Byro Sub-basin hydrogeophysical investigation

A case study combining airborne EM, aeromagnetics and geophysical drillhole measurements

This survey was completed for a mining company which has requested to remain anonymous. They have kindly allowed us to present the data and results at this conference.
Survey Location

Shark Bay
Scope

- A large volume water resource was required for a mining development project.
- GPX Surveys was contracted to fly a regional time-domain electromagnetic and magnetic survey using their XTEM helicopter-borne system.
- A borehole geophysical and hydrological survey was undertaken by Global Groundwater correlated with the XTEM results into a layered earth model.
Regional Geology

Figure 3. Stratigraphy and palynological zonation for the Carnarvon Basin showing correlation with northern Perth Basin stratigraphy.

Objectives

- Determine the capabilities of the XTEM system for mapping conductivity variation caused by geology in the survey area.
- The extent and depth of resistive sandy aquifers.
- To see if conductivity variation can be used as a tool for salinity distribution modelling.
XTEM System

**Transmitter**
- Waveform: 25% duty cycle square wave
- Pulse on Time: 5 ms (inc. 1ms cosine ramp on)
- Pulse off Time: 15 ms
- Pulse Current: 300 Amps
- Switch on Ramp: 1 ms
- Switch off Ramp: 45 μs
- Tx Loop Area: 344 m²
- Tx NIA: 103,200
- Tx Frequency: 25 Hz

**Receiver**
- A-D Circuitry: 24 bit
- Sample Time: 0 – 13 ms
- Sampling: 512 Linear channels
- Windowed Data: 30 channels

**Receiver Coil**
- Effective NA: 10,000 Square Metres
- Bandwidth: 45,000 Hz
Nabighian, 1979
Conductivity of major rock types

Figure 1: Resistivity and conductivity of major rock units, variation is often a result of water content. The hashed area, right of the red line is undistinguishable to the XTEM system and is broadly considered resistive.
Test lines

- 3 lines chosen to traverse across and parallel to the strike of the syncline.
- Positioned to pass near geophysical logged wells.
Conductivity Depth Image (CDI) produced using eMaxAir.
Test lines – and drillhole conductivity comparison
Test line CDI produced using eMaxAIR.

Conductivity affects the Depth of Investigation (DOI) measured where D2 becomes invisible from D1 in a layered earth model.
Extension to the full survey area

- 1000m line spacing over the main area of interest.
- Total of 2612 line km’s surveyed with XTEM.
XTEM Channels

Channel 10 – 353 us centre/ 50 us width

Channel 27 – 6382 us / 1300 us width
Other datasets

a) 1VD Magnetics
b) TMI Magnetics
c) Gravity
d) Elevation
Magnetics – Depth-to-basement modelling

- No magnetic susceptibility measurements taken in hard-rock basement.
- Unrestrained inversion yields a depth-to-basement of >7000 m.
Global Groundwater geophysical bores and salinity bores

BLUE WELLS – 2010
RED WELLS - 2011
BLACK – historical, salinity sampling only
Conductivity modelling for geological layers

- Gathering conductivity variation from drillholes.
- Downhole measurements are correlated with the calculated XTEM conductivities to produce models of the conductivity distribution.
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The sandy aquifer formations have a low conductivity of ~100 MS/m.
Comparison XTEM with Conductivity logs – Line 1550
Conductivity / Depth comparison with drillholes
Conductivity distribution in the Wooramel Group

- Confidence in the model is related to change in XTEM depth-of-investigation and distance from well logs.
Salinity distribution calculated by XTEM conductivities and borehole measurements.

A linear ratio of between 0.58 and 0.64 has been found as a good approximation of a factor between TDI and conductivity. (McNeill, 2000)

Higher conductivities may decrease the reliability of this model.
Summary

Advantages

- The XTEM system effectively mapped conductivity variation and the extent of geological units in the near surface and led to salinity distributions.
- Basin-scale structure and new exploration areas could be visualised in a regional conceptual model.
- XTEM conductivities were used in identifying potential recharge zones on the flanks of the syncline.
- Speed and scale of acquisition and imaging. Ability to manipulate the line spacing/resolution during the survey.

Obstacles

- Effectiveness limited by highly conductive salts and shales in the near surface.
Thanks to the mining company which kindly allowed the data in this presentation to be displayed publicly.