Metallogenesis of eastern Australia: links to the tectonic evolution of the Tasman Orogen

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Methodology

Geologic synthesis (orogen based)
Lachlan, Thomson, North Queensland & New England

Tectonic synthesis (cycle based)
Delamerian, Benambran, Tabberabberan, Kanimblan & Hunter-Bowen

Deposit synthesis (cycle based)
Description, mineral system, age

Mineral potential analysis
Known deposits + tectonic environment = mineral potential

Second in series synthesising
gedynamic evolution of Australia

Mines and Wines, September 2010
Geologic synthesis (e.g., Thomson Orogen)

- Summarised geology by region
- Correlated across regions
- Produced time-space diagrams

Then correlated between orogens using cycle framework
Tectonic synthesis – Cycles
(e.g., Collins and Richards, 2008)
### Tectonic cycles of the Lachlan Orogen

*(following Glen, 2005; Gray and Foster, 2004)*

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Age (Ma)</th>
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</thead>
<tbody>
<tr>
<td>Delamerian</td>
<td>600-490</td>
</tr>
<tr>
<td>Benambran</td>
<td>490-430</td>
</tr>
<tr>
<td>Tabberabberan (includes Bindian)</td>
<td>430-380</td>
</tr>
<tr>
<td>Kanimblan</td>
<td>380-350</td>
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<tr>
<td>Hunter-Bowen</td>
<td>350-230</td>
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</tbody>
</table>
Deposit synthesis and mineral potential assessment

Base after Collins and Richards (2008)
### Hunter-Bowen

- Kanimblan
- Benambran
- Tabberabberan
- Kanimblan

### Lachlan

- Delamerian

### Benambran

- Benambran

### New England

- Lode gold

### Thomson-North Queensland

- VHMS

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**Key**

- **Orthomagmatic Ni-Cu and PGE**
- **Porphyry Cu-Au**
- **Granite-related Sn-W**
- **High sulphidation Cu-Au**
- **Intrusion-related and skarn Au**
- **VHMS Zn-Pb-Cu**

- **Low sulphidation Au(Ag-base metals)**
- **Epigenetic Zn-Pb-Ag and Cu**
- **Avokury-type Ni**

- **Lode Au**
- **Sediment-hosted Zn-Pb**
- **Unconformity-related and other U**

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*Includes high sulphidation epithermal and VHMS deposits. Size of symbol indicates relative size of deposit. Normal text indicates well constrained ages; italics indicate ages inferred from geological framework. Hatching indicates spatial and temporal distribution of major contractional deformation events.*

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*Geoscience Australia*
Delamerian Cycle
(>600-490 Ma)

- Developed along margins of Proterozoic Australia
- Extensive felsic and mafic volcanics and associated sediments
- Deep marine turbiditic sediments
- Restricted granites

- Began with Rodinia break-up
- Ended with Delamerian Orogeny (ca. 520-490 Ma)
- Interpreted west-dipping subduction
- Relative position of Tasmania and Selwyn Block uncertain

- VHMS and hybrid Cu-Au deposits in western Tasmania
Mt Read Volcanics

- Middle Cambrian (~505 Ma) calc-alkaline volcanics
- Coeval granite belt on eastern margin
- Two groups of deposits
  - Hybrid Cu-Au and Au deposits
    - More proximal to granite belt
    - Advanced argillic alteration assemblages
    - Age: 500.4 ± 2.3 Ma (Re-Os)
    - Magmatic-hydrothermal?
  - VHMS Zn-Pb deposits
    - More distal to granite belt
    - Sericite-chlorite assemblages
  - Link to Savage River Fe?
    - Some late Cambrian ages (Bottrill and Taheri, 2010)
    - Apatite-magnetite
Eastern granite belt

Mt Lyell

Rosebery

Back-arc Basin
Back-arc volcanics and sediments

Arc

Fore-arc

Arc-related volcanics

Continental crust

Decompression melting:
High T, anhydrous melts

Flux melting:
Volatile-rich, oxidised melts

Mantle metasomatism

"Normal"
VHMS system

Zn-rich

Sea-water

Polyphase sill

Huston et al. (in press)

Mantle

Oceanic crust

Mantle

Cu-Au-rich

Sea-water

Plug-like intrusions

Magmatic-hydrothermal fluids

High sulphidation
VHMS system

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Delamerian Cycle mineral potential

- VHMS/Cu-Au & Ni-Cu-PGE potential extends into central and western Victoria, Koonenberry belt, Warburton Basin

- Is there a relationship to recently discovered VHMS deposits in Mt Riddoch Igneous Complex in Northern Territory?

