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: JOAN ESTERLE
Affiliation and position: SCHOOL OF EARTH AND ENVIRONMENTAL SCIENCES, UNI QLD
Collaborators: BHP and UQ students K. Dube, T. Yu, J. Cooling and G. Szekely
Project Title: STRATIGRAPHY AND MINERALOGY OF CENOZOIC SEDIMENTS OVERLYING THE MORANBAH AND RANGAL COAL MEASURES
Geographic Region: CENTRAL QUEENSLAND
Geological Province or Tectonic Unit: ?EMERALD and ?DUARINGA BASIN OVERLYING BOWEN BASIN

How will these samples benefit the National Argon Map?

The samples will provide high resolution age dates for sequential basalt flows, coupled with palynological age constraints, through a series of confined Cenozoic channels that incise Permian strata, are floored in a thin veneer of Cretaceous sediment and record the evolution of the Australian landscape, climate and corresponding flora that we see today.

Brief Project Description:

Uplift and incision of Permo-Triassic strata in the Cretaceous created a series of drainage networks that are variably filled with siliciclastic sediments, lignites and basalt flows of Cenozoic age. Whereas the occurrence of these Cenozoic channel systems can create geotechnical issues for some mines in the Bowen Basin, central Queensland, they also record the evolution of the Australian flora in response to changing climate, the timing of which can be supported by absolute age dating of the basalt flows in the sequence. The Palaeogene Duaringa and Neogene Suttor formations mapped from surface geology intersect in the Goonyella area (Figure 1), and are variably identified in drill holes by mining and gas companies operating in the area (Figure 2). Recently available core through these deep channels intersected a relatively complete stratigraphic sequence that, based on palynology was floored in a thin veneer of Cretaceous sediments overlain by Palaeogene strata that is capped by basalt flows, separated mid-way by Neogene strata and then topped by Quaternary alluvium (Dube, 2019; Figure 4 and 5).

Based on hyperspectral scanning of core DDG275 (Szekely, 2019), five basalt flows occur, each of which transition from aphanitic to vesicular basalt as the lava degases. Although weathered, mineralogy suggests that the basalts could originate from different volcanic sources, which requires further study. More relevant to this proposal, is that the 5 candidates sent for more detailed Corescan, thin section and XRD analysis contained unaltered minerals (pyroxenes, plagioclase, micas; see sample sheets) that can be potentially dated by $^{40}Ar/^{39}Ar$ (Figure 5). A second core 117868 has been drilled in the northern end of the study area where Cenozoic strata are dominated by sedimentary strata (in this core 75 m) and capped by two visible basalt flows separated by loam. This core is undergoing similar analysis (palynology, Hylogging, XRD) to determine the relative biostratigraphic age of the sediments, and it is anticipated that the basalts will contain unaltered sections suitable for absolute dating (Yu, in progress; Cooling, in progress). The absolute age dates will confirm the local stratigraphy, but also allow a high resolution timescale to be developed for the evolution of the Australian landscape, climate and palaeoflora.

