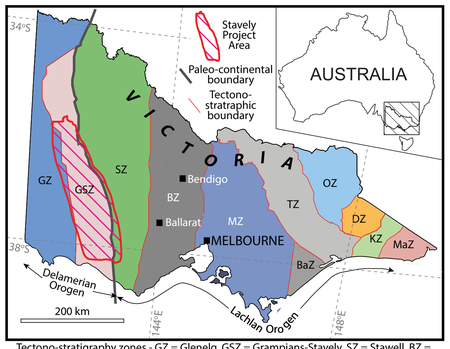
Living on the edge of the Cambrian Australian Proto-continent: potential for subduction-related mineral systems in the Stavely Arc, western Victoria

Rob Duncan, Ross Cayley, David Taylor, Phil Skladzien, Cameron Cairns, Mark McLean, Suzanne Haydon, Melanie Middleton, Megan Weatherman*
The Geological Survey of Victoria, Melbourne, Victoria Australia

Anthony Schofield, Chris Lewis, Sarlae McAlpine, David Huston, Evgeniy Bastrakov, James Goodwin, Matilda Thomas, Narelle Neumann, Tim Barton
Geoscience Australia, Canberra, Australian Capital Territory, Australia

** corresponding author - rob.duncan@ecodev.vic.gov.au*



Tectono-stratigraphy zones - GZ = Glenelg, GSZ = Grampians-Stavely, SZ = Stawell, BZ = Bendigo, MZ = Melbourne, TZ = Tabberabbera, OZ = Omeo, DZ = Deddick, KZ = Kuark, MaZ = Mallacoota, BaZ = Bass

Figure 1. *Location of Stavely Project Area which forms part of the Delamerian Orogen.*

Project Outline

This collaborative project between the Geological Survey of Victoria and Geoscience Australia aims to improve our understanding of the Cambrian Stavely Arc in the Grampians-Stavely Zone of western Victoria (Fig. 1) through collection of multi-disciplinary pre-competitive geoscientific data. It is envisaged that interpretation of these data will develop into greenfield exploration opportunities for arc-related mineral systems that may occur under younger cover rocks. Detailed information on the project and data associated with it are available from www.ga.gov.au/scientific-topics/minerals/unlocking-resource-potential/stavely-project

New Data

The work program focusses around 14 stratigraphic drillholes (sonic drillled in the cover units and diamond tailed in the basement units for a total of ~2700 m) that provided material for:

- **lithogeochemical** characterization and Nd isotopic analyses to assess juvenile/evolved magmatic input;
- **geochronology** to define igneous emplacement and volcanic eruption events, maximum depositional ages for metasedimentary units (U-Pb SHRIMP zircon), and mineralization events (Re-Os molybdenite);
- **chlorite and epidote** trace element geochemistry to determine potential fertility and proximity to mineralisation;
- downhole **petrophysical logging** (density, magnetic suceptibility, P-wave velocity, resitivity, natural gamma);
- downhole mineralogy using **hyperspectral logging** (Hylogger™);
- **sulfur and lead isotopes** to fingerprint sources of metals;
- a **regional-scale 3D model** of structures and volcanic belts.

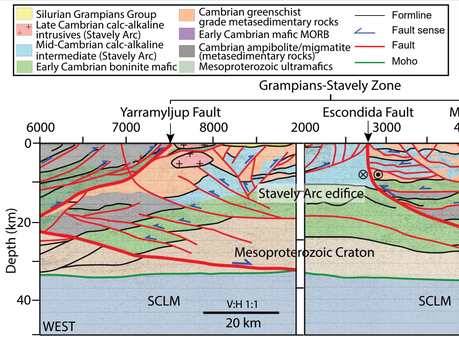


Figure 3. *Interpreted deep seismic reflection transects 09GA-SD1 and 09-GA-AR1 imaging the Stavely Arc edifice at depth.*

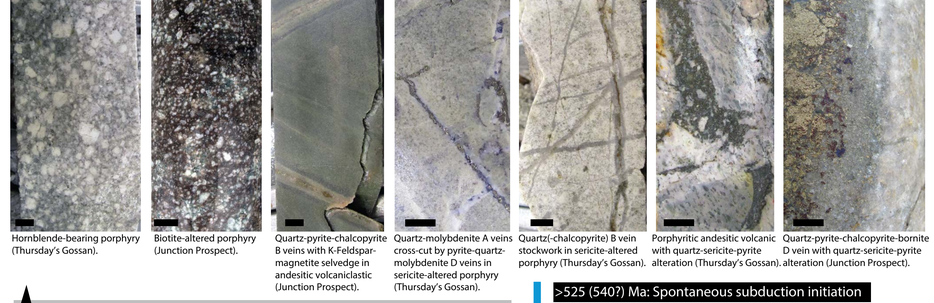


Figure 5. *Examples of rocks from the Stavely Arc displaying hydrothermal alteration and vein assemblages characteristics of porphyry mineralization (scale bar 1 cm).*