- What is relationship of Savage River iron to this cycle and Mt Read mineral system?
Benambran Cycle
(490-430 Ma)

- Widespread non-volcanic deep water sediments, and
- Calc-alkaline to shoshonitic magmatic arcs
- Ended with Benambran Orogeny (ca. 450-430 Ma)
- Subduction environment, complex configuration, modified by subsequent tectonism
- Relative position of Tasmania and Selwyn Block uncertain
- VHMS in north Queensland
- Major contemporaneous ore deposition in Victoria (Au) and NSW (Cu-Au)
Juxtaposition of Benambran lode Au and porphyry Cu-Au

Alternatively, Cayley (2010) inferred that the Macquarie Arc was transported southward during the Bindian Orogeny.

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Benambran Cycle mineral potential

- Interpreted widespread potential for VHMS & Cu-Au/Au early in the cycle
- Lode Au and porphyry Cu-Au late in the cycle
- Ar-Ar data suggests contemporaneous U mineralisation associated with shears in north Queensland
Tabberabberan Cycle (430-380 Ma)

- Widespread felsic magmatism
- Deep water sedimentation (Selwyn Block-Tasmania, north Queensland) and localised volcanic basins (NSW)
- West dipping subduction formed oceanic? Gamilaroi-Calliope Arc
- Ended with Tabberabberan Orogeny (ca. 390-380 Ma)
- Includes ca. 420-400 Ma Bindian Orogeny
- Final amalgamation of Lachlan
- Early cycle VHMS and granite-related mineralisation
- Bindian lode and intrusion-related gold and Cobar-type copper-gold
- Hybrid copper-gold (Mt Morgan)
New England Orogen

Gamilaroi-Calliope Arc

- 425-380 Ma island arc – western margin of New England Orogen
- Extends from northern New South Wales to central Queensland

- Hosts ~380 Ma Mt Morgan Au-Cu
- Potential under cover for Cu-Au, Cu-Mo and Au deposits
Kanimblan Cycle
(380-350 Ma)

- Widespread felsic magmatism
- Deep water sedimentation (north Queensland, New England Orogen)
- Terrestrial sedimentation elsewhere
- Andean-style continental arc, New England orogen
- Widespread intracratonic extension, rifting & basin formation, back-arc and inboard of arc
- Ended with Kanimblan Orogeny (ca. 350 Ma)

- Granite-related Sn-W in Tasmania
- Lode gold, Victorian Goldfields and Hill End Trough
Kanimblan Cycle – links to intracontinental deformation and mineralisation?
Hunter-Bowen Cycle (350-230 Ma)

- Terrestrial to marine sediments
- Widespread Kennedy Province magmatism
- Andean-style continental arc, New England orogen
- Sydney-Gunnedah-Bowen system - backarc
- Ended with Hunter-Bowen Orogeny (ca. 265-230 Ma)

- Extensive Sn-W, IRG, porphyry Cu-Mo-Au, epithermal Au associated with Kennedy magmatism
- Lode gold, VHMS
New results – Croydon zinc-copper-tin

GSQ regional aeromagnetic data

www.goldanomaly.com.au

Age ~285 Ma

Integrated Age (6474-02) = 286.0 ± 1.4 Ma
Integrated Age (6474-01) = 285.6 ± 1.8 Ma

Cumulative % Ar Released

285.0 ± 1.5 Ma
285.4 ± 1.2 Ma

www.goldanomaly.com.au
Conclusions

• Mineralisation is linked to tectonic cycles that developed episodically during the evolution of the Tasman Orogen

• The style of mineralisation is related to both spatial and temporal location within each cycle

• Because of this cyclicity, there have been repeated mineralising events of different types (e.g., VHMS, lode gold)

• These relationships can be used to predict locations and periods of mineralisation

• The evolution of the Tasman Orogen may have had significant repercussion in board – both in terms of orogenesis and mineralisation