Shoot first, ask questions later: application of seismic reflection to a greenfields zinc exploration project.

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SUMMARY

As exposed portions of premier Zn belts reach exploration maturity, targets become deeper and more challenging to explore. Explorationists are faced with having limited methods for effective deep exploration.

Seismic reflection is one method which can be used effectively to characterise geological targets at depth. Teck has applied seismic reflection at an early stage on several zinc exploration projects, including the greenfields Yalco Zn project.

Geophysical methods have been used to assess the structural architecture of the remote Yalco area, located within the highly prospective Emu Fault corridor. 2D Seismic reflection lines have been used in addition to potential field methods and magnetotellurics. The superior resolution of seismic reflection has allowed us to characterise the stratigraphy and map key structures in detail in order to validate a conceptual geological target. The preliminary interpretation of the seismic sections has confirmed favourable depths to host, and resulted in a re-evaluation of target locations.

Use of seismic reflection surveys at an early stage has the potential to reduce technical risk and increase the effectiveness of target testing.

Key words: seismic, zinc, greenfields

INTRODUCTION

In the search for giant Zn ore deposits, bold new strategies are required as exploration becomes deeper and more challenging. In well-endowed Zn belts, areas of good exposure generally have a high exploration maturity. New targets tend to be deep, or occur in covered terranes. The minerals industry has limited methods available to assist in identifying deep targets.

Seismic reflection is one method which can be reliably used in this new search space beyond 500 metres depth. Seismic has the added benefit of high spatial resolution, but the relatively high upfront cost involved can be a significant deterrent.

Province Endowment

The Carpentaria province of northern Australia boasts strong Zn endowment; six world-class Zn deposits, each containing greater than 10 million tonnes of contained zinc. The Sediment Hosted Massive Sulphide (SHMS) deposit style has been described by Large et al (2005). The Carpentaria deposits formed in the Paleo- to Meso-Proterozoic (1685 – 1570 Ma) within sag-phase sediments of the Isa superbasin.

Target characterisation

Significant SHMS deposits are expected to occur close to regionally significant fault systems (e.g. Emu fault), and to be associated with syn-sedimentary faulting, according to McGoldrick and Large (1998). The targeted host rock is a reduced carbonaceous and/or pyritic shale package.

Large et al (1998), showed that the giant McArthur River deposit sits within a sub-basin on the downthrown (western) side of a 2nd-order fault (Western Fault) which is west dipping. The host unit shows significant thickening against this syn-sedimentary fault, which is subordinate to the regionally-significant Emu fault.

Direct geophysical detection of SHMS deposits is challenging, particularly at depths beyond 500 metres. The geophysical signature is often ambiguous, and false-positives are common. An alternate path to discovery is to constrain the geological/structural setting, in order to define the most prospective sub-basins. This is done with the objective of generating a constrained target area to drill test.

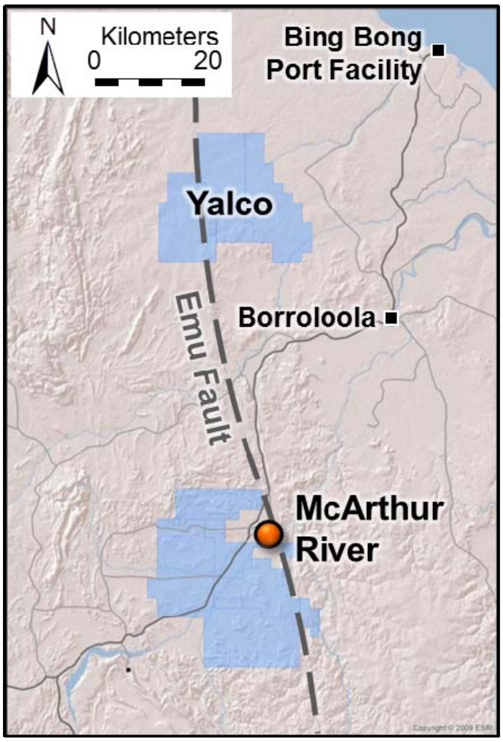

Figure 1: Location map showing the Yalco project in relation to the McArthur River Pb-Zn mine and the Teck Teena JV project area.

