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: ***An Antarctica perspective of the Kerguelen plume***
Geographic Region: East Antarctica, Australian Antarctic Territory
Geological Province or Tectonic Unit: Prince Charles Mountains, Lambert Rift

Brief Project Description:

Large igneous provinces (LIPs) are key features in Earth's system, coinciding with continental breakups, major climatic changes and mass extinctions. The Kerguelen LIP is the second-largest oceanic LIP, and recent publications question the role of the Kerguelen plume in the breakup of Gondwana [1] that led to the separation of India, Antarctica and Australia c. 137–120 million years ago. Moreover, the timing and duration of the Kerguelen LIP and its impact on the chemistry of newly formed oceanic crust remain controversial. In the past few years, new geochemical and geochronologic studies expanded the lateral extent of the now called Greater Kerguelen large igneous province, including records both on land (Australia, India, China)[2-6] and in the ocean (the Kerguelen, Naturaliste and Wallaby plateaus)[7-9]. However, so far eight geochronological datasets are available on the Kerguelen-related melt products for the Antarctica region [10-12].

The Prince Charles mountains (Australian Antarctic Territory) (Fig. 1) are located on the western flank of the Lambert outlet glacier. It features the Lambert rift, East Antarctica's largest tectonic structure (Fig. 1)[13]. Early rifting was accompanied by Late Carboniferous and Early Triassic magmatic activity [14]. During the Early Cretaceous, alkaline ultramafic magmas (lamprophyre, kimberlites, alkali tholeiites and picrites) formed an extended (40-km long) chain of stock-like and dike bodies in the Jetty Oasis (Fig. 1). So far, reliable geochronological data of the Cretaceous magmatism include one lamprophyre sample dated by biotite $^{40}Ar/^{39}Ar$ at 114 ± 0.6 Ma [10], and three kimberlite samples dated by U-Pb in perovskite at 125 ± 8, 121 ± 13 and 113 ± 13 Ma, respectively [11]. There are also less reliable and older K-Ar ages [12] and two-point Rb-Sr isochron ages [11]. Previous studies on lamprophyres and kimberlites have attributed the 120–114 Ma alkaline ultramafic magmatism to the early manifestation of the Kerguelen plume (Table 1).
In this proposal we wish to properly establish the timing and history of Cretaceous magmatism in the Prince Charles Mountains (administered by the Australian Government) by analyzing the alkali tholeiites and picrites (typical plume-generated High-T melt product), for which no geochronological data currently exists, and obtaining high-precision and high-quality age data on lamprophyres and kimberlites (Fig. 1). The samples will be made available through collaboration with Prof. German Leitchenkov, Head of the Department of Antarctic Geoscience of the I.S. Gramberg Research Institure for Geology and Mineral Resources of the Wold Ocean (VNIIOkeangeologia). The $^{40}Ar/^{39}Ar$ analyses will be conducted using the latest generation of $^{40}Ar/^{39}Ar$ multi-collector noble gas instruments (ARGUS VI) at the Western Australian Isotope Facility, Curtin University. The state-of-the-art capability permits ultra-high-precision dates on phlogopite and very high-precision on plagioclase [15] and even permits dating of pyroxene with <1% uncertainties [16]. The new geochronological data obtained on phlogopite and plagioclase mineral separates (or pyroxene if no other datable phases are present), together with new

geochemical and isotopic data will bring important new constraints on (1) the dynamics of mantle sources through time for the Cretaceous magmatism in the region, (2) the spatial-temporal extent of the Kerguelen plume, and (3) an improved understanding of Gondwana break-up's mechanism and process.