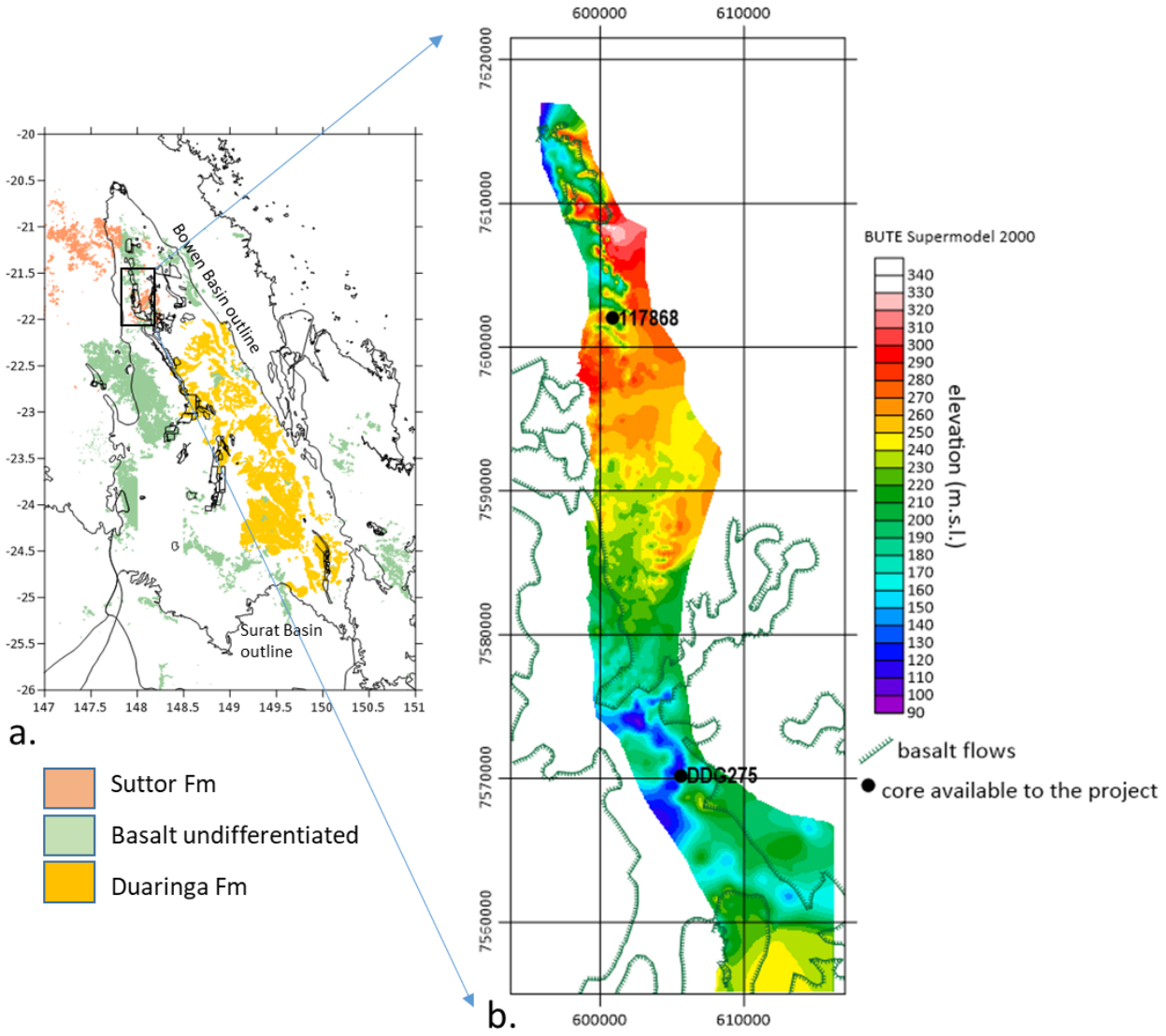

Figure 1. Location maps of study area a) in central Queensland relative to the Bowen Basin and illustrating the distribution of the Cenozoic basalts, Suttor and Duaringa formations mapped in the GSQ 1:100,000 scale map. Coal MDL's circa 2010 overlain for reference. b) location of available drill core relative to detailed structure contour map of the "Base of Tertiary" and mapped basalt flows in Esterle and Sliwa, 2000. Grid is 10 x 10 km.

