# National Argon Map: an AuScope Initiative
## $^{40}Ar/^{39}Ar$ Geochronology Laboratory Sample Submission Form

*This form must be completed and returned to Marnie Forster ([Marnie.Forster@anu.edu.au](mailto:Marnie.Forster@anu.edu.au)) before any work can be commenced in the Argon Laboratories.*

| |
|---|
| **Person submitting samples:** Mark Eastlake |
| **Affiliation:** Geological Survey of NSW |
| **Project Title:** New $^{40}Ar/^{39}Ar$ age constraints on the timing of deformation on major faults in the Lachlan Orogen, NSW |
| **Sample Number(s) (including IGSN if one exists):** ERIVMAE0691.01 |
| **Mineral separation required? Yes** |
| **Date submitted:** 27/05/2020 |

| | |
|---|---|
| **GEOGRAPHIC AREA/ PROVINCE/ BASIN:** Eastern Riverina district, southern central NSW/ Central Lachlan Orogen. | |
| **1:250k SHEET NAME:** Cootamundra | **NUMBER:** SI/55-11 |
| **1:100k SHEET NAME:** Barmedman | **NUMBER:** 8329 |
| **LOCATION METHOD:** GPS (GDA94) | |
| **ZONE:** 55 | |
| **EASTING:** | **NORTHING:** |
| **LATITUDE:** -34.20122333333 | **LONGITUDE:** 147.249125 |

| |
|---|
| **STRATIGRAPHIC UNIT FORMAL NAME *:** Yalgogrin Granite |
| **STRATIGRAPHIC UNIT INFORMAL NAME:** |
| **LITHOLOGY:** Granitic mesomylonite |

| |
|---|
| **DRILLHOLE ID (if applicable):** |
| **PROSPECT (if applicable):** |
| **DEPTH FROM (metres):** |
| **DEPTH TO (metres):** |

* Stratigraphic Unit names can be searched and checked within the Australian Stratigraphic Units Database via the following link: https://asud.ga.gov.au/

### Dating Objective

***What is the geological question $^{40}Ar/^{39}Ar$ analysis will address?***

This sample is a mesomylonite from the Ellon Vale Shear Zone, a broad sinistral strike-slip shear zone that overprints/offsets the mid-Silurian Yalgogrin Granite in the Central Lachlan Orogen. An $^{40}Ar/^{39}Ar$ age of fabric forming micas will constrain the timing of shear zone development and provide the opportunity to assess the consistency and reproducibility of $^{40}Ar/^{39}Ar$ ages from this structure by comparison with the results from sample ERIVMAE0052.01C.

***What type of age(s) are expected? (e.g. magmatic crystallisation, metamorphism, fluid alteration/mineralisation, cooling, shearing etc):***

$^{40}Ar/^{39}Ar$ dating of fabric forming micas is expected to yield a deformation age or potentially cooling age for the shear zone.

***Mineral target(s) for dating:***

The primary target for determining a deformation age is very fine-grained muscovite (sericite) defining the mylonitic foliation. These deformation related sericite form slender bladed crystals typically <0.05 mm long; although, slightly longer crystals up to 0.075 mm long are locally present in strain shadows and as replacements on mica fish. Further, they can be distinguished from relict igneous muscovite by their finer grainsize and morphology. It is also requested that neocrystalline biotite defining foliation also be considered for dating. This deformation related biotite may be distinguished from relict primary biotite on account of its finer grainsize, colour, absence of inclusions and morphology (see petrographic description).

Relict igneous muscovite and biotite (as mica fish) are secondary targets proposed for $^{40}Ar/^{39}Ar$ geochronology. Understanding the argon isotope systematics of these inherited mica populations may assist interpreting the results from the deformation related mica.

***Estimated $^{40}Ar/^{39}Ar$ age (e.g. Cenozoic, Mesozoic, Paleozoic, Proterozoic, Archean – provide estimated numerical age range if possible):***
Initial attempts to date the Ellon Vale Shear Zone by $^{40}Ar/^{39}Ar$ geochronology returned concordant apparent ages primarily in the range 405–418 Ma (e.g. samples ERIVMAE0003.01 and ERIVMAE0052.01 reported by Matchan & Phillips 2017). A similar Early Devonian age is anticipated with this sample.