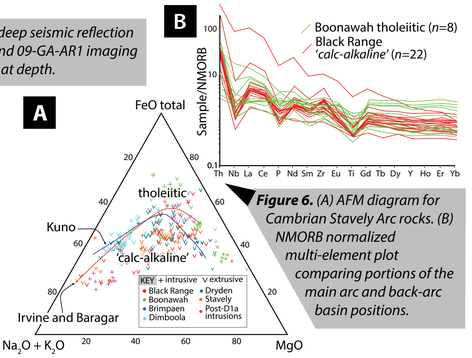


Figure 6. *(A) AFM diagram for Cambrian Stavely Arc rocks. (B) NMORB normalized multi-element plot comparing portions of the main arc and back-arc basin positions.*

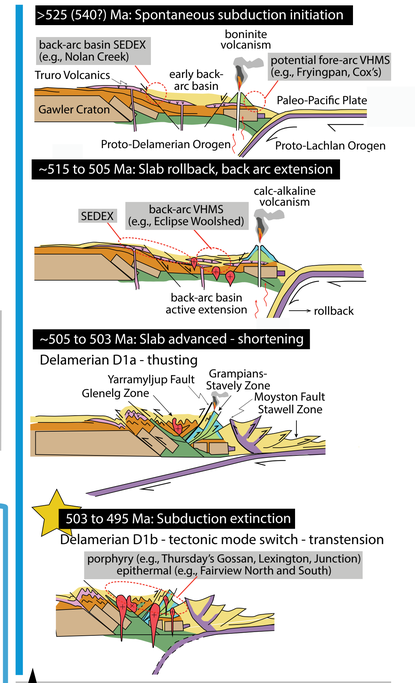


Figure 8. *Preferred Cambrian geodynamic evolution of Stavely Arc with potential mineralizing events identified - sinistral transtension at the end of the Delamerian Orogeny generates a pulse of magmatism associated in time with porphyry and epithermal mineralization.*

Historical Exploration Compilation

This work has demonstrated that the majority of mineral exploration efforts have been concentrated on a restricted zone where Cambrian rocks crop out at surface (Fig. 2). This previous work has been captured in a series of datasets:

- **surficial geochemistry data** that includes 5,200 stream sediments, 25,500 soil, and 2,150 rock chip sample analyses;
- **drilling data** that includes ~15,300 drillholes for ~460,000 metres - the majority of which were for heavy mineral sand exploration in Tertiary cover units and only average <30 m depth;
- compilation of **known mineral occurrences** to help provide geological context for potential mineral systems.

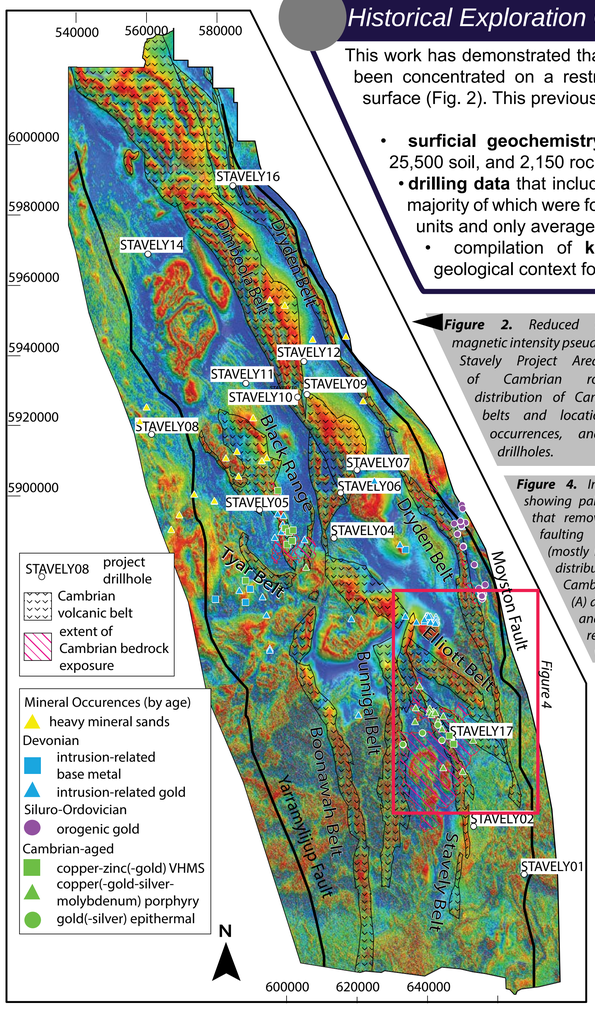


Figure 2. *Reduced to pole total magnetic intensity pseudocolor image for Stavely Project Area with extent of Cambrian rock exposure, distribution of Cambrian volcanic belts and location of mineral occurrences, and stratigraphic drillholes.*