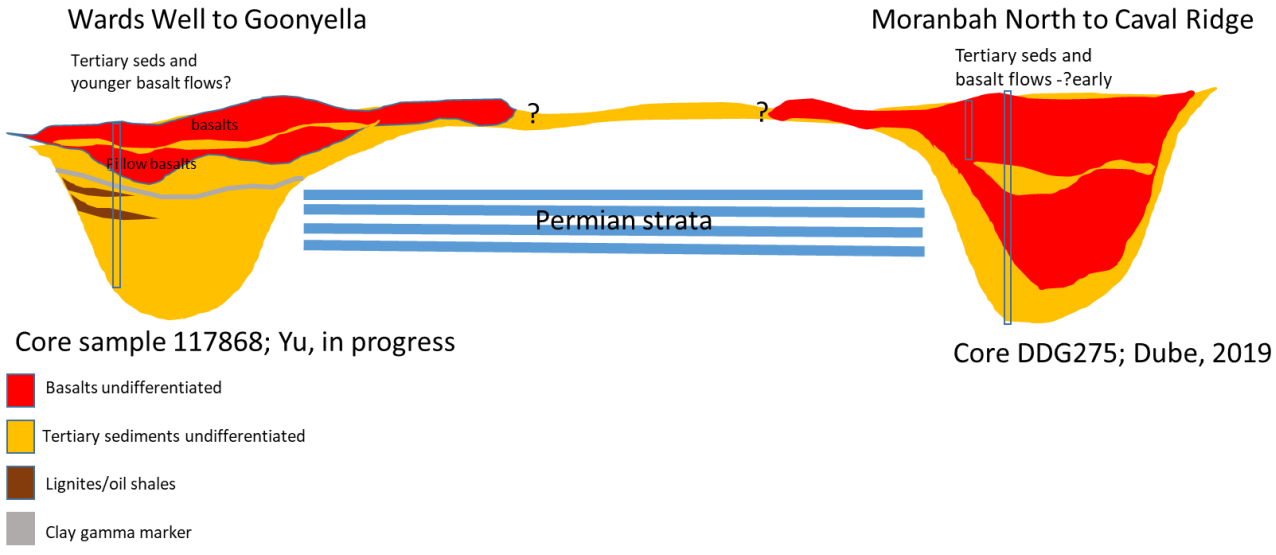

Figure 2. Conceptual working model of the distribution of basalts relative to Cenozoic (Tertiary) sediments intersected by the drill core in the study area. Not to scale.

Arrow Energy

Age		Stratigraphic Units	Lithology	Typical Thickness (m)
Cenozoic	Quarternary	Alluvium	Clays, silts, sand, gravel, and flood plain alluvium	13-15
Cenozoic	Tertiary – Neogene?	Suttor Formation	Clay, silt, sand, gravel, colluvium, fluvial and lacustrine deposits including cross-bedded quartz sandstone, conglomerate, claystone.	0-120
Cenozoic	Tertiary	Basalt	Olive-rich weathered basalt remnants, moderately weathered and fresh basalts	0-80
Cenozoic	Tertiary – Paleogene?	Duaringa Formation	Mudstone, sandstone, conglomerate, siltstone, some oil shale, lignite and basalt.	0-50
Mesozoic	Triassic	Moolayember Formation	Mustone, lithic sandstone, interbedded silstone, mudstone, sandstone and thin coal seams	0-200
Mesozoic	Triassic	Clematis Sandstone	Quartz sandstone, some quartz conglomerate, minor reddish brown mudstone	0-300
Mesozoic	Triassic	Rewan Formation	Green lithic sandstone, pebble conglomerate, reg and green mudstone.	200-800

BHP

Age		Stratigraphic Units	Lithology	Typical Thickness (m)
Cenozoic	Quarternary	Alluvium	Clays, silts, sand, gravel, and flood plain alluvium	37 m in surveyed area
Cenozoic	Tertiary	Basalt	Oliveine-rich basalt flows ???	35 m in surveyed area
Cenozoic	Tertiary – Neogene?	Suttor Formation	Clay, silts, sand, gravel, colluvial and residual deposits, fluvial and lacustrive deposits	80 m in surveyed area
Mesozoic	Triassic	Rewan Formation	Green lithic sandstone, pebble conglomerate, reg and green mudstone.	200-800

Figure 3. Cenozoic stratigraphy as applied by different companies.

Sample P1 (clay) was dominated by dry-adapting pollen including Araucaria wood pine, Salt marsh, Asteraceae, Dry eucalypt) suggesting an **arid environment:** likely **PLEICONE-QUATERNARY** in age.

Sample P8 (carb mud) included Nothofagus Moorei (Antarctic Beech), Grass pollen, Typha , Lillypilly (rain forest equivalent of Eucalypt), fern spores suggesting an aquatic, rainforest environment. P8 is interpreted to be **NEOGENE** in age.

Sample P14 (silty sand) contained abundant Fern spores, charcoal as well as Proteaceae. Fern spores occur during "disturbance" and are usually the first to appear after an eruption. Sample is likely **PALEOGENE (EOCENE-PALEOCENE)**

Sample P17 (carb silt) sits directly below **P16**. Sample has no pollen yield and is extremely heat affected and reworked. Contains possible **PERMIAN** wood fragments.