## Sample Information

***Location description (e.g. a sample of x was collected from y, z km from abc town):***
The sample was collected from low tabular outcrop developed on a northwest–southeast trending hill south of Ryalls Lane, c. 14.1 km west-southwest from Barmedman township.

***Lithological characteristics (rock description):***
The sample is a granitic mesomylonite comprising fine- to medium-grained (<4mm) feldspar porphyroclasts enveloped by mylonitic foliation with well-developed S–C fabrics and a clear lineation on the C-plane.

***Relative age constraints (pertinent geological relationships with surrounding rock units and any previous geochronology):***
The mylonite zone overprints the Yalgogrin Granite, which has indistinguishable U–Pb SHRIMP ages (determined on zircon) of 430.9 2.9 Ma (Black 2005) and 428.5 ± 2.3 Ma (Bodorkos et al. 2016). This provides the maximum age for the Ellon Vale Shear Zone. An earlier attempt by the GSNSW to date the Ellon Vale Shear Zone by 40Ar/39Ar geochronology on muscovite produced a spectrum of apparent ages mostly between c. 418–404 Ma, which may have included inherited argon from magmatic muscovite that was not completely recrystallised during deformation (Matchan & Phillips 2017).

***Thin section description (if available):***
The sample predominantly consists of medium-grained K-feldspar and plagioclase porphyroclasts as well as minor biotite and muscovite porphyroclasts enveloped by a mylonitic foliation. Relict igneous accessory phases include apatite, tourmaline and zircon.
The mylonitic foliation is defined by discontinuous polycrystalline quartz ribbons alternating with bands of fine-grained white-mica ± biotite. The quartz ribbons comprise fine-grained crystals with migrating Qz–Qz grain boundaries but locally achieving a polygonal microstructure. Neocrystalline muscovite and biotite defining the mylonitic foliation form slender blades typically <0.05 mm long with slightly larger laths up to 0.1 mm long occurring in strain shadows and as replacements of primary mica fish. The fabric defining biotite appear inclusion free and is gingerbread-brown, in contrast with the ‘foxy’ red-brown colour of relict primary biotite (described below).
Primary (igneous) biotite is foxy red-brown and commonly included with primary apatite and zircon with accompanying radiation halos. They occur as mica fish localised along mica-rich folia and as plates intergrown with or included in primary feldspar porphyroclasts and range in size from 0.3 to 2.3 mm at the long axis. Many primary biotite fish have σ-type mantles of fine-grained neocrystalline biotite that trail into the mylonitic foliation. In other examples, primary biotite fish are partially replaced by neocrystalline muscovite laths up to 0.1 mm long + a very fine-grained opaque oxide phase. There are also minor/rare yellowish-brownish-green blocky to irregular biotite plates c. 0.1 to 0.3 mm long associated with some feldspar porphyroclasts that are remnant of the primary assemblage.
Primary (igneous) muscovite typically occurs as mica fish localised along mica-rich folia and range from 0.125 to 1.2 mm long. There are also rare lenses/stringers up to 4 mm long of shredded/partly recrystallised muscovite fish.
The slightly blocky plagioclase porphyroclasts deform primarily by brittle fracture and show minimal signs of dynamic recrystallisation. Most have variably developed secondary sericite alteration across their cores, which may relate to pre-deformation deuteric alteration of the granite protolith. The more rounded looking perthitic K-feldspar porphyroclasts also deform by brittle fragmentation but show signs of dynamic recrystallisation across shears offsetting some crystals indicating a combination of brittle and ductile deformation behaviour. Many feature myrmekite replacements at the clast margins are some show dynamic recrystallisation into fine-grained strain shallows.

S–C fabric geometry, mica fish and σ-type strain shadows on K-feldspar porphyroclasts are consistent with sinistral strike-slip shear sense.

