

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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|---------------------------|---|
| Name: | Rob Duncan & Sam Waugh |
| Affiliation and position: | Geological Survey of Victoria |
| Collaborators: | ANU |
| Project Title: | Unravelling the timing of gold mineralisation across the world-class Victorian Goldfields |
| Geographic Region: | Central and northeastern Victoria |
| Geological Province: | Central and Eastern Lachlan Fold Belt / Bendigo, Melbourne, and Tabberabbera Zones |

How will these samples benefit the National Argon Map?

It has been over a decade since Ar-Ar geochronology was applied to orogenic gold systems in the Lachlan Fold Belt of Victoria. In this time our understanding of the distribution and controls on these orogenic systems has evolved as a result of new geodynamic models for the evolution of the Lachlan Fold Belt and very recent gold exploration success in a variety of settings – such as the ultra-high grade free gold mineralisation at depth in the Fosterville Gold Mine, new discoveries along strike from the Stawell Gold Mine in historical goldfields, and new discoveries under Murray Basin Cover at Four Eagles and Pyramid Hill. There is now a requirement to generate a new geochronological data for gold deposits that:

- Were previously undated because they are a recent discovery in both greenfield and brownfield mineral exploration settings;
- Have been dated previously, but those data are inconsistent with empirical observations or where sample material focussed on dating intrusive rocks and not dating hydrothermal phases.

We envisage that these data would be made public as soon as practicable after collection via the National Ar Map and the GSV/GA geochronological data delivery systems (at a minimum). The data and resulting interpretation would form the basis of a GSV technical record and peer-reviewed publications with involvement from collaborators.

Brief Project Description:

The aim is to test the relationships in space and time between orogenic gold mineralisation and tectonic events. Analysis of a compilation of legacy geochronological data has identified three major gold mineralising events across Victoria related to the Benambran (~445 to 440 Ma), Bindian (~420 to 415 Ma) and Tabberabberan (390 to 380 Ma). There is debate about which event was the most significant and at individual deposits.

Proposed samples are from across the Western and Central Lachlan Fold Belt and concentrate the Victorian National Drilling Initiative Mineral Exploration CRC area of

interest (Tabberabbera and Melbourne zones). Most proposed samples are from drillholes that are accessible at the GSV Drill Core Library in Werribee, other will require fieldwork to undertake sampling and understanding geological context. Samples would be sourced from quartz-sericite-pyrite hydrothermal alteration assemblages associated with high grade gold(-stibnite) mineralisation expressed as veins or disseminations.

The aim will be addressed through targeting sampling of material as detailed below. A priority has been attached to each proposed sample given the total number of proposed samples.

| Geological Zone | Deposit / Drillhole ID | Target (examples of grade intersected) | Stratigraphic Unit | Science question | Location of sample material | Existing geochron | Priority |
|--------------------------|---|--|----------------------------------|---|-----------------------------|---|----------|
| Tabberabbera (MinEX AOI) | Victory Mine / CM002 | Vein / disseminated gold in sandstone unit py-asp-ccp / assays in historical data | Pinnak Sandstone (Oap) | Testing the timing of mineralisation associated with NNE trends and deposits with an intrusion-related character (base metal enrichment – Cu) | GSV drill core library | N/A | 1 |
| Tabberabbera (MinEX AOI) | Chiltern / DD93AL1 | Vein / disseminated gold in sandstone unit asp 0.3 m @ 250 g/t and 0.7 @ 17.1 g/t Au | Pinnak Sandstone (Oap) | Testing the timing of mineralisation associated with an intrusion related character (W enrichment) | GSV drill core library | N/A | 1 |
| Tabberabbera (MinEX AOI) | Chiltern / DD94AL15 | Bedding parallel fault in sandstone with lower grade 2 m @ 0.87 g/t Au | Pinnak Sandstone (Oap) | Testing the timing of mineralisation associated with NNW trends | GSV drill core library | N/A | 1 |
| Melbourne (MinEX AOI) | Balaclava Hill / WHROO 1 | Vein / disseminated gold in sandstone unit / assays in historical data | Puckapunyal Formation (Dxp) | Testing the timing on mineralisation associated with unusual E-W trends | GSV drill core library | N/A | 1 |
| Melbourne (MinEX AOI) | Golden Camel / interval to be selected | Undefine style of mineralisation (e.g., 13 m at 4.0 g/t Au) | Mount William Metabasalt(- Chm) | Address the age of sulphide-hosted mineralisation that is hosted in Cambrian volcanic rocks | Kangaroo Flat Core Shed | N/A – but Ar-Ar on muscovite from Heathcote Fault Zone to south | 1 |
| Melbourne (MinEX AOI) | Tooleen / V25 DDH1 | Quartz-carbonate vein hosted mineralisation (e.g., 4.5 m at 15.9 g/t Au) | Mount William Metabasalt(- Chm) | Address the age of sulphide-hosted mineralisation that is hosted in Cambrian volcanic rocks | GSV drill core library | As above | 1 |
| Melbourne (MinEX AOI) | Costerfield / interval or underground sample to be selected | Cuffley Lode | Costerfield Siltstone (Sxc) | Timing of sub-vertical stibnite(-gold) mineralisation | Costerfield | N/A | 1 |
| Melbourne (MinEX AOI) | Costerfield / interval or underground sample to be selected | Augusta (N Lode) | Costerfield Siltstone (Sxc) | Testing timing of sub-vertical stibnite(-gold) mineralisation in similar | Costerfield | N/A | 1 |
| Melbourne (MinEX AOI) | Costerfield | Augusta (E or D Lode) | Costerfield Siltstone (Sxc) | Testing timing of more gently dipping mineralisation | Costerfield | N/A | 1 |
| Melbourne (MinEX AOI) | Costerfield | Youle | Costerfield Siltstone (Sxc) | Timing of relatively gold-rich stibnite mineralisation - test age of more gently dipping zones of mineralisation | Costerfield | N/A | 1 |

