Airborne electromagnetics in Pilbara manganese exploration
A case study

Adrian Noetzli, Mark Lowe, Joe Kita, Nataya Kusumaputri, Trevor Saul
Introduction

- History
- Geology
- Airborne EM test survey and results
- Complete tenement survey and results
Airborne electromagnetics in Pilbara manganese exploration
A case study

Butcherbird Tenement

Butcherbird

Newman

~100km
Airborne electromagnetics in Pilbara manganese exploration
A case study

Butcherbird History

[Map showing Butcherbird Copper and Ilgararie Copper with the period 1913-1970's highlighted]
Airborne electromagnetics in Pilbara manganese exploration
A case study

Butcherbird History

BHP
- High grade Mn in gravel pits
- Mapping and sampling
- No drilling
- 15-20m tonnes sub economic Mn

Ilgararie Hill

Yanneri Ridge
Airborne electromagnetics in Pilbara manganese exploration
A case study

Butcherbird History

Alcoa
- drill hole to 350m
- 102m @ 8.3% Mn from surface
Airborne electromagnetics in Pilbara manganese exploration
A case study

Butcherbird History

2002 - 2009

Pilbara Manganese
- 7 EL
- Structural Analysis
- Hyperspectral mapping
- Geological mapping
- Rock chip sampling
- Digging of four test costeans
- Magnetic surveys
- No drilling
- Low probability of large tonnage, high grade Mn deposit
Airborne electromagnetics in Pilbara manganese exploration
A case study

Butcherbird History
Airborne electromagnetics in Pilbara manganese exploration
A case study

Butcherbird Manganese
Airborne electromagnetics in Pilbara manganese exploration
A case study

Yanneri Style MnO Mineralisation

High grade (40%+ MnO) surface expression

MnO sheets 2cm-20cm thick
Clay oxide bands up to 20m thick
Shale containing Mn and silicates

Water table
Montezuma’s Objective

Knowns
- MnO at surface
- Drilled two main areas and found more below surface
- Shallow target
- MnO is a conductor

Unknowns
- Extent of the MnO below surface
- Will airborne EM work for this area?

Let’s do a trial survey!!
Which Airborne EM System for this Area?

- **Vertical Resolution**
  - (ie High Bandwidth)

- **Spatial Resolution**
  - (ie Low Flying & Light Filtering)

- **Depth**
  - (ie Power)

**Skytem**

**Reptem**

**Xtem**

**VTEM**

Image courtesy of A. Boyd (IGS) 2009
Airborne electromagnetics in Pilbara manganese exploration
A case study

What is XTEM?

In-loop time-domain system

Transmitter
- Square wave
- 5mS on-time 15mS off-time
- Tx Frequency 25 Hz (or 30Hz)
- 325 square metre Tx loop
- Max current 300 Amp
- Moment NIA 103200 Am²
Airborne electromagnetics in Pilbara manganese exploration
A case study

What is XTEM?

**Receiver**
- Measures dB/dZ
- Bandwidth up to 20kHz
- Spherics rejection
- North West Cape rejection
- 50Hz/60HZ noise rejection

**Final data**
- DEM, Magnetics, 30 Channel EM, CDI and pseudo depthslices
- Sample rate 9-10m
Airborne electromagnetics in Pilbara manganese exploration
A case study

Phase 1 - Butcherbird Test Area

Survey specifications

• Line direction 063-243°
• Line spacing 100m
• Number of lines 7

• Line direction 130-310°
• Line spacing 100m
• Number of lines 7

• Total planned distance 245km
Airborne electromagnetics in Pilbara manganese exploration
A case study

Test Results

Channel 15 (629-729 µSec)
Airborne electromagnetics in Pilbara manganese exploration
A case study

Test Results

Line 20040 EmaxAir CDI with approximate drill hole locations
Test Conclusions

- Airborne EM confirms first pass drilling
- Couple of blind discoveries?
- Let’s fly more!!!
Airborne electromagnetics in Pilbara manganese exploration
A case study

Phase 2 – Complete Butcherbird Survey
(Perpendicular to strike)

Survey specifications

• Traverse line direction 000-180°
• Line spacing 200m
• Number of lines 102

• Tie line direction 090-270°
• Line spacing 2000m
• Number of lines 9

• Total planned distance 1018.7km

(Based on test results)
Airborne electromagnetics in Pilbara manganese exploration
A case study

What does a Butcher bird look like?