***Photograph(s) e.g. field site, hand-specimen, photomicrograph:***

*Figure 1 View to the west across a low ridge outcrop of mylonite defining the Ellon Vale Shear Zone at the sample site. Chisel (right-of-centre) is approximately 200 mm long.*


*Figure 2 Cut surface oriented perpendicular to foliation and parallel to lineation. Top-to-the-right shear sense indicated by S–C fabrics in this view translates to sinistral strike-slip shear sense at the outcrop. Major increments of scale are 10 mm.*

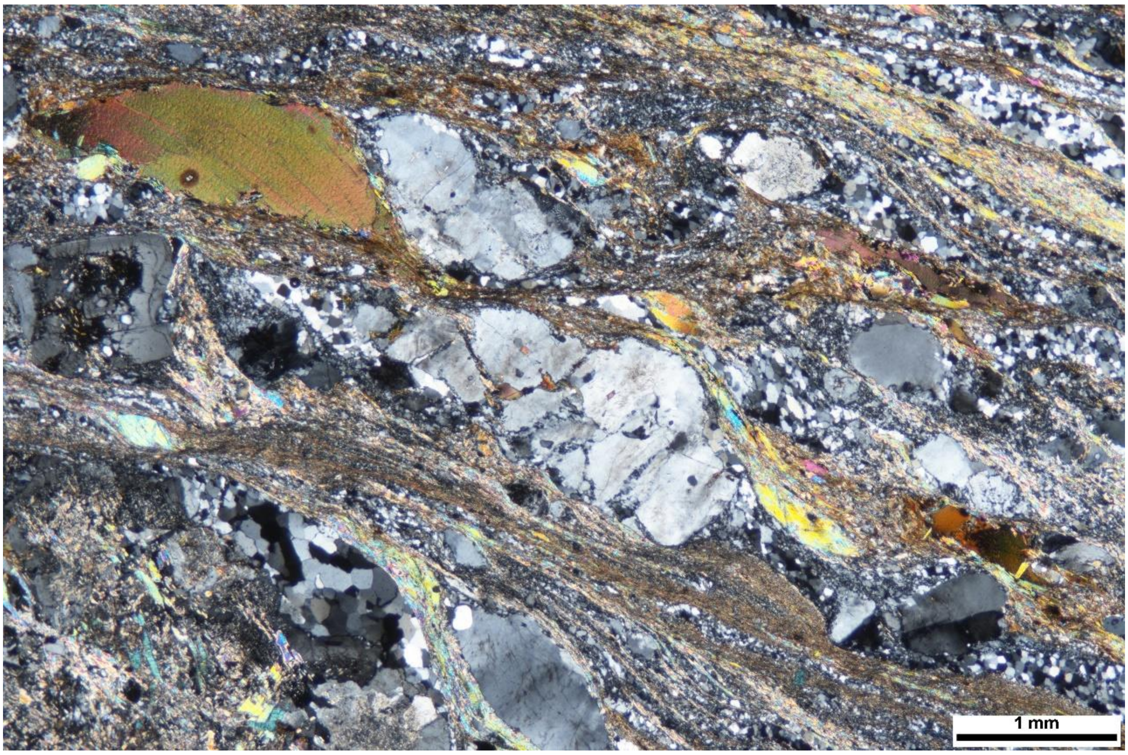


*Figure 3 Photomicrograph in cross-polarised light showing mica-rich foliation domains deflecting around porphyroclasts of biotite (top-left, lower-right), K-feldspar (centre, bottom-right) and plagioclase (middle-left).*