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| Melbourne (MinEX AOI) | Golden Camel / interval to be selected | Undefine style of mineralisation (e.g., 13 m at 4.0 g/t Au) | Mount William Metabasalt(- Chm) | Address the age of sulphide-hosted mineralisation that is hosted in Cambrian volcanic rocks | Kangaroo Flat Core Shed | N/A – but Ar-Ar on muscovite from Heathcote Fault Zone to south | 1 |
| Melbourne (MinEX AOI) | Tooleen / V25 DDH1 | Quartz-carbonate vein hosted mineralisation (e.g., 4.5 m at 15.9 g/t Au) | Mount William Metabasalt(- Chm): | As above | GSV drill core library | As above | 1 |
| Bendigo | Fosterville – Phoenix Zone / UDE114 | Disseminated arsenopyrite-hosted mineralisation (e.g., 5.6 m @ 7.6 g/t Au) | Castlemaine Group – Lancefieldian (Ocl) | Timing of sulphide-hosted mineralisation in shallow portions of the deposit | GSV collection | No age constraints from the main zones of mineralisation – only on felsic intrusion rocks | 1 |
| Bendigo | Fosterville – Ellesmere Zone / SPD150 | Disseminated arsenopyrite-hosted mineralisation (e.g., 8.2 m @ 6.5 g/t Au) | Castlemaine Group – Lancefieldian (Ocl) | As above | GSV drill core library | As above | 1 |
| Bendigo | Fosterville – Swan Zone / UDH1501 | Visible gold-bearing quartz vein in anticline closure (e.g., 12.5 m at 501 g/t Au inc 1.5 m at 3850 g/t Au) | Castlemaine Group – Lancefieldian (Ocl) | Timing of later free gold mineralisation at depth – test multiple phases of mineralisation separated by large periods of time (>30 myrs) | GSV collection | As above | 1 |
| Bendigo | Fosterville – Swan Zone / UDH3167 | Visible gold-bearing quartz vein in anticline closure (e.g., 7.4 m @ 976 g/t Au inc 1.3 m @ 5710 g/t Au) | Castlemaine Group – Lancefieldian (Ocl) | As above | Fosterville core shed | As above | 1 |
| Bendigo | Lockington South / 05LODH001 | Sulphide-hosted gold mineralisation on western limb of anticline (e.g., 7.7 m @ 4.24 g/t) | Group – Lancefieldian (Ocl) | Test timing relationships with similar sulphide-hosted gold mineralisation at Fosterville | GSV drill core library | No age constraints from the main zones of mineralisation – only on felsic intrusion rocks | 1 |
| Bendigo | Lockington South / 05LODH004 | Sulphide-hosted gold mineralisation on western limb of anticline (e.g., 12.0 m @ 2.47 g/t) | Castlemaine Group – Lancefieldian (Ocl) | Test timing relationships with similar sulphide-hosted gold mineralisation at Fosterville | GSV drill core library | As above | 1 |
| Bendigo | Boyd's Dam - Four Eagles / FEDD031 | Vein-hosted mineralisation in anticline hinge zone (e.g., 11 m at 23.7 g/t Au) | Castlemaine Group Undiff (Occ) | Testing the timing of mineralisation associated with NNW trend 60 km along strike from Bendigo | Kangaroo Flat Core Shed | N/A | 1 |
| Bendigo | Boyd's Dam - Four Eagles / FEDD011 | Vein-hosted mineralisation in anticline hinge zone (e.g., 16 m at 8.2 g/t Au) | Castlemaine Group Undiff (Occ) | As above | Kangaroo Flat Core Shed | N/A | 1 |
| Bendigo | Pickles Zone - Four Eagles / FE328 | Vein-hosted mineralisation in anticline hinge zone (e.g., 6 m @ 82.7 g/t Au) | Castlemaine Group Undiff (Occ) | As above | Kangaroo Flat Core Shed | N/A | 2 |
| Bendigo | Tomorrow Zone - Tandarra / DDT020 | Vein-hosted mineralisation in anticline hinge | Castlemaine Group – Bendigonian (Ocb) | Testing the timing of mineralisation associated with NNW trend 40 km | Kangaroo Flat Core Shed | N/A | 2 |