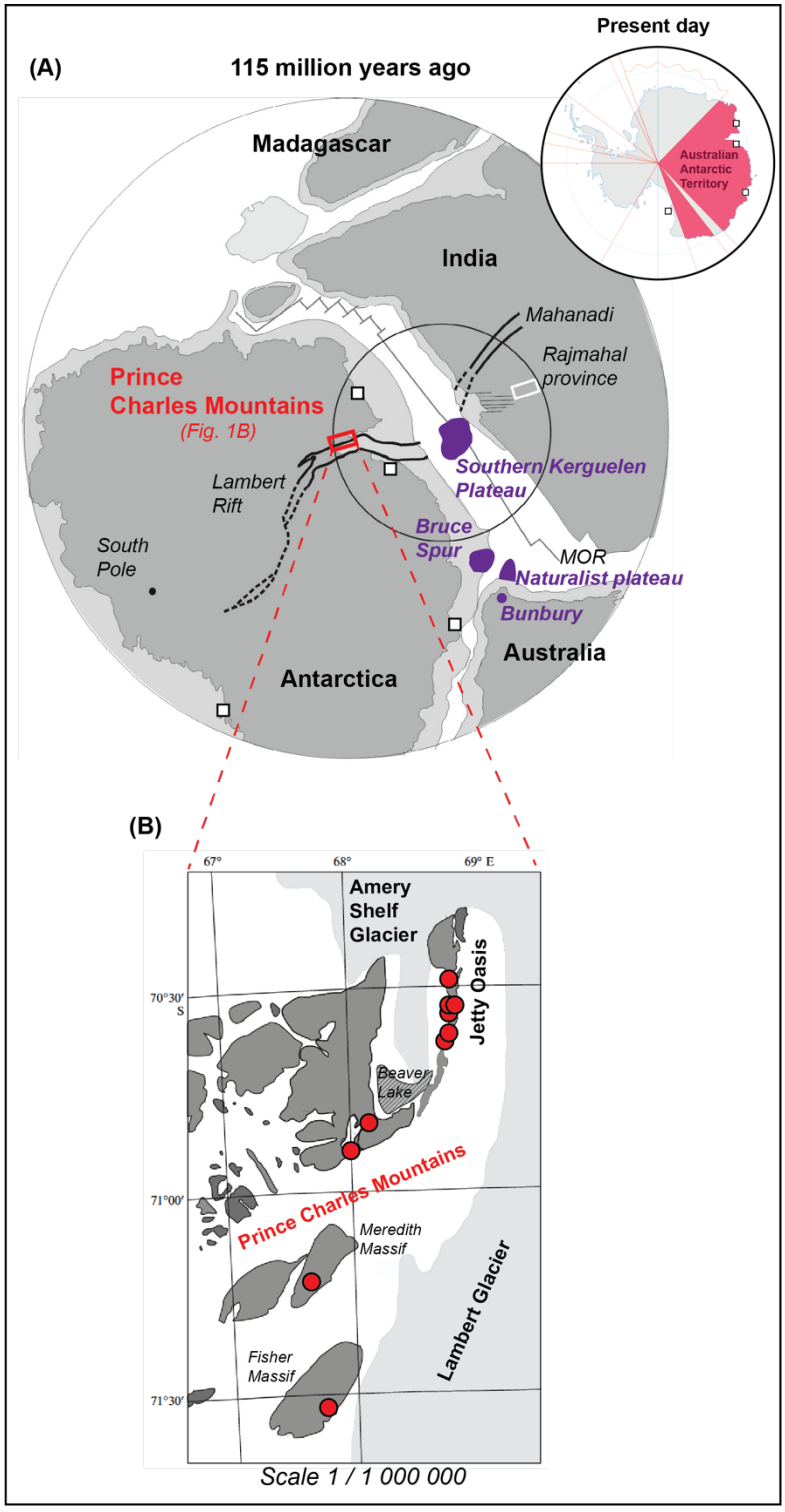

Figure 1: (A) Location map of Prince Charles Mountains, in present day Antarctica and 115 million years ago, (B) location map of alkali tholeiites and picrites (red circles). Maps modified from [17]. Also shown are early products of the Kerguelen plume (purple), the Rajmahal province (white rectangle). Note the position of the Australian station (white squares) and the Australian Antarctic Territory (pink).

Table 1: geochronological data on Prince Charles Mountain lamprophyres and kimberlites

Sample name	Method	Sample type	Mineral	Age	±(2σ)	ref
69280152	K/Ar	lamprophyre	mica	110	3	Walker and Mond 1971
69280153	K/Ar	lamprophyre	mica	110	3	Walker and Mond 1971
69280334	K/Ar	lamprophyre	mica	108	3	Walker and Mond 1971
D17	$^{40}Ar/^{39}Ar$	lamprophyre	biotite	114.0	0.6	Coffin et al., 2002
77063	U-Pb *in-situ*	Kimberlite	perovskite	113	13	Yaxley et a., 2013
77081	U-Pb *in-situ*	Kimberlite	perovskite	125	8	Yaxley et a., 2013
77082	U-Pb *in-situ*	Kimberlite	perovskite	121	13	Yaxley et a., 2013
77063	Rb-Sr isochron	Kimberlite	Phlogopite	117	1	Yaxley et a., 2013

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

15 samples

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

- Lamprophyres and kimberlites (phlogopite, K-richterite, yimengite, wadeite and Jeppeite)
- Mafic basaltic dikes (plagioclase ± pyroxene)
- Picrite (pyroxene ± plagioclase)

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

Curtin, Western Australian Argon Isotope facility – this project will be integrated into an ongoing project on the geochronology of the Kerguelen province currently carried out at Curtin University.

Reference

[1] HK Olierook et al., Earth and Planetary Science Letters **511**, 244 (2019).
[2] HK Olierook et al., Earth and Planetary Science Letters **440**, 20 (2016).
[3] Y Shi et al., Acta Geochimica **37** (3), 441 (2018).
[4] S-S Chen et al., Earth and Planetary Science Letters **491**, 21 (2018).
[5] B Liu et al., Lithos **260**, 253 (2016).
[6] NC Rao et al., Earth-Science Reviews **136**, 96 (2014).
[7] HK Olierook et al., Lithos **282**, 163 (2017).
[8] HK Olierook et al., Geology **43** (11), 971 (2015).
[9] N Direen et al., Australian Journal of Earth Sciences **64** (7), 851 (2017).
[10] MF Coffin et al., J Petrol **43** (7), 1121 (2002).
[11] GM Yaxley et al., Nature Communications **4** (1), 1 (2013).
[12] KR Walker and A Mond, Report 1971/108 (1971).
[13] F Ferraccioli et al., Nature **479** (7373), 388 (2011).
[14] J Hofmann, presented at the International symposium on Antarctic earth sciences. 5, 1991 (unpublished).
[15] A Marzoli et al., J Petrol **60** (5), 945 (2019).
[16] B Ware and F Jourdan, Geochim. Cosmochim. Acta **230**, 112 (2018).
[17] N Sushchevskaya et al., Geochemistry International **56** (11), 1051 (2018).