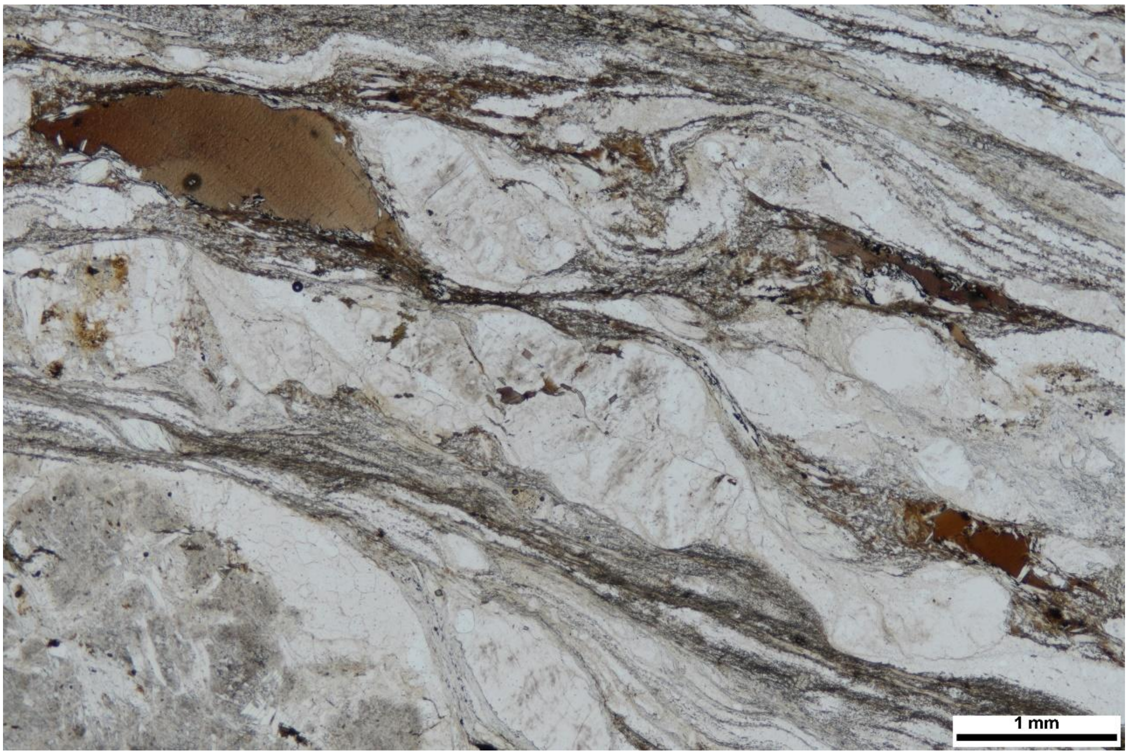


*Figure 4 Field of view as for Figure 3 in plane-polarised light.*

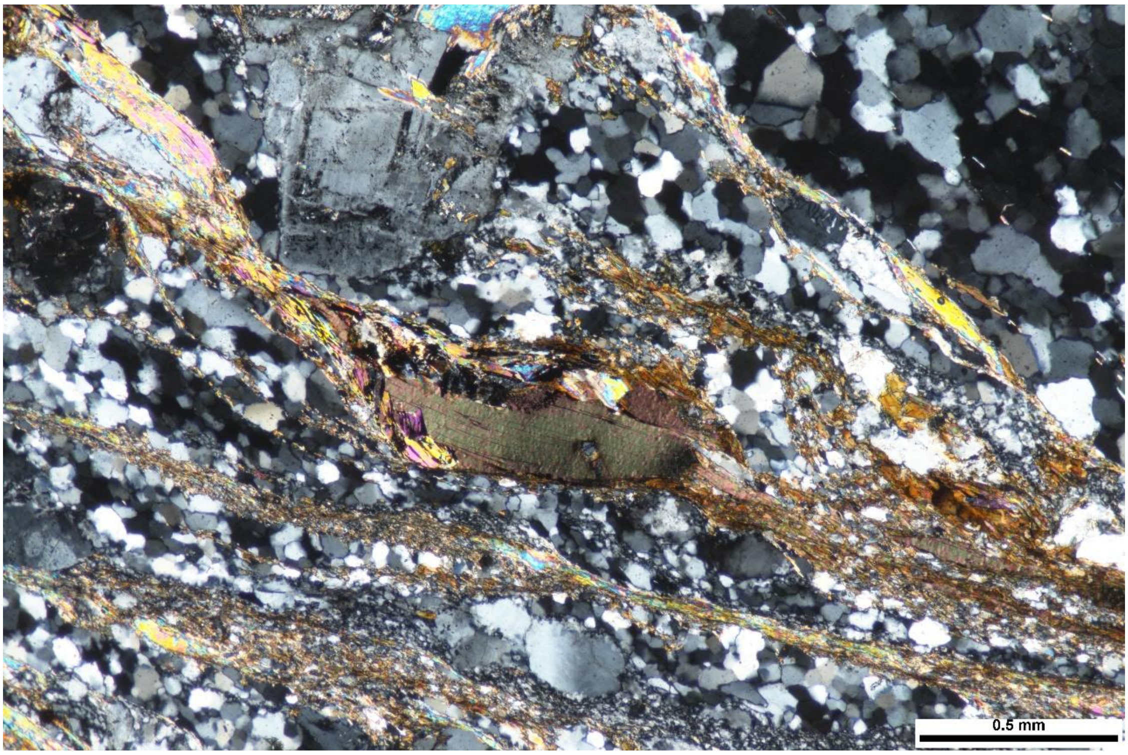


*Figure 5 Photomicrograph in cross-polarised light showing a biotite fish that is partly replaced by neocrystalline muscovite + an opaque oxide phase along the left porphyroclast margin. The same porphyroclast is also recrystallised to fine-grained biotite trailing into the foliation from the lower-right of the crystal.*