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| | | zone (e.g., 0.4 m at 243 g/t Au) | | along strike from Bendigo | | | |
| Bendigo | Tomorrow Zone - Tandarra / DDT023 | Vein-hosted mineralisation in anticline hinge zone (e.g., 3 m at 4.7 g/t Au) | Castlemaine Group – Bendigonian (Ocb) | As above | Kangaroo Flat Core Shed | N/A | 2 |
| Bendigo | Pyramid Hill – Karri / PHD001 | Gold mineralisation in anticline hinge (e.g., 11.45 m @ 1.0 g/t Au inc 2.55 m @ 2.3 g/t Au) | Castlemaine Group – Bendigonian (Ocb) | Testing the timing of mineralisation associated with NNW trend 80 km along strike from Bendigo | Pyramid Hill Core shed | N/A | 2 |
| Bendigo | Mustang / MU19DD04 | Gold (e.g., 1.42 m @ 261.3 g/t Au) | Castlemaine Group (Ochc) | Testing timing of mineralisation along Schicer Gully Fault on western limb of anticline | Wattle Gully Core Shed | N/A | 2 |
| Stawell | Resolution Lode / RD006 | Broad intervals of Au mineralisation and white mica alteration (e.g., 18.7 m @ 7.1 g/t Au) | Magdala Volcanics (- Cxd) / Albion Formation (- Caa) | Test timing of to Au mineralisation in footwall to metabasalt – similar structural position to world-class Stawell deposit 20 km to northwest | GSV drill core library | N/A | 2 |
| Stawell | Resolution Lode / RD0012 | Broad intervals of Au mineralisation and white mica alteration (e.g., 10.6 m @ 6.2 g/t Au) | Magdala Volcanics (- Cxd) / Albion Formation (- Caa) | As above | GSV drill core library | N/A | 2 |
| Stawell | Wildwood / WWD 025 | Broad interval of Au mineralisation | Magdala Volcanics (- Cxd) / Albion Formation (- Caa) | Test timing of to Au mineralisation in footwall to metabasalt – similar structural position to world-class Stawell deposit 24 km to southeast | GSV drill core library | N/A | 2 |
| Stawell | Kingston | Au mineralisation associated with white mica alteration (e.g., 3.0 m @ 0.64 g/t Au) | St Arnaud Group (-Cs) | E-W trend – different to other goldfields in Stawell Zone – testing the limit of Bindian and Tabberabberan gold mineralising events | GSV drill core library | N/A | 2 |

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

20 priority 1 samples and additional 9 priority 2 samples for a total of 29 samples.

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

Largely Ordovician-Silurian sandstones and siltstone of Castlemaine Group and Pinnak Sandstone. Also includes samples from Cambrian metabasalts and

Target mineral is sericite associated with mineralised veins and disseminated mineralisation. In metabasalts stilpnomelane may be present instead.

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

ANU preferred due to previous discussions and research focus on tectonic evolution of southeastern Australia.

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) or Geoff Fraser (Geoff.Fraser@ga.gov.au)