PATERNSON TEMPEST AEM SURVEY
Data Acquisition, Processing, and Inversion

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Onshore Energy and Minerals Division
PATERSON AEM SURVEY

Coverage 47 600 km²
Total Kilometres 28 200 line km
Line Spacing
Deposit Scale 200m 1000 m
Regional Scale 2000 m 6000 m
Line Direction North Paterson E-W
Line Direction South Paterson NE-SW
Infill Companies 5
Investment (approx) $4 million
Data Acquisition

TEMPEST – Fugro Airborne Surveys
fixed wing time domain system

[Flight Path Diagram]

- Aircraft Turn
- Field Processed Data supplied by contractor
- 1000m overfly

[Images of TEMPEST aircraft]
## Survey Timing

### Milestone

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Survey planning started</td>
<td>Jan-07</td>
</tr>
<tr>
<td>Flying commenced South Paterson</td>
<td>Oct-07</td>
</tr>
<tr>
<td>Flying completed South Paterson</td>
<td>Nov-07</td>
</tr>
<tr>
<td>Flying recommenced North Paterson</td>
<td>May-08</td>
</tr>
<tr>
<td>Flying completed North Paterson</td>
<td>Oct-08</td>
</tr>
<tr>
<td>Final data received from Contractor South Paterson</td>
<td>Jan-09</td>
</tr>
<tr>
<td>Final data received from Contractor North Paterson</td>
<td>Apr-09</td>
</tr>
<tr>
<td>Final data South Paterson</td>
<td>RELEASED</td>
</tr>
<tr>
<td>Final data North Paterson</td>
<td>RELEASED</td>
</tr>
<tr>
<td>Final data North Paterson</td>
<td>Apr-09</td>
</tr>
</tbody>
</table>
Purpose

*Provide geoscience data to encourage energy and mineral exploration in Australia*

<table>
<thead>
<tr>
<th>Feature</th>
<th>Paterson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to Basement</td>
<td>✓</td>
</tr>
<tr>
<td>Basement Structures</td>
<td>✓</td>
</tr>
<tr>
<td>Regolith Mapping</td>
<td>✓</td>
</tr>
<tr>
<td>Graphitic Units in the Basement</td>
<td>✓</td>
</tr>
<tr>
<td>Location and Morphology of Paleovalleys</td>
<td>✓</td>
</tr>
<tr>
<td>Hydrogeological Elements</td>
<td>✓</td>
</tr>
</tbody>
</table>

Detecting these geological features reduces exploration risk
Forward Modelling

Determining the probability of detection of a geological target

Model 1; Coolbro Sandstone overlain by the Rudall complex

This model had a low probability of detection ... BUT theoretically it was possible
Forward Models – Real Data

Geoscience Australia Layered Earth Inversion sections over surface geology

Surface Geology

Depth (m) below surface

Depth of investigation
Percent Data influence

Bottom Surface
No Data

Top Surface
Topography

The Truth is in the Drilling
AEM survey detects major unconformity

Paterson AEM survey directly detects major unconformity near Kintyre, WA

- the unconformity was anticipated to have a complex structural nature because of post-depositional tectonics; and
- reports indicated that the alteration zone at the unconformity may not have sufficient conductivity to be measured.

Evidence for the Coolbro–Rudall unconformity

AEM data were interpreted using an integrated approach incorporating the Geoscience Australia 1:100,000 Surface Geology of Australia map (Stewart, 2008), solid geology (Clift et al., 2010), publicly available drill hole logs (Roads, 2009) and the results of the layered earth inversion process developed by Geoscience Australia (GA LEI, Lane et al., 2004).

The investigation focused on areas where surface mapping indicated that the Coolbro–Rudall unconformity was expected to lie under cover.

Figure 3 shows GA LEI conductivity depth sections for three conservative 200m spaced flight lines proximal to the Coolbro–Rudall unconformity, as geologically mapped near the Kintyre uranium deposit, which lies about 4km offshore to the east.

The depth of investigation line, which normally measures an electromagnetic depth of several tens of metres, is below the data shown in these
Data Processing QA/QC

Data Fields
Flight path
Terrain Clearance
Altimeters
Noise Analysis
Statistics
Metadata
Logistics
Base Station Data
Communication

Nulls, level shifts, coherency, noise, interpretability....

Zero – high altitude noise analysis
Data Fields
Flight path
Terrain Clearance
Altimeters
Noise Analysis
Statistics
Metadata
Logistics
Base Station Data
Communication
Multiplots

They are used in QA/QC, to assess noise, pick basement conductors, viewing conductivity edges…..

