Overview

- Overview of Evolution
- Exploration Strategy

- Using geochemistry & spectral analysis in exploration
  - Examples from Queensland
Evolution Mining overview

- FY17 production: 844 koz
- AISC: A$907/oz
- Operating cash flow: $707m

What we’re looking for

- Gold discoveries >2 Moz
- Host rock resource inventory
- 1997 – 2011

Source: SNL Metals & Mining 2011

- Our exploration focus
  - Epithermal and greenstone/orogenic deposits
  - Will consider intrusion-related gold ± copper or iron oxide copper-gold deposits (opportunistic)

- Our appetite for risk
  - Moderate (ie mine extensions) to very high (ie conceptual targets in endowed districts)

- Playing to our exploration and operating strengths
  - Epithermal deposits (Cracow and Mt Carlton)
  - Greenstone gold deposits (Mungari)
  - Driven by our ability to discover an orebody across a 3 – 5 year period

Gold discoveries >2 Moz
Host rock resource inventory
1997 – 2011

Source: SNL Metals & Mining 2011
Regional Focus

Yilgarn >400 Moz
(Greenstone Au)

Tanami >30 Moz
(Orogenic Au)

Telfer >30 Moz

Lachlan >80 Moz
(Epithermal & Porphyry)

New England >15 Moz
(Epithermal, IRG)

Charters Towers >35 Moz
(Epithermal, IRG)

Tennant Creek >5 Moz
(IOCG)

Mt Isa >17 Moz
(IOCG)

Gawler >100 Moz
(IOCG)

Victoria >40 Moz
(Orogenic Au)

Pine Creek >20 Moz
(Orogenic Au)

Exploration Geochemistry

- Basics (aka fundamentals)
- A case for 4 acid digest ICP-MS & ASD
  - Lithogeochemistry
  - Alteration Geochemistry
  - Pathfinder elements
  - Alteration minerals
- Examples from Mount Rawdon and Mount Carlton
What do you want to achieve? (do you know what you can achieve?)

- What do you need to measure?
  - Elements
  - Detection limits
  - Assay Method
    - Digestion
    - Analysis

- Where do you need to measure it?
  - Data distribution
  - Program design

Geochemical Zonation

- Pattern Recognition
  - Visualisation is key
Geochemical Zonation

- Program Design & Data Distribution
  - Context is everything
  - No substitute for coverage

Geochemistry Fundamentals

- Program Design
- Soils
  - Map systems with >400m data
- Drilling
  - ≥1 sample/lithology (minimum 1 every 20m)
  - Extra to characterise mineralisation/alteration
Geochemistry Fundamentals

- Analysis Methods - Digestion
  - Fusion can’t do Ag, As, Bi, Cu, Mo, Pb, Sb, Se, Te, Zn…
  - Aqua regia won’t get majors, litho trace elements, Sb, W

Geochemistry Fundamentals

- Analysis Methods: Detection Limits
  - Are they low enough to capture the full anomaly?

<table>
<thead>
<tr>
<th>Detection Limit</th>
<th>pXRF</th>
<th>AAS/ NAA</th>
<th>ICP-AES/ OES</th>
<th>ICP/MS</th>
<th>Average crustal abundance</th>
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<td>X</td>
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</table>
**Geochemistry Fundamentals**

- **Pathfinders**
  - Tl, Sb, As, Ag, Zn, Pb, W, Bi, Se, Te, Sn, Cu, Mo
    - ICP-OES: no Te, Se; poor Ag, Sb, W, Bi, Mo
    - pXRF: no Te, Se; very poor Ag, Sb, W, Bi, Mo
    - Aqua regia: poor Sb, W

- **Alteration Geochemistry**
  - Majors - K, Na, Ca, Mg, Fe, Al, (Si)
    - ICP-OES: great
    - pXRF: no Na & Mg
    - Aqua regia: useless
Geochemistry Fundamentals

- Lithogeochemistry
- Immobiles - Ti, Sc, V, Ni, Zr, Th, Nb, Ce, Y, Lu, etc
  - 4AD: Zr, Hf, HREE dodgy
  - ICP-OES: only Ti, V, Ni, Cr
  - pXRF: Ti, Zr, V, (Ni, Cr)
  - Aqua regia: useless
Spectral Fundamentals

- Instruments
  
  **ASD TerraSpec**
  
  **Halo**
  
  **HyLogger**

HyMAP

Satellites (ASTER, HISUI, EnMAP)

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Spectral Fundamentals

- Short Wave Infrared

![Spectrum line](image)

