New directions in metamorphic studies at GSWA

Presented by

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Introduction – Why should we care about metamorphic rocks?

- Record the pressure ($P$)–temperature ($T$)–time ($t$)–deformation–fluid evolution on many scales
- Crustal response to broader tectonothermal processes
- Assemblage may record a composite history
- New techniques to interrogate the rock record
Metamorphic data points → State Metamorphic Map

- GOLDEN SPIKES of robust metamorphic data across the State
- Retrieval of robust and standardized $P-T-t$ data
  - Thermobarometry, mineral chemistry, in situ geochronology
  - Integrated with mineralization studies
  - Utilizing state-of-the-art techniques
  - From field to microanalytical scale

- Data capture and query: Geochronology and Mineral Chemistry database (in development)
Pressure ($P$)–temperature ($T$) estimates: example

Petrography and mineral chemistry

1. Garnet (cores + Qtz–Ilm–Mu–Chl)
2. Garnet (rims) + Staurolite (Qtz–Ilm–Bt)
3. Foliation: Chl–Bt–Mu–Qtz

Grossular % (Ca) in garnet
Pressure ($P$)–temperature ($T$) estimates: isochemical phase diagrams

- Constructed for specific bulk composition
- Chemical system closely approximates nature
- Minerals and fluids
- Observe changes in model assemblages with $P$–$T$–composition ($X$)
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Garnet cores: $X_{Ca} = 0.18$, $X_{Mn} = 0.09$
Garnet rims: $X_{Ca} = 0.08$, $X_{Mn} > 0.08$
In situ geochronology: monazite

The hunt for monazite:
TESCAN integrated mineral analyser (TIMA) scan

GSWA 212305, West Kimberley

- Quartz
- Biotite
- Unclassified
- Sillimanite, Andalusite
- Kaolinite
- Albite
- Orthoclase
- Cordierite
- Muscovite
- Schorl
- Diopside
- Staurolite
- Calcite
- Anorthite
- Ilmenite
- Monazite
- Apatite
- Zircon
In situ geochronology: monazite (laser ablation split stream)

\[ M_1: 1854 \pm 4 \text{ Ma (monazite in Sill1 and surrounding biotite, some matrix grains)} \]

\[ M_2: 1823 \pm 6 \text{ Ma (monazite with biotite and Sill2 aligned in the foliation)} \]

212316 (1.5 km W, same unit)
- Zircon (SHRIMP) age: 1865 \( \pm \) 8 Ma \( (M_1) \)
- Monazite age: 1826 \( \pm \) 9 Ma \( (M_2) \)

30 Myr of high \( T \), melt-present conditions
Monazite trace element chemistry

GSWA 212314
West Kimberley

Possible garnet growth
New directions in metamorphic studies at GSWA – where we have been, where we are, and where we are going...

PAST:
• Field-based work, geophysics, geochemistry, geochronology
• Metamorphic studies not routinely done at GSWA; not standardized

PRESENT: GOLDEN SPIKES of robust metamorphic data across the State
• Protocol developed for the construction of isochemical phase diagrams (pseudosections)
• Protocols and work flow now in place for routine and standardized mineral chemistry and in situ monazite geochronology (+ trace elements)
• Detailed field and microanalysis integrated with P–T–t data
• Continuing to explore and apply new techniques, particularly in regards to thermobarometry (e.g. Raman barometry, trace element thermometers)

FUTURE:
• Metamorphic History Records (linked with GeoVIEW)
• Geochronology and Mineral Chemistry database
• Metamorphic State Map (descriptive versus interpreted)