Mineral potential mapping – it works!

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Why mineral potential studies?
GSNSW is embarking on a statewide mineral potential mapping project that will:

- develop mineral system models and identify economic potential for key mineral systems
- replace the ‘potential’ layer in the current Mineral Resource Audit mapping
- have results which can trigger land-use referrals
- include Kenex spatial analysis
- identify land-use pressures
- result in availability of good metallogenic mapping, seamless geology and derivative maps.

Introduction
Spatial analysis: weight of evidence

- Create study area – 50 m x 50 m grid.
- Select training points.
- Select unit cell – 1 km$^2$ for all models (~ extent of mineral system).
- Determine prior probability (odds of a training deposit in a unit cell).
- Create predictive maps and perform spatial analysis.
- Select predictive maps.
- Run mineral potential model.
- Test model success rate.
Which mineral systems?
1. **Intrusion-related tin-tungsten** (IR Sn-W)  
   [GS2017/0617](#)
2. **Intrusion-related gold** (IR Au)  
   [GS2017/0618](#)
3. **Orogenic gold-antimony**  
   (orogenic Au-Sb)  
   [GS2017/0619](#)
**Mineral systems – Zone 54 (Released)**

1. Shear-hosted iron-oxide copper gold (Copper Blow type)
   - GS2018/0371
2. Orogenic gold
   - GS2018/0372
3. Volcanic-associated massive sulphide (Grasmere type)
   - GS2018/0370
4. Broken Hill type Pb-Zn-Ag
   - GS2018/0400
Mineral systems – Zone 55E (Release July 2019)

1. Porphyry centred Cu-Au
2. Orogenic gold
3. Volcanic-associated massive sulphide
4. Post Ordovician magmatic hydrothermal skarn systems
Methodology and outputs
Selecting predictive maps

Source: Knox-Robinson & Wyborn 1997
Data: map-based

- Seamless
  - reactive rocks
  - igneous metal fertility
  - fault attribution
  - metamorphic map
  - geology.

- Geophysics
  - rad, gravity, mag + worms.
Data: point-based

- 783 radiometric ages.
- 6,788 whole-rock geochemistry.
- 11,160 mineral occurrences.
- 12,150 thin-section descriptions.
- 17,703 structural readings (including vein-sets).
- 28,719 drilling lithology logs.
- 42,633 field observations.
- 241,478 assays (drillhole, stream sediments, rock-chip, soil).
IR Sn-W: mineral system model

- Found in the apical regions of strongly fractionated, reduced I-type felsic granitoids of Permo-Triassic age (254–245 Ma).
- Stockwork/sheeted vein style – Torrington (e.g. Taronga, Great Britain), Pound Flat.
- Disseminated greisen – Fielders Hill.
- Breccia pipe – Glen Eden.
- Skarn/carbonate replacement – Attunga (Kensington W).
### IR Sn-W training points

<table>
<thead>
<tr>
<th>Name</th>
<th>Metal District</th>
<th>Commodity Major</th>
<th>Commodity Minor</th>
<th>Mineralisation Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Attunga tungsten deposit (prospect 1)</td>
<td>Attunga</td>
<td>Au, W, Mo</td>
<td></td>
<td>W skarn</td>
</tr>
<tr>
<td>2 Butlers lode</td>
<td>Torrington</td>
<td>Sn, W</td>
<td>Pb, monazite, Ag, Zn</td>
<td>Sn-(W) vein</td>
</tr>
<tr>
<td>3 Dutchmans &amp; Harts</td>
<td>Torrington</td>
<td>Sn</td>
<td></td>
<td>Sn-(W) vein</td>
</tr>
<tr>
<td>4 Elsmore tin lodes</td>
<td>Elsmore</td>
<td>Sn</td>
<td>Bi, W, Ag, Au</td>
<td>Sn-(W) vein/greisen</td>
</tr>
<tr>
<td>5 Fielders Hill south</td>
<td>Torrington</td>
<td>W, Bi, topaz - industrial</td>
<td>Sn, Cu, fluorite, cryolite, U, Au</td>
<td>topaz-W greisen</td>
</tr>
<tr>
<td>6 Fitzpatrick and Spillers deposit</td>
<td>Bingara extended</td>
<td>Sn</td>
<td></td>
<td>Sn-(W) vein</td>
</tr>
<tr>
<td>7 Glen Eden mines</td>
<td>not assigned</td>
<td>Mo, W</td>
<td>Sn, Bi, fluorite, cryolite, Cu, beryl - industrial</td>
<td>Mo porphyry</td>
</tr>
<tr>
<td>8 Great Britain deposit</td>
<td>Emmaville</td>
<td>Sn</td>
<td></td>
<td>Sn-(W) vein</td>
</tr>
<tr>
<td>9 Kensington Scheelite Deposit</td>
<td>Attunga</td>
<td>W</td>
<td></td>
<td>W skarn</td>
</tr>
<tr>
<td>10 Leviathan lode</td>
<td>Tingha</td>
<td>Sn</td>
<td>As, Cu, W</td>
<td>Sn-(W) vein</td>
</tr>
<tr>
<td>11 Lode Hill</td>
<td>not assigned</td>
<td>Sn</td>
<td></td>
<td>Sn-(W) vein</td>
</tr>
<tr>
<td>12 Pound Flat prospect</td>
<td>not assigned</td>
<td>Sn, As</td>
<td>Zn, Pb, W, Cu</td>
<td>Granite-related polymetallic veins</td>
</tr>
<tr>
<td>13 Taronga deposit</td>
<td>Emmaville</td>
<td>Sn</td>
<td>Cu, As, Ag, Zn, W, Pb, Mo, Bi</td>
<td>Sn-(W) vein</td>
</tr>
</tbody>
</table>
**IR Sn-W: final predictive maps**

