Discovery of the West Musgrave Ni-Cu-PGE Sulphide District

Jon Hronsky
CET Discovery Day
February 24, 2015
Acknowledgements

- Success in modern mineral exploration effort is inevitably the result of a team effort involving many people

- In particular, I would like to acknowledge the following:
  - The WMC project exploration team, in particular Project Leader Rob Waugh, geochemist Phil Baker and Geophysicist Andrew Boyd
  - The support of WMC Exploration Management for persisting with this project even though it did not “fit the mould”, particularly Dave Miller who could also see the new paradigm after Mabo
  - The support of John Simmonds (WMC Ni specialist) in the model development process
  - The BHP Billiton MinEx team who successfully extended the camp

- BHP Billiton are thanked for permission to reproduce figures from old WMC reports
External Context: Three Critical Events

- 1989 Berlin
- 1992 Canberra
- 1994 Labrador
Ramifications (1): 1989 - Fall of Communism

- First Western access to the giant, very rich Noril’sk NiS camp
- Broadening of the WMC perspective on NiS deposits – previously entirely WA Komatiite focused
- Russian dumping of scrap Ni metal depressed market and effectively derailed WMC Ni growth strategy built around development of Mt Keith
- Strategic perspective developed that Ni prices would stay low for a long time or decline further and only option was discovering next major NiS camp; strong fear that whoever did this first would then totally dominate world Ni market
- Significant resources allocated to developing target model to find the next Noril’sk
- Globalisation of the Western world exploration industry which taught industry need for, and skills required to, negotiate land access in challenging environments.
Sulphate-rich Footwall sequence

1992-1993:
Noril’sk Analogue Targeting Model Developed
Emphasised Flood Basalts overlying Sulphate-Rich Evaporites
Essentially adaptation of existing Kambalda sulphide assimilation models

(Diakov et al, 2002)
Ramifications (2): 1992 - Mabo Decision

- With the 1992 High Court decision against Terra Nullius and in favour of Eddie Mabo the land-access environment for exploration in Australia changed forever.
- One, possibly unexpected consequence was a perception that the relative risk between Aboriginal Free-hold land and Crown Law land had been inverted.
- Previously Aboriginal Free-hold was considered a total “No-Go” for explorers.
- After Mabo, it started to look just the same as any of the many developing countries explorers were operating in, with the advantage over much of the rest of Australia that traditional ownership was clear.
Ramifications (3): 1994 - Discovery of Voisey’s Bay

- Created an internal ‘shock” within WMC when implications fully recognised in mid 1995.
- Represented the feared major discovery that would deliver Ni industry dominance to a competitor
- Was in a terrane that had not even been recognised as possibly prospective during a major global NiS targeting effort by WMC
- Had no resemblance to the Noril’sk Analogue model driving WMC Ni exploration
- Was associated with host rocks (Troctolites) that no-one in the NiS academic community had considered prospective
- First knee-jerk response by some WMC Exploration Management was to call for the development of a Voisey’s Bay Model to replace the Noril’sk Model (classic “Availability Bias” behaviour)
- Fortunately, instead we were able to do something a bit more innovative
Development of a New Paradigm

- Over the period 1993-1995 a new perspective on NiS targeting was developed at WMC’s Kalgoorlie office

- It was recognised, first for Yilgarn Komatiite systems and then for Mafic-intrusion systems, that the most important controls were:
  1. Lithospheric Architecture
  2. Evidence for focused magma flux

- It was realised that these were generic attributes, *not* dependant on the details of particular deposit models

- It was also realised that these critical targeting ingredients (unlike the parameters of detailed deposit models) might be able to be interpreted from commonly available regional geoscientific data-sets
<table>
<thead>
<tr>
<th>Catalogue No</th>
<th>Item Type</th>
<th>Title</th>
<th>Author</th>
<th>Item Date</th>
<th>Document No</th>
</tr>
</thead>
<tbody>
<tr>
<td>87343</td>
<td>MEMO</td>
<td>FROM JON HRONSKY TO THOSE CONCERNED: NiS TARGETING IN THE WESTERN MUSGRAVE BLOCK OF WESTERN AUSTRALIA</td>
<td>HRONSKY J</td>
<td>22 AUG 1996</td>
<td>XBT96-211</td>
</tr>
<tr>
<td>67016</td>
<td>MEMO</td>
<td>J.M.A. HRONSKY TO D.R. MILLER: MAGMATIC NICKEL SULPHIDE TARGETING IN WA: CURRENT STATUS AND FURTHER WORK REQUIRED</td>
<td>HRONSKY J M A</td>
<td>01 NOV 1995</td>
<td>XKG95-130</td>
</tr>
<tr>
<td>57156</td>
<td>MEMO</td>
<td>J.M.A. HRONSKY TO D.R. MILLER: A PROPOSED REGIONAL CONCEPTUAL AND TARGETING MODEL FOR KOMATIITE-ASSOCIATED NICKEL SULPHIDE DEPOSITS (RP274)</td>
<td>HRONSKY J M A</td>
<td>02 NOV 1994</td>
<td>XKG94-122</td>
</tr>
</tbody>
</table>
1994: The First Step
Recognition that Eastern Yilgarn Komatiite NiS deposits were controlled by an inherited rift architecture we could see in geology and gravity

