Airborne Electromagnetics for definition of manganese mineralisation: a case study in the Eastern Pilbara region, Western Australia
Consolidated Minerals Limited (“CML”) is an independent private company incorporated in Jersey. CML is a manganese and chromite ore producer with operations in Australia and Ghana, complemented by a trading-arm based in Singapore.

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Contents

- Previous work
- Case study area
  - Location + design
  - AEM system specifications
  - Data profiles and channel grids
  - CDI processing
- Conclusions
Location

- Woodie Woodie Manganese mine is located in the East Pilbara region of Western Australia.

- The mine consists of approximately 100km$^2$ of mine corridor and 5500km$^2$ of greenfields area outside of this corridor.

- Pilbara Manganese supplies high-grade ore to the international steel industry.
Stratigraphy

- Manganese in the Woodie Woodie region is hosted by Carawine Dolomite, chert breccia, and the overlying Manganese Subgroup sedimentary rocks.

- Orebodies show a range of orientations, from stacked bedding-parallel lenses (stratabound) to steeply dipping or plunging bodies (fault hosted).

- Average deposit size is 0.5Mt (0.2 – 5.5Mt), generally 50-100m wide, 100-600m long and deepest ore zones extend 200m below surface (open at depth).

From Jones, 2011
Physical Properties

- Manganese (Mn) is often conductive compared to host rocks
  - Chert and dolomite are resistive
  - Permian clays and Jeerinah formation black shales are conductive and must be accounted for during processing/interpretation

- Conductivity response related to mineralisation can depend on Mn mineral type, grade and iron content
Initial AEM Surveying

- A HoisTEM survey was flown by GPX surveys over the Woodie Woodie mine corridor in 2002
  - Discrete targets were interpreted and a number tested by drillholes
  - Chris D deposit was an EM discovery – mineralisation below 30-50m of conductive cover

- AEM surveys were flown over regional project areas based on the success of targets from the HoisTEM survey
Case Study Area Location

- Bee Hill
  - Regional project area
  - Approximately 60km SW of Woodie Woodie mine

- Case study area chosen based on detailed geological mapping, previous drilling and geophysical surveying
Case Study Area
Geology
Case Study Area
AEM Systems

- Three heli-borne AEM systems were flown over the case study area
  - RepTEM in May 2008 by GPX Surveys
  - VTEM in May 2009 by Geotech Airborne
  - XTEM in November 2009 by GPX Surveys
### Case Study Area

#### System Specifications

<table>
<thead>
<tr>
<th></th>
<th>RepTEM</th>
<th>VTEM (12)</th>
<th>XTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moment (Am²)</td>
<td>112 000</td>
<td>400 000</td>
<td>102 000</td>
</tr>
<tr>
<td>Duty Cycle (%)</td>
<td>25</td>
<td>36.7</td>
<td>25</td>
</tr>
<tr>
<td>Waveform shape</td>
<td>Square</td>
<td>Trapezoidal</td>
<td>Square</td>
</tr>
<tr>
<td>Ramp Off (µs)</td>
<td>40</td>
<td>1340</td>
<td>45</td>
</tr>
<tr>
<td>Data Channels</td>
<td>21</td>
<td>28 (35*)</td>
<td>30</td>
</tr>
<tr>
<td>Along line sampling (m)</td>
<td>9</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

- Historically, systems with resolution in the early times were considered ideal for near-surface, moderately conductive bodies.

- New geology model suggested deeper bodies and structural relationship important.
Case Study Area
Survey Specifications

- Flight line direction for all systems was E-W, perpendicular to geology and structures of interest
- Line spacing was determined for each system based on the transmitter parameters and resolution of manganese targets
  - 80m for RepTEM and XTEM
  - 100m for VTEM
- Traditionally, AEM systems measure the time rate of change of the magnetic field (dB/dt) = RepTEM and XTEM
- VTEM calculates the B-field data from dB/dt, equivalent to a direct measurement of the magnetic field
Case Study Area
Prospect of Interest

-38000m
-39000m
L2740 RepTEM
L19940 VTEM
L40100 XTEM
-40000m
-19000m
-20000m
-21000m
-22000m
500m
N
13
Case Study Area
Data Profiles

RepTEM

XTEM
Case Study Area
Data Profiles

VTEM B-field - original

VTEM B-field - reprocessed
Case Study Area
Channel Grids

- Each time channel was gridded for the three systems, including both B-field and dB/dt, original and reprocessed data for the VTEM survey
  - Earliest time channel available (not noise)
  - Mid-time channel
  - Latest time channel (before signal over-ridden by noise)
Case Study Area
Conductivity Depth Imaging

- EM data from each system was inverted using EMFlow software to produce a conductivity depth model
- Equivalent lines from each system windowed to the prospect of interest are presented
  - L2740 RepTEM
  - L19940 VTEM
  - L40100 XTEM
Case Study
Drilling

Proterozoic shale with Mn ± Fe

7m @ 32% Mn, 20% Fe
4m @ 37% Mn, 19% Fe

Chert/highly silicified dolomite

21m @ 32% Mn, 19% Fe
10m @ 39% Mn, 16% Fe

CDI anomaly outline

50m
Fig Tree – a quick comparison

- Project area approximately 40km South of Woodie Woodie mine
- VTEM survey flown in 2009 using 100m line spacing with lines oriented perpendicular to major structures and lithology trends

- Dominantly resistive host geology, dB/dt and B-field responses very similar
Conclusions

- Three time domain airborne EM systems flown over a case study area with known manganese mineralisation
- Each system showed a discrete anomalous response in channel time data and a conductor in the CDI related to Mn
- High signal to noise and the B-field option of the VTEM system provides an advantage over traditional dB/dt systems
  - shows target into late time channels when conductive overburden response has decayed
- Geology of the survey area should be considered when targeting Mn using AEM
  - Conductive overburden = B-field data for target discrimination
  - Dominantly outcropping resistive geology = dB/dt data provides reasonable targets