**Source**
- Chlorite, carbonate or fluorite gangue
- Granite age and type
- Granite textures
- hhp granites
- Granite in drill logs
- Isolated Mineral Occurrences Sn-W

**Transport**
- Magnetic Worms
- Hunter Bowen Contraction Faults
- Intrusion contacts: type and age

**Trap**
- Veins
- Greisen (qtz-mus)
- High U
- High Th
- SS Sn
- SS W
- Sn mineral occurrence density
- Rock Sn and W

**Deposition/preservation**
- Knox-Robinson & Wyborn 1997
Orogenic Au-Sb: final predictive maps

Source
- Association with mafic and ultramafic rocks
- Association with deep marine units

Transport
- Vein Density
- Fault dip orientation
- Thrust faults
- 4th order faults and veins

Trap
- Veins
- Fault bends
- Competency contrast
- Intersection between faults and reactive rocks
- Felsic intrusion size
- Magnetic lows along structural lineaments

Deposition/preservation
- Placer Au deposits
- Placer Au source
- Mineral occurrence density: Au, Sb, Stibnite, W, Hg
- SS Au
- Rock Au
- Rock As, Sb, W

Knox-Robinson & Wyborn 1997
## Final model results: what are the odds?

<table>
<thead>
<tr>
<th></th>
<th>IR Sn-W</th>
<th>IR Au</th>
<th>Orogenic Au-Sb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Probability</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0024</td>
</tr>
<tr>
<td>Post Probability</td>
<td>0.7366</td>
<td>0.9373</td>
<td>0.9412</td>
</tr>
<tr>
<td>Prospective area</td>
<td>6% (1.2%)</td>
<td>8% (1.4%)</td>
<td>4.5% (0.5%)</td>
</tr>
<tr>
<td>Efficiency</td>
<td>99.5%</td>
<td>99.5%</td>
<td>97.6%</td>
</tr>
</tbody>
</table>
**Zone 54 – hot off the press**

Table 3-2. Stream sediment sample anomaly thresholds for Curnamona study area.

<table>
<thead>
<tr>
<th>Element</th>
<th>Threshold</th>
<th>75th Percentile</th>
<th>85th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag ppm</td>
<td>0.114</td>
<td>0.065</td>
<td>0.114</td>
<td>1</td>
</tr>
<tr>
<td>Au ppm</td>
<td>0.015</td>
<td>0.00255</td>
<td>0.015</td>
<td>1.98</td>
</tr>
<tr>
<td>As ppm</td>
<td>12.9</td>
<td>7.58</td>
<td>12.9</td>
<td>100</td>
</tr>
<tr>
<td>Ba ppm</td>
<td>270</td>
<td>0.0001</td>
<td>270</td>
<td>410</td>
</tr>
<tr>
<td>Bi ppm</td>
<td>0.29</td>
<td>0.0003</td>
<td>0.29</td>
<td>0.7</td>
</tr>
<tr>
<td>Co ppm</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Cu ppm</td>
<td>34.4</td>
<td>28.3</td>
<td>34</td>
<td>52</td>
</tr>
<tr>
<td>Ni ppm</td>
<td>24</td>
<td>20</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>Pb ppm</td>
<td>44.1</td>
<td>35.9</td>
<td>44.1</td>
<td>84</td>
</tr>
<tr>
<td>Sb ppm</td>
<td>0.49</td>
<td>0.41</td>
<td>0.49</td>
<td>0.65</td>
</tr>
<tr>
<td>U ppm</td>
<td>2.97</td>
<td>1.95</td>
<td>2.97</td>
<td>4</td>
</tr>
<tr>
<td>W ppm</td>
<td>3.8</td>
<td>1.9</td>
<td>3.8</td>
<td>15</td>
</tr>
<tr>
<td>Zn ppm</td>
<td>94.9</td>
<td>80.6</td>
<td>94.9</td>
<td>149</td>
</tr>
</tbody>
</table>

Table 3-3. Combined rock chip and drill hole anomaly thresholds for Delamerian-Thomson study area.