Hronsky (1994)
1994:
Rift Inversion Model for Komatiites

Hronsky (1994)
1995: First “Craton-Margin” NiS Targeting in WA

- The first “craton-margin” style regional interpretation and targeting was carried out in WA in 1995
- Key Model Ingredients:
  - Area of complexity and/or intersection along “craton margin”
  - Evidence for focused mantle-derived magma flux (volume, differentiation)
  - Evidence for major, deep-seated paleo-magma chamber (based on gravity)
- The West Musgrave area (western end of the Giles Complex) emerged as the most obvious area, apart from the East Kimberly which was already known to host Mafic-Intrusion NiS but considered mature
- Previously tight internal “model discipline” focused on direct Noril’sk analogues was relaxed after the discovery of Voisey’s Bay
- The (largely internal) challenges of the totally new process of negotiating access to Aboriginal free-hold land delayed the start of active exploration on this project for some time
- In the interim, a lower priority target, the Pleiades Lakes project was acquired associated with a zone of local complexity along the SE Yilgarn craton margin
- Although no Ni encouragement was obtained, in 1997 a major regional Au anomaly was discovered at Pleiades Lakes. However, WMC management did not support pursuing this. This anomaly ultimately led to the Tropicana discovery.
Reconstruction of First “Craton-Margin” Interp of Gravity Data in 1995
Pleiades Lakes Project (Later Tropicana)
West Musgrave Project Area (in 2002, so somewhat expanded after the discovery)
West Musgrave Project
WMC Current Tenement Holdings

- WMC Granted tenements
- WRF Securities JV

Hronsky (2003)
Conceptual “Problems” with the West Musgrave Target

- The validity of the West Musgrave targeting concept was not fully accepted internally throughout WMC until the Babel-Nebo discovery

- Major concerns were:
  - The absence of any sulphidic country rocks
  - The general historical perception that the Giles Complex was not prospective for NiS
  - The perception of a deeply eroded, deep-crustal setting that was not prospective (cf generally near- paleo surface context of most other well-known NiS deposits)
Prospects for the Giles Complex having potential for magmatic chromite–sulphide–PGE mineralisation are considered to be limited, as these intrusions have important differences from economically important complexes such as the Bushveld, Great Dyke or Stillwater intrusions (cf. Naldrett et al. 1986).
1996: A more detailed focus on the West Musgrave Region and the significance of the Mundrabilla Corridor.
West Musgrave Project History (1995-2000)

- 1995: Regional targeting
- 1996: Tenement Acquisition
- 1998-1999: Reconnaissance Geophysics and Geochemistry
- June 1999: Babel geochemical anomaly located
- Aug-Dec 1999: Follow up at Babel & Nebo; Coincident EM anomalies defined; Babel gossan (an extremely small subcrop) located by Rob Waugh
- April 2000: Discovery hole – diamond drill testing of EM anomaly at Nebo (followed immediately) by first drill hole at Babel
Babel-Nebo Area looking towards the Jameson Range
Fig. 2. Previously mapped outcrop from a 900 km² area (Daniels 1971).
Fig. 4. Ni in broad spaced definition lag samples from a 900 km² area.

Fig. 5. Cu in broad spaced definition lag samples from a 900 km² area.

Baker & Waugh (2005)
Fig. 3. Ni versus Cu in 1747 deflation lag samples collected where possible on an approximate 1 km × 0.5 km grid covering an area of 1100 km².

Table 2. Babel deposit deflation lag discovery samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ni (ppm)</th>
<th>Cu (ppm)</th>
<th>Cr (ppm)</th>
<th>Pt (ppb)</th>
<th>Pd (ppb)</th>
<th>Au (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD024009</td>
<td>547</td>
<td>662</td>
<td>131</td>
<td>27</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>GD024011</td>
<td>566</td>
<td>950</td>
<td>97</td>
<td>11</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

Baker & Waugh (2005)
Babel Gossanous Float
(Hronske 2003; photo by R.Waugh)
First Drilling – April 2000
WMND 4: Discovery Hole
26.55m @ 2.46% Ni, 1.78% Cu, 0.38 g/t PGE

Andrew Boyd, Rob Waugh
First Set of Significant Intersections Reported to ASX – Nebo