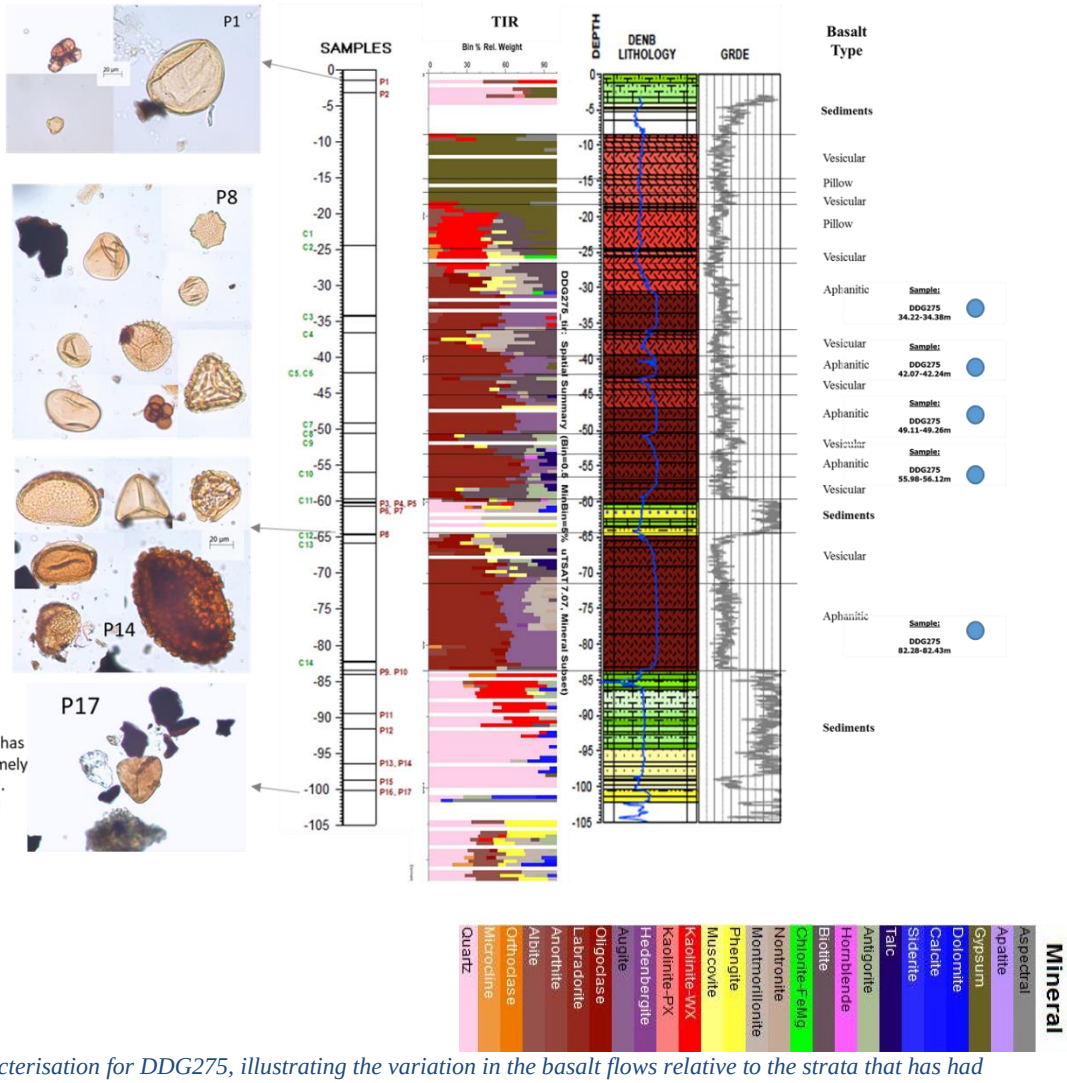

Figure 4. Core characterisation for DDG275, illustrating the variation in the basalt flows relative to the strata that has had preliminary age dates from palynology (Dube, 2019) and mineral identification using Hylogger™. (Mauger, 2019; Szekely, 2019). Samples selected from unaltered basalt for subsequent Corescan, XRD and thin section work, as as candidates for $^{40}Ar/^{39}Ar$ dating shown by blue dots to right of log.

