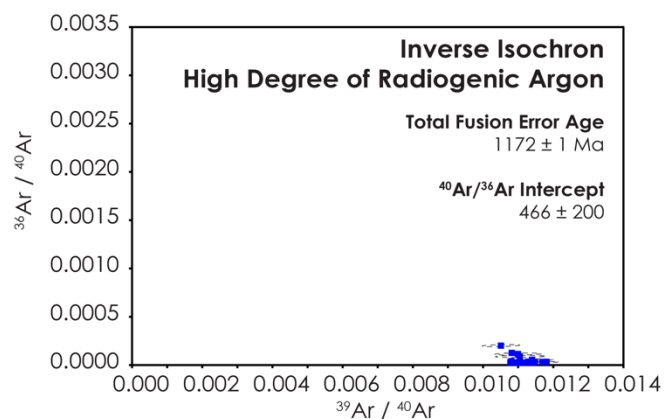
**Lithologies and minerals proposed for  $^{40}\text{Ar}/^{39}\text{Ar}$  analyses:**

Spodumene (Li Pyroxene)



Source: GSWA, Investment Opportunities Li for FY2017-2018

Figure 1. Lithium (and tantalum) bearing mines, deposits and prospects in WA. Li-bearing pegmatites may be grouped into four main ‘pegmatite ‘fields’; Southern, Goldfields, Murchison and Pilbara.



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

The Curtin University, Western Australian Argon Isotope Facility of the John de Laeter Centre for Isotope Research is preferred as this is where I (Bryant) worked to develop utilizing the  $^{40}\text{Ar}/^{39}\text{Ar}$  technique on the mineral pyroxene with Fred Jourdan.

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

**Impact:** to what extent new  $^{40}\text{Ar}/^{39}\text{Ar}$  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  $^{40}\text{Ar}/^{39}\text{Ar}$  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  $^{40}\text{Ar}/^{39}\text{Ar}$  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  $^{40}\text{Ar}/^{39}\text{Ar}$  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  $^{40}\text{Ar}/^{39}\text{Ar}$  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  $^{40}\text{Ar}/^{39}\text{Ar}$  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  $^{40}\text{Ar}/^{39}\text{Ar}$  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

- $^{40}\text{Ar}/^{39}\text{Ar}$  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](mailto:Marnie.Forster@anu.edu.au)) or Geoff Fraser ([Geoff.Fraser@ga.gov.au](mailto:Geoff.Fraser@ga.gov.au))