<table>
<thead>
<tr>
<th>Element</th>
<th>Threshold</th>
<th>75th Percentile</th>
<th>85th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag ppm</td>
<td>0.098</td>
<td>0.0492</td>
<td>0.098</td>
<td>1</td>
</tr>
<tr>
<td>Au ppm</td>
<td>0.097</td>
<td>0.00298</td>
<td>0.0099</td>
<td>0.097</td>
</tr>
<tr>
<td>As ppm</td>
<td>27.5</td>
<td>13.9</td>
<td>27.5</td>
<td>92</td>
</tr>
<tr>
<td>Ba ppm</td>
<td>805</td>
<td>218.9</td>
<td>360</td>
<td>805</td>
</tr>
<tr>
<td>Bi ppm</td>
<td>6</td>
<td>0.61</td>
<td>1.97</td>
<td>6</td>
</tr>
<tr>
<td>Ca ppm</td>
<td>3400</td>
<td>3400</td>
<td>14000</td>
<td>41100</td>
</tr>
<tr>
<td>Co ppm</td>
<td>48</td>
<td>32.3</td>
<td>48</td>
<td>119</td>
</tr>
<tr>
<td>Cu ppm</td>
<td>72.8</td>
<td>46</td>
<td>72.8</td>
<td>273</td>
</tr>
<tr>
<td>Eu ppm</td>
<td>1.2</td>
<td>0.6</td>
<td>1.2</td>
<td>2.7</td>
</tr>
<tr>
<td>F ppm</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fe ppm</td>
<td>5200</td>
<td>51400</td>
<td>88100</td>
<td>16900</td>
</tr>
<tr>
<td>K ppm</td>
<td>100</td>
<td>762</td>
<td>1300</td>
<td>2400</td>
</tr>
<tr>
<td>Mg ppm</td>
<td>2200</td>
<td>2200</td>
<td>5700</td>
<td>13800</td>
</tr>
<tr>
<td>Mn ppm</td>
<td>8132</td>
<td>1030</td>
<td>1762</td>
<td>8132</td>
</tr>
<tr>
<td>Na ppm</td>
<td>800</td>
<td>200</td>
<td>400</td>
<td>800</td>
</tr>
<tr>
<td>Ni ppm</td>
<td>98.4</td>
<td>60.4</td>
<td>98.4</td>
<td>850</td>
</tr>
<tr>
<td>P ppm</td>
<td>589</td>
<td>589</td>
<td>1130</td>
<td>2930</td>
</tr>
<tr>
<td>Pb ppm</td>
<td>82</td>
<td>24.8</td>
<td>37</td>
<td>82</td>
</tr>
<tr>
<td>PGE ppm</td>
<td>0.2537</td>
<td>0.252</td>
<td>0.252</td>
<td>0.2537</td>
</tr>
<tr>
<td>REE ppm</td>
<td>210.51</td>
<td>210.51</td>
<td>210.51</td>
<td>228.67</td>
</tr>
<tr>
<td>S ppm</td>
<td>1100</td>
<td>200</td>
<td>400</td>
<td>1100</td>
</tr>
<tr>
<td>Sb ppm</td>
<td>3.9</td>
<td>0.79</td>
<td>1.26</td>
<td>3.9</td>
</tr>
<tr>
<td>Si ppm</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>U ppm</td>
<td>1.53</td>
<td>1.53</td>
<td>2.99</td>
<td>8</td>
</tr>
<tr>
<td>W ppm</td>
<td>0.2</td>
<td>0.09</td>
<td>0.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Zn ppm</td>
<td>270</td>
<td>80</td>
<td>109</td>
<td>270</td>
</tr>
</tbody>
</table>
Curnamona modelling results
Koonenberry modelling results
Predictive maps – diamonds in the rough
Geochemical maps

- Use stream seds, rock chips and whole rocks analyses.
- Cleaned and levelled stream sed data (a first for NEO).
- Each layer is a useful synthesis of data, often tens of thousands of data points.
- Example: stream sed Bi.
Fault bends

- Interpretation of seamless fault attribution map.
- Example: fault bends.
- Correlation with IR training points poor as most fault beds are in terranes away from contemporaneous granite formation.
Competency contrast

- Around granite contacts, adjacent faults, major rock boundaries.
- Sent to IR Au model.
- Can be modified or used for other models.
Gravity worms

• Magnetic worms map geological contacts that could represent faults or granite boundaries.

• Select worms with Cont_ht = 11 944.

• Buffer 10 km at 100 m intervals around worms using Spatial Analyst distance buffer tool.

• Tested with training data – included in IR Sn-W model (migration to trap).
Data delivery & going undercover
**Data Delivery – reports, shape files, spatial data tables**

**NSW Geological Survey**
- Provide simple yet robust predictive maps to inform land use planning.
- Distil mineral system knowledge, expressed spatially.
- Improve data quality - shows data gaps (quality and coverage).

**Explorers**
- New to the province.
- Want to test new ideas.
Check out MinView!

Fault dip orientation

Faults, from the NEO Fault attribute database, with a west, northwest or southwest dip direction, buffered to 4500m (flinnswest4500).

Opacity 33

Legend
- Indicative
Predictive mapping – moving mineral potential under cover

- How much and what type of data is needed to inform meaningful potential mapping under cover?
- What proxies can be used undercover?
- Training of systems using legacy drill coverage in combination with new geophysics in Cobar.
Predictive mapping – moving mineral potential under cover
Predictive mapping – moving mineral potential under cover
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