*Figure 6 Field of view as for Figure 5 in plane-polarised light.*

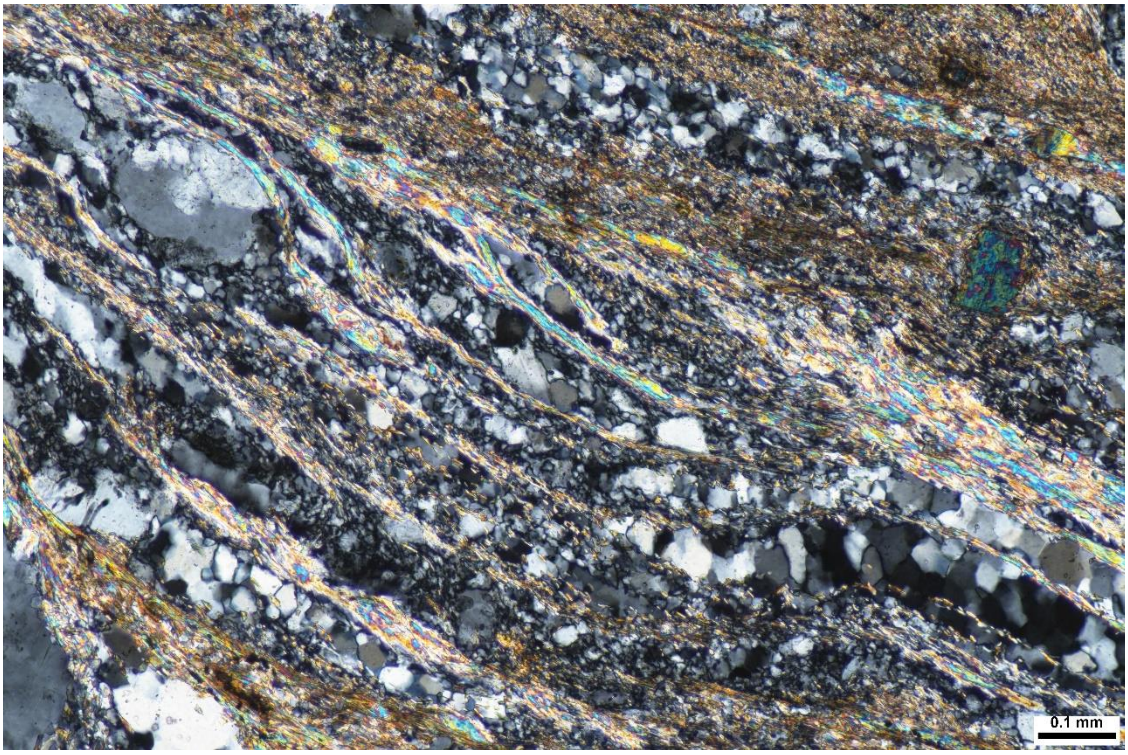


*Figure 7 Photomicrograph in cross-polarised light show detail of the mylonitic foliation (oriented top-left to bottom-right) defined by mica-rich domains alternating with polycrystalline quartz bands. The foliation wraps around porphyroclasts of K-feldspar (upper-left), tourmaline (upper-right) and a muscovite fish (upper-right). Note the slightly lobate myrmekite replacements along the K-feldspar porphyroclast margins.*