Yalco project overview

The Yalco project is an earn-in and joint venture agreement between Teck Australia Pty. Ltd. and Marindi Metals Ltd. The project area is located approximately 25km northwest of the town of Borroloola in the Northern Territory (Figure 1). The target deposit type is sediment-hosted massive sulphide (SHMS) Zn (+Pb, Ag), similar in style to the McArthur River deposit, which is located approximately 80 km to the southwest of Yalco. The project falls within the highly prospective Batten Trough, where units of the Proterozoic McArthur Group host multiple occurrences of stratiform Zn mineralisation.

The Yalco project has low exploration maturity, especially in the west of the project area near the North-trending Emu Fault zone. Here the fault splits into two sub-parallel limbs 2-4 kilometres apart. Exploration within the Emu corridor is expected to be difficult, as the depth to the target horizon is inferred to be at least 700 metres. Confirmation that the host package is within explorable depths is a key question at this early stage.

In order to assess the prospectivity of the Emu corridor, three transects were chosen for detailed investigation. (These are annotated in both Figures 2 and 3). Each of these transects crosses both limbs of the Emu fault corridor. The oblique line in the North is oriented to also cross the Northeast-trending Pine Creek fault zone. The project was also previously covered by detailed aeromagnetic and ground gravity surveys.

Geophysical methods have been used to assess the architecture of the sub-basin within the Emu Fault corridor. Potential field methods have been augmented with deep-sensing, complementary methods: magnetotellurics and reflection seismic.

METHOD AND RESULTS

Petrophysics/Forward modelling

The Teena prospect, being explored by Teck Australia Pty Ltd. (Figure 1), provided an opportunity to study rocks of the same stratigraphy as Yalco. P-wave velocities observed in sonic logs, and measured on samples in the laboratory, show a large range from 4,500 to 7,500 m/s. The host shale package shows a significant contrast in density compared with the dolomitic country rocks (2.6 g/cc average for shale, compared with 2.9 g/cc for dolostone).

Seismic forward modelling, using the 2D exploding-reflector methodology, showed that strong reflectivity is expected at stratigraphic boundaries. The modelling clearly showed that large offsets were required to properly image high angle faults, and this influenced our choice of seismic survey parameters.

Potential field methods

An airborne magnetic survey was flown over the entire tenement package at 100 metre line spacing in 2014. The magnetic response is very low over the prospective Emu Fault corridor. Negligible magnetic contrast is seen within the units of the McArthur Group, however the Emu Fault corridor is clearly defined in the derivative images (Figure 2).

Ground gravity was done over the area of interest at 500 metre station spacing (Figure 3). The Emu corridor is defined well by the gravity data, with the units within the corridor showing an asymmetric response. No firm indication of fault dip was apparent in these datasets. The potential field datasets were not able to indicate favourable areas between the fault limbs.

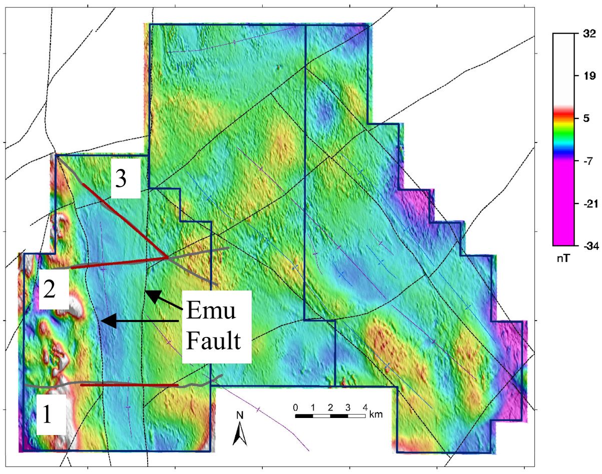

Figure 2: Magnetic image; TMI RTP Gaussian residual (10km) with NE sun shade. Transects are numbered 1 – 3; seismic = grey, magnetotelluric = red.