Reflection (%) vs. Wavelength (nm)

- Absorption features:
  - ~1400, 1412 nm
  - ~1830 nm
  - ~2312, 2380, 2350 nm
  - ~2162 nm
  - ~2206 nm
Spectral Fundamentals

- Mineral Identification

- **SWIR**
  - Al-OH – Clays & micas - kaolinite, smectite, dickite, illite, pyrophyllite
  - Fe-OH & Mg-OH – Chlorite, biotite, epidote, etc
  - CO$_3$ – carbonates
  - SO$_4$ – alunite

- **VNIR**
  - Fe-oxides

- **NOT**
  - *Quartz*, feldspar, sulphides, non-hydrous silicates

Mount Carlton Exploration Model

- Deposit Alteration Zonation

**Metal Zonation**
- >5Line Disseminated Pyrite
- Pb + Zn >300ppm
- Pb + Zn >2000ppm
- As > 100ppm; Cu > 300ppm
- As > 500ppm; Cu > 1000ppm
- Enargite-pyrite vein/breccia
- High grade gold

**Lithology**
- Upper andesite
- Rhyodacitic fragmentals
- Rhyodacite
- Lower andesite
- Granite basement

**Alteration Zones**
- Pyrophyllite (+ quartz, alu, dk)
- Alunite (+ quartz + dik, ka)
- Dickite (+ quartz – ka)
- Illite (+ quartz, chl)
- Illite-smectite (+ chl, ka)
Mount Carlton: Lithogeochemistry

- Lithogeochemistry

**Lithogeochemical Units**
- Post-mineral mafic dyke phases
- Post-mineral high Ti-Nb mafic dykes
- C Unit andesite
- Upper Rhodacite (dacite)
- V Unit andesite-dacite
- Rhodacite (undiscriminated)
- Lower Rhodacite (rhyolite)
- Z Unit andesite
- Basement granite

Mt Carlton United

2km

Far East

A39

V2

Mount Carlton: Pathfinder Elements

**: As >5 ppm**

**: Ti >1 ppm**

**: Mo >0.8 ppm**
Mount Carlton: SWIR

- Camp Scale Alteration Zonation

![Map of Mount Carlton with alteration zones and mineralization styles](image)

Mount Carlton: SWIR

- Deposit Alteration Zonation

![Map showing deposit alteration zones](image)
Example: Mount Rawdon

- Epizonal intrusion-related gold deposit
- Reserves (Dec 16): 0.87 Moz @ 0.83g/t Au
- Production + Resources: 2.7 Moz

Mount Rawdon: Lithogeochemistry

- Differentiate phases of volcanics and dykes
- Recognition of late-mineral rhyolite plug
Mount Rawdon: Alteration Geochem

- Mt Rawdon major element mass changes

![K-Feldspar NaK GER Diagram](image)

Alteration Geochemistry

- Subtle/variable in most areas
- Mineralised zone-parallel, gold-bearing structures control alteration
Mount Rawdon: Pathfinder Elements

- Large, well zoned footprint

<table>
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<tr>
<th></th>
<th>Deep</th>
<th>Shallow</th>
<th>Marginal</th>
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</tbody>
</table>

Silver >2ppm
>4ppm

Te >0.5ppm
>1ppm

Mn >1900ppm
>2400ppm
Mount Rawdon: Pathfinder Elements

- Defined visually, correlation coefficients & PCA on Z-scores
  - Log Z-scores
  - Averaged for each association
  - Association with max value shown

Metal Associations

<table>
<thead>
<tr>
<th>Group</th>
<th>Secondary</th>
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<tbody>
<tr>
<td>Mn-Zn-Pb</td>
<td>(Ag-Pb)</td>
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<tr>
<td>Zn-As</td>
<td>(Cu-Se)</td>
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<tr>
<td>Sb-As</td>
<td>(Bi-Pb-Zn)</td>
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<tr>
<td>Ag-Cu</td>
<td>(Mo)</td>
</tr>
<tr>
<td>Bi-Te</td>
<td></td>
</tr>
</tbody>
</table>

Mount Rawdon: SWIR

- Sericite Crystallinity

Low Crystallinity
Increasing Temp
High Crystallinity
Summary

- Visualise data to see patterns
- Know what you CAN do and what you want to do
- Context is everything
- Do 4 acid digest ICP-MS
- pXRF is cheap and good for some things
  - Spend a bit more to get a lot more
Summary

*ASD and Mass Spectrometer sold separately