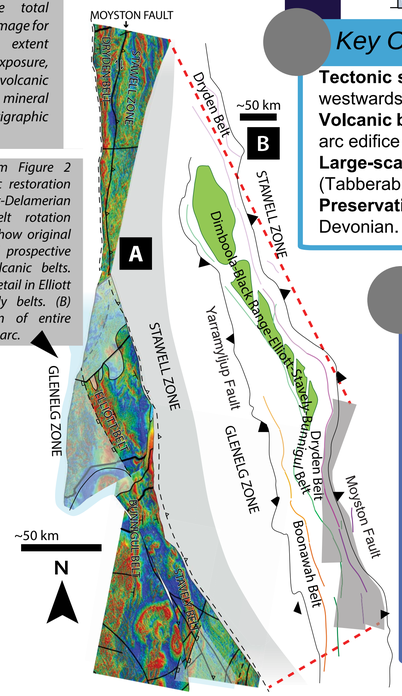


Figure 4. *Inset from Figure 2 showing palinspastic restoration that removes post-Delamerian faulting and belt rotation (mostly D4) to show original distribution of prospective Cambrian volcanic belts. (A) area of detail in Elliott and Stavely belts. (B) restoration of entire volcanic arc.*

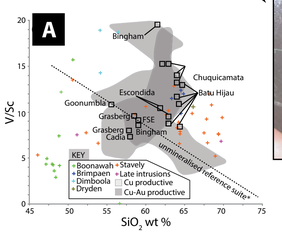
Key Outcomes 1 - Geodynamic setting and timing of arc development

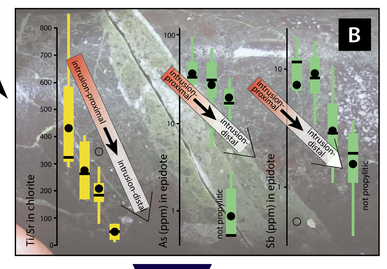
Tectonic setting and age - the Stavely Arc consists of a series of volcanic belts that formed above thinned continental crust in response to westwards dipping subduction from 525 to 500 Ma (and potential as old as 540 Ma) associated with the Delamerian Orogeny,
Volcanic belt arrangement - the **belts are 3 to 8 km wide and fault-bound** (Fig. 2), in the mid-crust they transition to a largely intact volcanic arc edifice (Fig. 3) and near-surface the belts are separated by Cambrian marine sedimentary rocks,
Large-scale belt reconstruction has removed the effects of post-eruption (and mineralization) associated with Devonian deformation (Tabberabberan Orogeny - D4) and restores the belts to three main sub-parallel belts that have a total strike length of over 1100 km (Fig. 4),
Preservation potential for arc-related mineral systems is increased by the fact that the arc has undergone relatively little uplift since the Devonian.

Key Outcomes 2 - Prospectivity for arc-related mineral systems

Prospects with both **porphyry and epithermal affinities occur both within and between the volcanic belts** (Figs. 2 and 5) and mineralization is constrained to 510 to 500 Ma - meaning that mineralization could be hosted in both igneous and sedimentary Cambrian rocks. Intrusions thought to be spatially and genetically associated with mineralization post-date the main phase of thrusting associated with the Delamerian Orogeny (D1a) and are predicted to be **preserved largely upright**,
Porphyry and epithermal-style mineralization in the Stavely Arc is likely associated with **calc-alkaline rocks which have typical subduction signatures** (low LILE, LREE enrichment over HFSE, and negative Ti and Nb anomalies - Fig. 6),
Volcanic-hosted massive sulfide-like mineralization is likely to be associated with rocks in the western volcanic belts that are **tholeiitic MORB-like compositions** (with some evidence of modification through subduction),
Key geochemical indicators, such as **Sr/Y** and **V/Sc** ratios for Cambrian intrusions and trace elements in **epidote** and **chlorite** from propylitic hydrothermal alteration assemblages (Fig. 7), suggest that the Stavely Arc has the potential to host arc-related mineral systems (Fig. 8).

Figure 7. *Geochemical indicators of mineralization fertility for Stavely Arc rocks. (A) V/Sc versus SiO_2 for unaltered rocks compared with known mineralized systems (Loucks 2014 - Aus J Earth Sci). (B) Chlorite-epidote laser ablation trace element analyses for Thursday's Gossan and Eclipse prospects.*





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