<table>
<thead>
<tr>
<th>Hole ID</th>
<th>Width(m)</th>
<th>Ni (%)</th>
<th>Cu(%)</th>
<th>Pd + Pt (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMND 4</td>
<td>26.55</td>
<td>2.45</td>
<td>1.78</td>
<td>0.38</td>
</tr>
<tr>
<td>(Discovery Hole)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WMN 11</td>
<td>21.60</td>
<td>2.04</td>
<td>1.05</td>
<td>0.35</td>
</tr>
<tr>
<td>WMN 23</td>
<td>9.5</td>
<td>1.20</td>
<td>0.67</td>
<td>0.16</td>
</tr>
<tr>
<td>WMN 24</td>
<td>11.38</td>
<td>1.25</td>
<td>0.36</td>
<td>0.28</td>
</tr>
<tr>
<td>WMN 62</td>
<td>16.70</td>
<td>1.25</td>
<td>0.75</td>
<td>0.17</td>
</tr>
<tr>
<td>WMN 63</td>
<td>32.6</td>
<td>0.83</td>
<td>0.74</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Hronsky (2003)
# First Set of Significant Intersections Reported to ASX – Babel

<table>
<thead>
<tr>
<th>Hole ID</th>
<th>Width(m)</th>
<th>Ni (%)</th>
<th>Cu(%)</th>
<th>Pd + Pt (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMND 7 (Discovery Hole)</td>
<td>148.9</td>
<td>0.30</td>
<td>0.42</td>
<td>0.29</td>
</tr>
<tr>
<td>WMN 1001</td>
<td>105.00</td>
<td>0.31</td>
<td>0.33</td>
<td>0.20</td>
</tr>
<tr>
<td>WMN 1006</td>
<td>41.30</td>
<td>0.34</td>
<td>0.36</td>
<td>0.26</td>
</tr>
<tr>
<td>WMN 1015</td>
<td>15.36</td>
<td>0.64</td>
<td>0.32</td>
<td>0.19</td>
</tr>
<tr>
<td>WMN 1016</td>
<td>5.50</td>
<td>3.12</td>
<td>0.35</td>
<td>0.89</td>
</tr>
<tr>
<td>WMN 1031</td>
<td>21</td>
<td>0.8</td>
<td>1.4</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Hronsky (2003)
Schematic Plan of Nebo & Babel Geology

Hronsky (2003)

Original gossan subcrop

Dolerite
Olivine Dolerite
Gabbro Norite
Leuco Gabbro Norite
Mineralised Leuco Gabbro Norite
Mineralised Gabbro Norite
Xenolithic Leuco Gabbro Norite
Mafic Body at depth
Intrusive Breccia

0  800 metres
3D Model of Babel - Nebo

Chonolith geometry recognised – similar to Noril’sk

Hronsky (2003)
WMC’s First Resource (2005)

- A resource estimated of 392 million tonnes at 0.3% nickel, 0.3% copper and 0.18 g/t PGE (> 1 Mt Ni metal) was published by WMC in 2005 as part of its Part B response to the Xstrata take-over.

- However, like any large deposit this simply represented one chosen point on a tonnes-grade curve.
BHP Billiton expands the Camp (2005-2011)

- BHP Billiton acquired WMC Resources in 2005
- West Musgrave becomes a key project in portfolio of BHB Billiton’s global mineral exploration group
- Subsequent infill drilling:
  - Babel – 200 x 200m and 200 x 400m
  - Nebo – 200 x 200m
- Major phase of regional exploration in 2009, driven by regional air-core reconnaissance geochemical drilling and high-power ground EM surveying
- Significant new prospects discovered at Yappsu, and subsequently Esagila and Succoth
- Interestingly, Succoth, Esagila and several other prospects were associated with a different, probably earlier, intrusive event that has higher Cu/Ni ratios than the Babel-Nebo-Yappsu system
- Succoth in particular was recognised as a significant discovery and significant follow up drilling carried out in 2010-2011
Now a 20 km long mineralised intrusive complex
Cassini takes the project forward (2014 >)

- Following a change of corporate strategy, BHP Billiton divested the West Musgrave project to Cassini Resources in April 2014
- Cassini subsequently implemented a strategy during 2014 of:
  - Defining and validating a high-grade resource at Nebo and Babel with infill drilling, to support immediate mine development
  - Following up the large regional-scale exploration potential of the camp, starting at Succoth – a major body of mineralisation with very limited drilling
- Highlights of the Cassini 2014 program include:
  - Discovery of a new high-grade ore position (the Sugar Lode) on the northern margin of the Nebo intrusion
  - Intersection of previously unknown high-grade “Nebo-style” mineralisation at Babel (CZC129; 18m @ 1.52% Ni, 1.50% Cu) – follow up required in 2015
  - Significant mineralisation intersected at Succoth in late 2014, including 8m of massive sulphide, confirming the significance of this system
In April 2014, Cassini released a JORC (2012) compliant resource for Babel-Nebo, based on previous BHP Billiton drilling.