“They get their name from their habit of impaling captured prey on a thorn, tree fork, or crevice.”
Airborne electromagnetics in Pilbara manganese exploration
A case study

Survey Results

Magnetic Data

Channel 15 (629-729 µSec)
Airborne electromagnetics in Pilbara manganese exploration
A case study

Survey Results

20m Pseudo Depthslice

Channel 15 (629-729 µSec)
Airborne electromagnetics in Pilbara manganese exploration
A case study

Survey Results

40m Pseudo Depthslice

Channel 15 (629-729 µSec)
Airborne electromagnetics in Pilbara manganese exploration
A case study

Survey Results

Channel 15
Airborne electromagnetics in Pilbara manganese exploration
A case study

Survey Results

L1530 CDI

Drainage

Channel 15
Airborne electromagnetics in Pilbara manganese exploration
A case study

Survey Results

L1530 CDI

Drainage

L1420 CDI

Channel 15

L1420

???

Mn

Mn

Mn
Airborne electromagnetics in Pilbara manganese exploration
A case study

2011 Drilling Program

Channel 15 with drill holes completed in 2011 (black)
Airborne electromagnetics in Pilbara manganese exploration
A case study

2011 Drilling Program (Yanneri Ridge & Coodamudgi)

Channel 15 with drill holes
Airborne electromagnetics in Pilbara manganese exploration
A case study

Profile of Line 1420 with Mn Resources
Airborne electromagnetics in Pilbara manganese exploration
A case study

Profile of Line 1420 with Mn Resources

Yanneri Ridge
Coodamudgi
Illgararie Ridge
Airborne electromagnetics in Pilbara manganese exploration
A case study

Profile of Line 1420 with Mn Resources

Yanneri Ridge
Coodamudgi
Illgararrie Ridge

Graphitic shale
Airborne electromagnetics in Pilbara manganese exploration
A case study

Bonus: signal strength anecdotally correlates to resource grade.
## Resource Estimates (using 10% cut-off)

<table>
<thead>
<tr>
<th>Deposit</th>
<th>JORC Estimate (Mt)</th>
<th>Mn (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bindi Bindi Hill</td>
<td>8.75</td>
<td>11.09</td>
</tr>
<tr>
<td>Budgie Hills</td>
<td>1.03</td>
<td>10.82</td>
</tr>
<tr>
<td>Cadgies Flats</td>
<td>0.25</td>
<td>11.08</td>
</tr>
<tr>
<td>Coodamudgi</td>
<td>12.9</td>
<td>11.48</td>
</tr>
<tr>
<td>Illgararie Ridge</td>
<td>17.0</td>
<td>10.71</td>
</tr>
<tr>
<td>Mundawindi</td>
<td>14.2</td>
<td>12.23</td>
</tr>
<tr>
<td>Richies Find</td>
<td>16.1</td>
<td>11.56</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td><strong>70.2</strong></td>
<td><strong>11.4</strong></td>
</tr>
<tr>
<td>Yanneri Ridge</td>
<td>48.8</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>GLOBAL TOTAL</strong></td>
<td><strong>119.0</strong></td>
<td><strong>11.6</strong></td>
</tr>
</tbody>
</table>

*Reported exploration target est. 410kt – 780kt DSO @ 40-42% Mn*
Airborne electromagnetics in Pilbara manganese exploration
A case study

Yanneri Ridge Deposit and Mine Lease
Airborne electromagnetics in Pilbara manganese exploration
A case study

Line Spacing Comparison

200m Line Spacing (Channel 15)

400m Line Spacing (Channel 15)
Airborne electromagnetics in Pilbara manganese exploration
A case study

Line Spacing Comparison

200m Line Spacing (Channel 15)  600m Line Spacing (Channel 15)
Results and Conclusions

Before drilling
- Ground confirmation of EM anomalies
- Use EM to define drill pattern

After drilling
- Drill results correlate well with airborne EM data
- EM Channel 10-20 (328 – 1756 μSec) had best correlation
- MnO occurs in smaller discrete EM responses
- EM signal accentuation where shale and Mn are combined

Bonus
- Generally the manganese grade ∝ strength of EM response
- EM survey extends the known low-salinity water resource

EM SURVEY HAS BEEN KEY IN MAPPING THE EXTENT OF THE MANGANESE RESOURCES
Acknowledgements

Montezuma
• Trevor Saul
• Justin Brown

GPX Surveys
• Katherine McKenna