Geochronology of mineralisation in the Cobar Basin
Where and when are we now, and where to next?

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Basin fill and orebodies – What's good for dating?

Source has lead to detrital Ti-oxide-rich basin

Heavy mineral-rich sands

Hydrothermal rutile-chlorite-apatite

Detrital ilmenite and rutile breakdown =

Very abundant hydrothermal titanite and rutile

Approaching mineralisation

Hydrothermal veins rich in rutile and titanite

Hydrothermal titanite in veins
Hera orebody

- Late-stage faulting
- Massive sulfide ore
- Foliated orebody margin
Orebody paragenesis – prograde skarn and retrograde Zn-Pb sulfide mineralisation

Prograde skarn, peak temperature
- Reduced, low-CO$_2$ Ca-Mn distal skarn

Tremolite-rich hydrous retrogression
- Main sulfide mineralising stage

sulfide-tremolite hydrous skarn
complete recrystallisation

garnet-diopside-anorthite-titanite skarn

garnet-pyroxene skarn

sulfide-tremolite hydrous rind
textural preservation

Titanite
Preliminary ~395 Ma age
Orebody paragenesis – Au

Titanite (SHRIMP) 400.3 ± 4.6 Ma, (TIMS) 403.39 ± 0.97 Ma

Gold

Fe-poor sphalerite

Galena

Sphalerite

Tremolite-anorthite

Low Fe sphalerite mineralisation

Appears to overprint skarn K-feldspar replacement

Sphalerite

Tremolite

anorthite skarn

Titanite (SHRIMP) 400.3 ± 4.6 Ma, (TIMS) 403.39 ± 0.97 Ma

Titanite

Galena

Sphalerite

Tremolite-anorthite

Titanite

Gold

Fe-poor sphalerite
Gold in biotite foliation

Tremolite-rich hydrous skarn

Biotite-rich foliation overprinting skarn

Orebody paragenesis – deformation

Biotite (Ar-Ar) 390.3 ± 0.23 Ma

Remobilisation?

or

New mineralisation?
Orebody paragenesis – brittle faulting

Titanite (SHRIMP) $383.9 \pm 2.2$ Ma, (TIMS) $383.98 \pm 0.43$ Ma
**Orebody paragenesis – post-deformation**

- Mineralisation that crosscuts foliation
- New or remobilised?

### Muscovite (Ar-Ar) 381.0 ± 2.2 Ma

- Sample HRD018 Muscovite
- Plateau age = 381.9 ± 2.2 Ma (1σ, including r error of 0.54%)
- MSWD = 1.4, probability = 0.24
- Includes 95% of the Ar

**Massive galena and post-S1 folding**

**Sphalerite and post-S1 folding**
CSA orebody

- Note the orebody geometry
- Consider the Hera orebody model and age dating
CSA orebody

- Two generations of hydrothermal titanite
  - Deformed mineralised veins
    - **408.6 +/- 4.7 Ma**
  - Cross-cutting barren veins (similar to Hera)
  - Located at ore lens terminations
    - **390.3 +/- 7.3 Ma**
CSA orebody – in situ dating

- Hydrothermal rutile
  - Massive cubanite/chalcopyrite
    - 413.1 +/- 9.0 Ma
  - Titanite replacing rutile in foliation
    - 374 +/- 16 Ma
Perseverance orebody

Perseverance - Chronos

Steven et al 2017
Perseverance and Chronos orebodies

- Hydrothermal veins
  - Biotite-titanite-sulfide veins
    - Linear vein arrays in the mineralised rhyolite.
  - Chlorite-titanite-sulfide veins
    - Deformed veins within sedimentary rocks

- Ages all within error

  \[409 \pm 3.7 \text{ Ma}, \ 411 \pm 4 \text{ Ma} \]
  and

  \[413 \pm 4 \text{ Ma}\]

Peak rhyolite - \[418.3 \pm 3.0 \text{ Ma}\]
What does it all mean?

- **Syn rift/sag mineralisation**
  - c. 420 Ma dates e.g. Mineral Hill.

- **Cobar sweet spot – 413–400 Ma**
  - c. 413–408 Ma
    - late syn- to post-sag phase
    - 411 Ma intrabasin magmatism
    - Includes rutile/titanite U-Pb and mica Ar-Ar.
  - Hera skarn (c. 405–400(395?) Ma)
    - high heat flow, renewed magmatism
    - I-type magmatism of this age to the east, south and north of Cobar
    - does the Cobar basin still cover the culprit?
    - consistent with c. 410–390 Ma extension and I-type magmatism in Victoria.
The numbers game - where next?

- Need to directly date mineralisation in as many orebodies as we can.

- As many different minerals/methods as we can.

- Mixing apples and oranges - zircon Vs titanite Vs rutile Vs mica.

- Rutile is the new titanite
  - in many of the orebodies it appears to predate the titanite – encouraging result at CSA
  - extreme rutile enrichment in parts of the Southern Nights orebody.
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