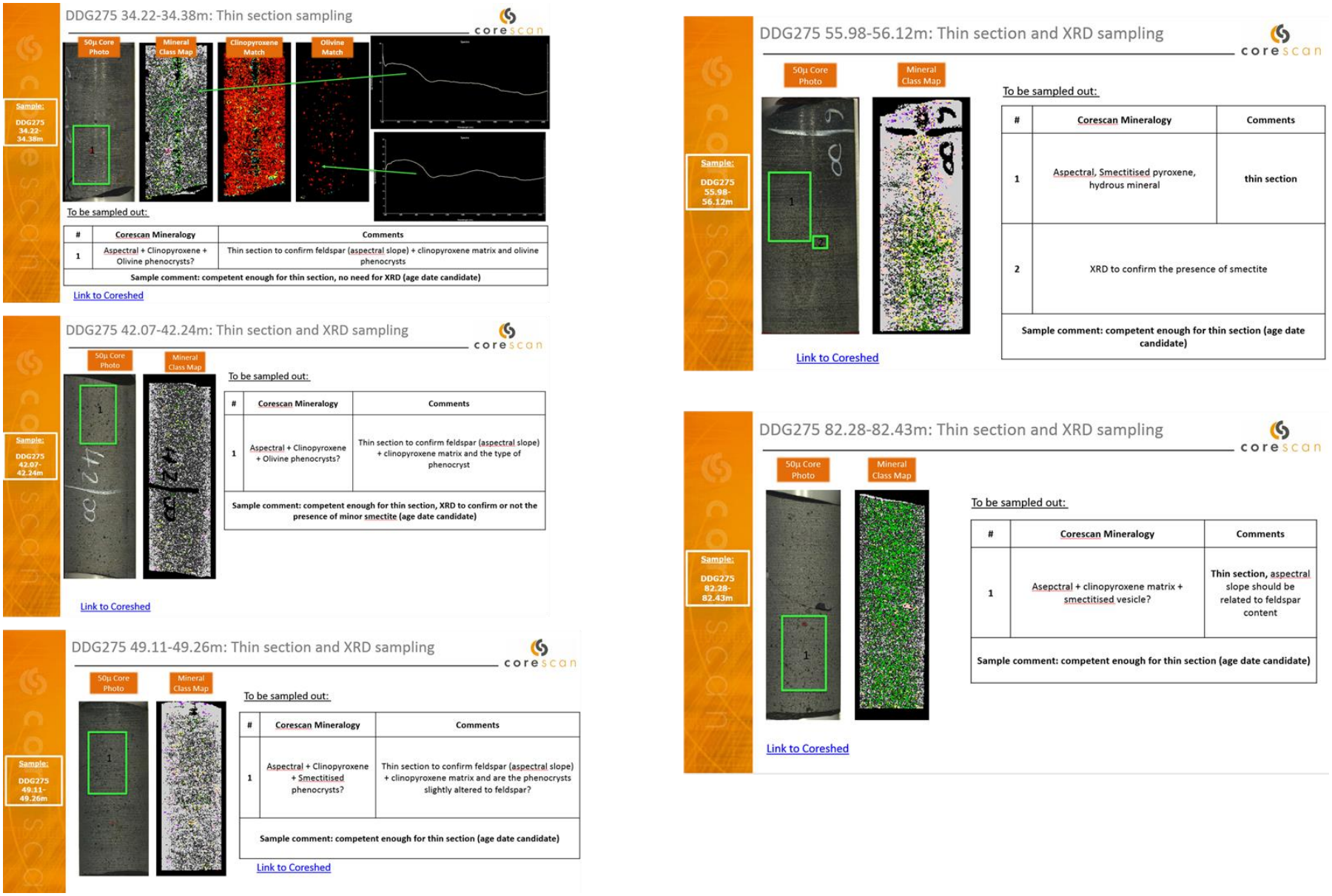

Figure 5. Mineralogical analysis of candidate basalt samples for dating by $^{40}Ar/^{39}Ar$. Fonteneau (2019).

Approximate number of samples proposed for $^{40}Ar/^{39}Ar$ analyses:
We propose seven (7) samples for analysis; 5 from the deep channel with multiple flows and 2 from the shallower channel where sediments are capped by basalt. The samples are ready now. If successful, then there is a potential larger study of the flows encapsulated in Cenozoic channels that intersect the Permian coal measures in the basin.

Lithologies and minerals proposed for $^{40}Ar/^{39}Ar$ analyses:
The samples are basalt that contain pyroxenes, plagioclase and micas suitable for dating. See attached sample sheets.

Do you have a preferred ^{40}Ar-^{39}Ar laboratory? (ANU, Curtin, UQ, UMelb):
We don't have a preferred laboratory; these data will form part of the Honour's thesis for Yu, expected completion 2021.

References

Cooling, J., in progress. Palynological investigation of Core 117868. University of Queensland, Research Project. Unpublished.

Dube, K., 2019. Determining the architecture of Tertiary Channels cutting the Bowen Basin, Central Queensland. University of Queensland, Honours Thesis, unpublished.

Esterle, J., & Sliwa, R., 2002. Supermodel 2000 Bowen Basin a regional three-dimensional model of the Moranbah-German Creek coal measures. Australian Coal Association Research Project final report.

Fonteneau, L., 2019. Preliminary interpretation of Corescan spectra in VNIR and SWIR for selected basalts from Core DDG275. Personal Communications, unpublished.

Mauger, A., 2019. Hylogger data for Core DDG275. Unpublished.

Szekely, G., 2019. Application of hyperspectral scanning to mineralogical characterisation of basalts and their weathering profiles. 3rd Year Indpendent Research Study, unpublished.

Yu, T., in progress. The origins of kaolinite-rich clays in Cenozoic channels of Eastern Australia: a case study at Goonyella-Riverside Mine, Bowen Basin, Queensland. University of Queensland Honours Thesis.

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)