Contiguous line by line assessment
Fit For Purpose

The accuracy, integrity and useability of AEM data are reliant upon

- flight height
- system geometry
- noise
- repeatability

The AEM data is of acceptable standard to be interpreted, inverted and manipulated
Induction Conductivity Logging

Feed into forward models
Ground truth AEM results
Use for geological interpretation

Inversion Profile
Conductivity Log Profile

Logged hole is proximal but not under flight line

Drill holes vs GA-LEI
Solves for conductivity and the unmeasured elements of the system geometry using the observed total field X and Z component data.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Phi_d$</td>
<td>Data misfit</td>
</tr>
<tr>
<td>TX Height</td>
<td>Transmitter height</td>
</tr>
<tr>
<td>TX Attitude</td>
<td>Transmitter attitude</td>
</tr>
<tr>
<td>$D_x$</td>
<td>In line horizontal sep</td>
</tr>
<tr>
<td>$D_z$</td>
<td>In line vertical sep</td>
</tr>
<tr>
<td>$R_p$</td>
<td>Receiver pitch in degrees</td>
</tr>
<tr>
<td>X and Z</td>
<td>Window Amplitude</td>
</tr>
<tr>
<td>GA-LEI</td>
<td>Section</td>
</tr>
</tbody>
</table>
Conductance

30 layer GA-LEI
Start Model 0.004 S/m
Reference model 0.004 S/m

Salt Lake

Coolbro Sandstone

Conductive
Resistive

Conductance 0 - 400 m

Line 30870
Line 41870

( siemens)
Both highlight the unconformity between the Coolbro Sandstone and Rudall Complex.

**EMFlow over 300m**
(provided by Fugro)

**GA-LEI**
30 layers over 500m

**GA-LEI**
30 layers over 200m
EMFlow and GA-LEI
Products

Phase 1 Contractor supplied
GA funded data Released 2009
Infill company funded data released April 2010

Logistics report
ASCII data
Multiplots with EMFlow
Gridded data

ERMmapper Grids

METADATA VIP for data exchange and archiving
Phase 2
GA LEI and enhance products
Released April 2010
ASCII Data Conductance
ASCII Data Elevation Slices
Grid Total Conductance
Grids Elevation slices (Sea Level)
Grids Depth Slices (Topography)
Geo-referenced GA LEI cross-sections
Geo-referenced Grid jpegs
AEM GO MAP
Report

Products

Depth slice grids
Depth of Investigation blanked out

Geo-referenced jpegs
GA LEI sections and grids for GIS packages

... and metadata
Airborne Electromagnetics Project

Overview
Under the Australian Government’s Onshore Energy Security Program, Airborne Electromagnetic (AEM) data are being acquired in areas considered to have potential for uranium or thorium mineralisation.

The surveys, which are part of the Airborne Electromagnetic Acquisition and Interpretation project, are designed to reveal new information about regions by acquiring the AEM data at line spacings of one to six kilometres over relatively large areas. The improved understanding of the regional geology resulting from the surveys will be of considerable benefit to mining and mineral exploration companies, who can obtain more detailed data over a specific area of interest by contributing additional funds to the acquisition cost.

As a result of reviews of AEM system capabilities and relevance to energy commodities, acquisition is directed principally at providing geophysical and inferred geological insights in areas considered to be prospective for unconformity-related and palaeochannel-hosted uranium.

As well as enhancing the search for uranium and other energy sources, the survey results will be relevant in exploration for a variety of commodities and other resources, including groundwater. The program is aimed at reducing exploration risk and promoting exploration activity. Three priority projects emerged from mineral systems analysis and discussions with the State and Northern Territory Geological Surveys. They are:

1. Paterson Province (Western Australia)
2. Pine Creek (Northern Territory)
3. Frome Embayment - Murray Basin (South Australia)

Status
The objectives and status of the three priority projects are:

Project 1 - Paterson Province, Western Australia
The Paterson project is centred on the Kintyre uranium deposit and covers much of the surrounding exposed and near surface Paleoproterozoic Era Rudall Complex which in the surrounding area is unconformably overlain by Neoproterozoic Era sediments of the Yeneena Basin.

Data availability
- Regional data for Paterson South TEMPEST AEM Survey consisting of one kilometre (west) and two kilometre (east) line spacings are available as a free data download from the Geoscience Australia Sales Centre.
- Regional data for Paterson North TEMPEST AEM Survey consisting of one kilometre, two kilometre and six kilometre line spacings are available as a free data download from the Geoscience Australia Sales Centre.
Acknowledgements

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