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

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Project Title: Mid-Cenozoic chronostratigraphy of central and northern Tasmania
Geographic Region: Central and northern Tasmania
Geological Province or Tectonic Unit: Late-Paleogene to early-Neogene basalts and interbedded non-marine sediments

How will these samples benefit the National Argon Map?

Provide a succinct answer to this question, see the suggestions in the Guidelines and Criteria on the next page.

The suite of samples described herein addresses multiple objectives of the National Argon Map. First, the samples will help fill in the current geographic gap of numerical ages in central and north-central Tasmania evident in both the current National Argon Map and MRT's collation of Cenozoic $^{40}Ar/^{39}Ar$ and ^{40}K-^{40}Ar ages (attached map). Second, the ages will help address key research questions about Tasmania's Cenozoic Earth and Earth-surface processes including the timing and duration of effusive volcanism, timing of floral transitions and the onset of Tertiary glaciation, and rates of landscape modification and weathering that have implications for the location and extent of modern slope-stability issues. Third, these new ages will complement and calibrate other existing and planned chronostratigraphic records (palynology and magnetostratigraphy) that require numerical ages to be of greatest use.

Furthermore, by dating superimposed flows spanning several hundred metres of stratigraphy, the samples will provide an important framework for expanding Tasmania's mid-Cenozoic chronostratigraphy over the coming years. All $^{40}Ar/^{39}Ar$ data will be made publicly available through MRT reports, together with new detailed geochemical, petrological, and palaeomagnetic data that will be collected for the dating samples as well as with magnetostratigraphy and palynostratigraphy developed for key sequences.

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).

Mid-Cenozoic chronostratigraphy of central and northern Tasmania

Basaltic volcanism in Tasmania, at the southern end of the Eastern Australian Cenozoic volcanic province, ranges from small plugs to thick (>360 m) flow sequences intercalated with

volcaniclastics and non-marine sediments[1]. The basalt-sediment sequences record volcanism and palaeo-environmental change when Tasmania's climate and biota were in transition due to northward drift driven by rapid Antarctic-Australian spreading. Existing geochronological and geological constraints show that volcanism spanned >70 Ma to ~10 Ma[2,3]. However, nearly half of the published ages are pre-1990 ^{40}K-^{40}Ar analyses and may thus be unreliable; furthermore, several are best interpreted as minimum ages or are from isolated plugs with limited stratigraphic context[2]. Consequently, the chronostratigraphy of several thick volcanic sequences is very poorly known.

We propose to refine and expand central and north-central Tasmania's mid-Cenozoic geochronology by dating basalt from outcrops and diamond drill cores in thus-far poorly dated areas, chiefly where flows fill or cap palaeovalleys. These high-precision ^{40}Ar/^{39}Ar data will help address multidisciplinary research questions about landscape evolution, climate history, biotic change, and modern geohazards. Such questions include constraining the timing and duration of effusive volcanic episodes, approximating rates of landscape change, constraining the onset of Tertiary glaciation and timing of floral transitions, and evaluating the role of weathering histories in producing geomechanical instability of basalts and interbedded clay-rich lacustrine units. The new ages will also provide important control for expansion of Tasmania's Cenozoic chronostratigraphy planned for the next five years using palynostratigraphy and, particularly, magnetostratigraphy.

The ^{40}Ar/^{39}Ar targets outlined below are from petrologically well documented samples and core already held by MRT. We will target the lowest and highest unweathered basalts in thick sequences. Of the diamond drill cores, all but one (Maggs Mountain) has existing broad chronostratigraphic constraint from palynostratigraphy. New geochemical, petrologic, and palaeomagnetic analyses conducted by MRT will support correlations of undated basalt sequences with the newly argon-dated ones. Additionally, primary remanent magnetization measurements of each sampled flow will assist in refining ^{40}Ar/^{39}Ar ages through comparison with the geomagnetic polarity timescale.

Dating targets:

- Ages from the 500-m-long Maggs Mountain core will constrain the timing of apparently widely spaced periods of effusive volcanism as well as the ages of overlying pre-Late Pleistocene glacial and underlying non-glacial sedimentation, with support from new palynostratigraphy.
- Diamond drill cores at Lemonthyme Creek penetrate valley-fill sediments including tillite with unweathered[4], likely distantly sourced[5] basalt clasts. Palynostratigraphy from overlying lacustrine sediments[4] and ^{40}K-^{40}Ar analysis (26.7±0.3 Ma) of basalt capping nearby correlative silts[6] provide an early-Oligocene minimum age constraint on glaciation. Dating of basalt clasts from the tillite will provide a maximum age constraint that will be further refined using tillite-matrix polarity.
- Core from Emu Plains – adjacent to Lemonthyme Creek – includes 70 m of basalt. Ages from this basalt succession will support comparison with the Maggs Mountain core and test – together with petrological and geochemical analyses – the hypothesis that basalt clasts in the Lemonthyme tillite are not locally sourced.
- Cores near Waratah penetrate several hundred metres of stacked basalt flows and occasional interbedded sediments containing late-Eocene through early-Oligocene pollen assemblages[7]. Basalt magnetostratigraphy from core SBDP5 also suggests an earliest Oligocene age[8]. ^{40}Ar/^{39}Ar ages from SBDP5 will greatly improve dating of the sequence and provide much-needed calibration of these common Tasmanian pollen assemblages.
- ^{40}Ar/^{39}Ar ages will provide the first robust age constraints for the thick lava piles in Tasmania's southern central plateau (e.g. Tarraleah, Bronte, Ouse) and the central-north (e.g. Sheffield, Burnie). Well constrained ages will allow placement of this significant phase of volcanism within the broader context of Tasmania's geological evolution.