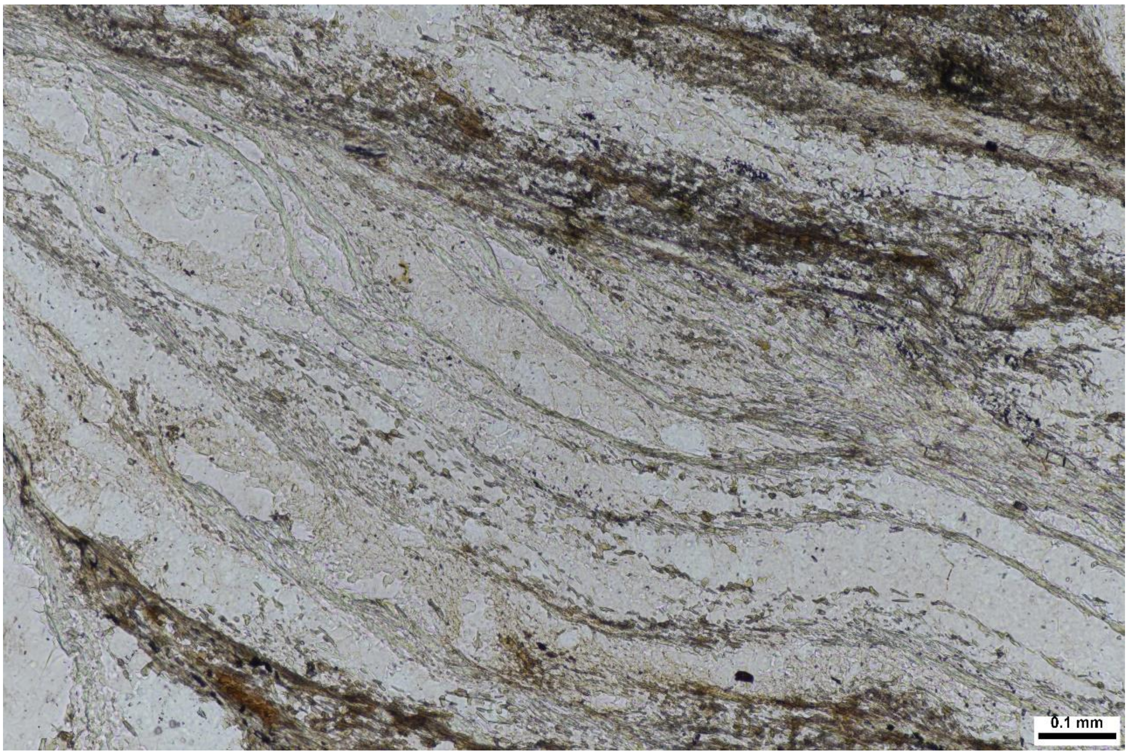


*Figure 8 Field of view as for Figure 7 in plane-polarised light.*

***Relevant bibliographic references:***

Black L.P. SHRIMP U–Pb zircon ages obtained during 2004/05 for the NSW Geological Survey. Geological Survey of New South Wales, File GS2005/745.

Bodorkos S., Bull K.F., Campbell L.M., Eastlake M.A., Gilmore P.J. & Trigg S.J. New SHRIMP U-Pb ages from the central Lachlan Orogen and New England Orogen, New South Wales. Geoscience Australia, Record 2016/21. Geological Survey of New South wales, Report GS2016/0343.

Matchan E. & Phillips D. 2017. $^{40}Ar/^{39}Ar$ step-heating analysis of muscovite from East Riverina samples ERIVMAE0003.01B, ERIVMAE0052.01B and ERIVMAE0229.01D (Wagga Omeo Belt). Report UM17-0601, School of Earth Sciences, University of Melbourne.