Importantly, for the first time a higher-grade resource was reported at a 0.5% Ni cut off grade.

### Nebo-Babel Inferred Resource Estimate (JORC 2012)

<table>
<thead>
<tr>
<th>Prospect</th>
<th>Cut-off Ni%</th>
<th>Mt</th>
<th>Ni%</th>
<th>Cu%</th>
<th>As ppm</th>
<th>Co ppm</th>
<th>Fe %</th>
<th>MgO %</th>
<th>S %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nebo</td>
<td>0.2</td>
<td>84</td>
<td>0.39</td>
<td>0.31</td>
<td>3</td>
<td>153</td>
<td>9.5</td>
<td>5.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Babel</td>
<td>0.2</td>
<td>362</td>
<td>0.32</td>
<td>0.36</td>
<td>3</td>
<td>118</td>
<td>9.9</td>
<td>7.8</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.2</strong></td>
<td><strong>446</strong></td>
<td><strong>0.33</strong></td>
<td><strong>0.35</strong></td>
<td><strong>3</strong></td>
<td><strong>125</strong></td>
<td><strong>9.9</strong></td>
<td><strong>7.4</strong></td>
<td><strong>2.2</strong></td>
</tr>
<tr>
<td>Nebo</td>
<td>0.5</td>
<td>15.9</td>
<td>0.82</td>
<td>0.48</td>
<td>3</td>
<td>323</td>
<td>14.2</td>
<td>3.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Babel</td>
<td>0.5</td>
<td>17.3</td>
<td>0.64</td>
<td>0.70</td>
<td>3</td>
<td>196</td>
<td>12.9</td>
<td>6.0</td>
<td>4.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.5</strong></td>
<td><strong>33.2</strong></td>
<td><strong>0.73</strong></td>
<td><strong>0.59</strong></td>
<td><strong>3</strong></td>
<td><strong>257</strong></td>
<td><strong>13.5</strong></td>
<td><strong>4.9</strong></td>
<td><strong>5.0</strong></td>
</tr>
</tbody>
</table>
Cassini infill drilling at Babel-Nebo
Nebo – Status Nov 2014

NEBO DEPOSIT
DRILL COLLAR PLAN
AND MINERALISED ZONES

Legend
- Massive breccia sulphide
- Massive and disseminated sulphide
- Heavily disseminated sulphide
- Weakly disseminated sulphide
- Drill collar
- Extent of current low grade resource (0.2% Ni)

CZC0024
7m @ 0.99% Ni, 1.13% Cu

CZC0053
49m @ 0.98% Ni, 0.53% Cu

CZC0029
8m @ 2.23% Ni, 1.57% Cu

CZC0015
28m @ 1.38% Ni, 0.87% Cu

CZC0018
23m @ 0.88% Ni, 0.89% Cu

CZC0047
8m @ 1.28% Ni, 0.78% Cu

CZC0050
5m @ 1.13% Ni, 0.30% Cu

CZC0065
35m @ 1.54% Ni, 1.04% Cu

CZC0038
34m @ 1.32% Ni, 1.11% Cu

CZC0042
25m @ 0.65% Ni, 0.51% Cu

CZC0067
17m @ 0.46% Ni, 0.65% Cu

CZC0061
13m @ 0.91% Ni, 0.67% Cu

DISCOVERY HOLE
WMND4
26.55m @ 2.45% Ni, 1.78% Cu

CZI ASX Release – 24 Nov 2015
Nebo cross-section

NEBO DEPOSIT
SECTION 371800mE
GEOLOGICAL INTERPRETATION AND RESULTS

CZI ASX Release – 5 Nov 2014
Babel – Status Jan 2015

Legend
- Red: Matrix and heavily disseminated sulphide
- Pink: Heavily disseminated sulphide
- Yellow: Weakly disseminated sulphide
- Black: Drill collar
- Orange: Extent of current low grade resource (0.2% Ni)

BABEL DEPOSIT
DRILL COLLAR PLAN
AND MINERALISED ZONES

Section

CZI ASX Release – 21 Jan 2015
Succoth Deposit

Succoth Prospect Geological Plan

CZI ASX Release – 16 Dec 2014
Succoth cross-section

Succoth Prospect
Section 102 100mN
Geological Interpretation and Results

CZI ASX Release – 16 Dec 2014
Key Learnings

- Be wary of analogue targeting models – focus on fundamental process and the entire system
- Architecture and related focused energy flux trumps everything else
- It is all about creating a new exploration search space
- What seems like a major problem (eg Mabo) may turn out to be an opportunity
- Remember that greenfields discovery can grow over time into major camps – think about the option value