[1] Corbett, 2014. A summary of Tasmania's geology and geological history. In *Geological Evolution of Tasmania* (Corbett et al. [Eds.]). Geol. Soc. Australia, p. 1-12.

[2] Quilty et al., 2014. Cretaceous-Neogene evolution of Tasmania. In *Geological Evolution of Tasmania* (Corbett et al. [Eds.]). Geol. Soc. Australia, p. 409-509.

[3] Tasmania Cenozoic basalt distribution and existing $^{40}Ar/^{39}Ar$ and ^{40}K-^{40}Ar ages (attached map).

[4] Macphail et al., 1993. Glacial climates in the Antarctic region during the late Paleogene: evidence form northwest Tasmania, Australia. Geology 21: 145-148.

[5] Paterson et al., 1967. Notes on the Pleistocene deposits at Lemonthyme Creek in the Forth Valley. Pap. Proc. Roy. Soc. Tas. 101: 221-225.

[6] Macphail & Hill. 1994. K-Ar dated palynofloras in Tasmania 1. Pap. Proc. Roy. Soc. Tas. 128: 1-15.

[7] Seymour, 1989. St Valentines Geological Survey Explanatory Report, (ER8015S). MRT, 147 pp.

[8] Lucas, 1988. Magnetics of the Tertiary basalts of north-western Tasmania. University of Tasmania B.Sc. Thesis. 109 pp.

Approximate number of samples proposed for $^{40}Ar/^{39}Ar$ analyses:
Eighteen samples (typically 2 from each of 9 sites) will be taken from outcrop samples and diamond drill core currently held in MRT's core library.

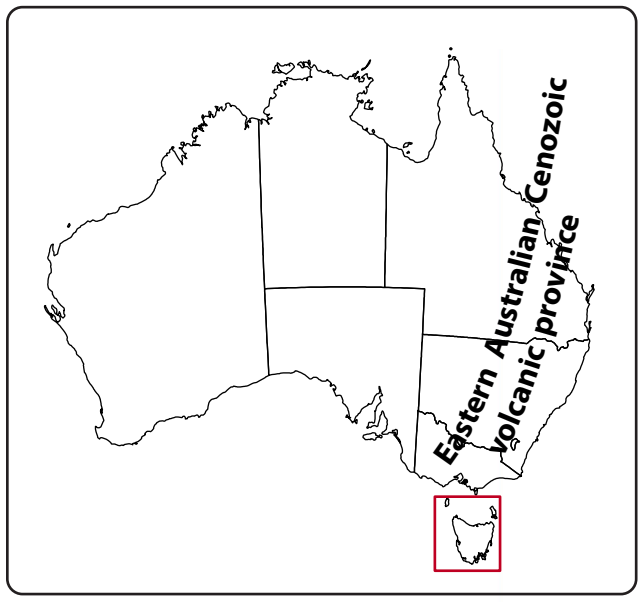
Lithologies and minerals proposed for $^{40}Ar/^{39}Ar$ analyses:
Samples will be from i*n situ* basalt flows from outcrop and in core (12-14 samples) and transported basalt clasts within a deeply buried tillite penetrated by core (2 samples). All samples will comprise unweathered phyric and microcrystalline basalts, enabling ^{40}Ar-^{39}Ar plateau ages to be determined from crystals or groundmass. Sample preparation will be done at the University of Tasmania under the supervision of a post-doctoral researcher (Dr. Jodi Fox) with significant experience in mineral separation at Curtin University, with support from MRT staff.

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):

Dr. Jodi Fox has conducted sample preparation for $^{40}Ar/^{39}Ar$ on Tasmanian Cenozoic basalts at Curtin University during the last 5 years. We prefer to use the same laboratory for this project.

Tasmania Cenozoic basalt distribution and existing $^{40}Ar/^{39}Ar$ and ^{40}K-^{40}Ar ages

(prepared from MRT's geochronology database)



Bass Strait

Southern Ocean

Burnie
SBDP5
Sheffield
Lemonthyme Ck. & Emu Plains
Maggs Mtn
Bronte
Tarraleah
Ouse R.

Proposed NAM samples
- From diamond drill core
- From outcrop

Existing ages (Ma)
- $^{40}Ar/^{39}Ar$ plateau
- $^{40}Ar/^{39}Ar$ integrated or approx.
- ^{40}K-^{40}Ar

- Approximate basalt limit
- Lake
- Outcropping basalt

0 50 100 200 km