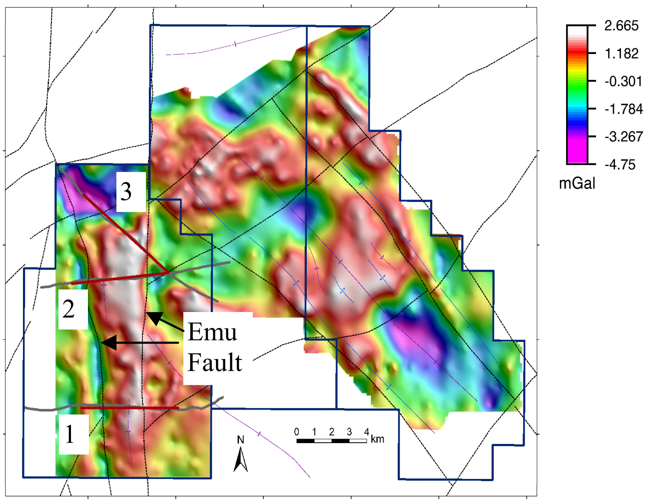

Figure 3: Ground gravity image; Bouguer anomaly 2.67g/cc, Gaussian residual (25km) with NE sun shade. Transects are numbered 1 – 3; seismic = grey, magnetotelluric = red.

Magnetotellurics

Magnetotelluric arrays were deployed along the same three lines as the seismic (see Figures 2 and 3), although the lines (shown in red) were shorter as MT has less need for offset readings. The main objective of the survey was to aid in basin characterisation and target validation. There was also the possibility of direct detection of mineralisation, as the sulphide mineralisation is expected to be anomalously conductive within the host sequence. The shale host rock (HYC shale) is also expected to be weakly/moderately conductive.

Ex dipoles were spaced at 100 metre intervals, with Ey dipoles spaced 400m apart, and H measurements every 1,400m. 2D inversions were done on each line by Quantec Geoscience using the Wannamaker algorithm (TE + TM modes).

The MT inversion sections show widespread conductive overburden (The inversion for Line #2 is shown in Figure 4.). Only very subtle contrasts were detected within the basement. The locations of the major structures are evident in the section, as is the dip of a weak stratigraphic conductor within the Emu corridor.

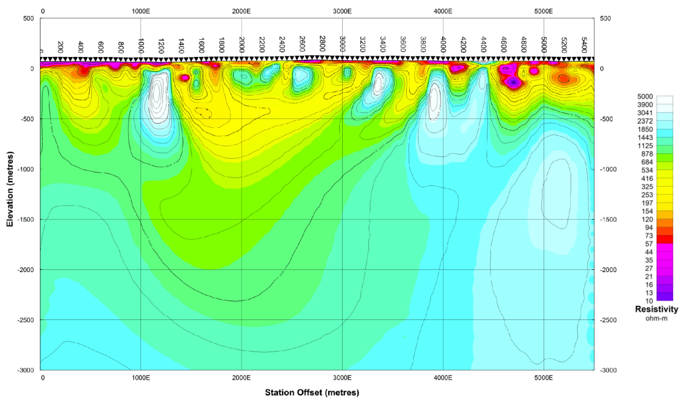

Figure 4: Magnetotelluric inversion section Line 2.

2D Seismic reflection

The seismic program was conducted along three lines of approximately 12km each in length (Figures 2 and 3). The data were acquired in October 2015 with a single vibroseis source (60,000 lb). Source spacing was 20 metres. The geophones groups (6 phones per group) were spaced at 10 metres. The geophone spreads used an offset of 5,000m. The survey is described in detail in Sully (2016).

The data quality was adversely affected by poor source coupling in sandy areas, and some out-of-plane reflections were recognised in the data. However, overall the data quality was very good, with coherent reflections seen at up to 2 seconds TWT. Stacking velocity is seen to increase sharply with depth, from low velocities associated with sandy unconsolidated surface sediments of ~300m/s, increasing to over 6,000 m/s in the basement rocks. Figure 5 shows the pre-stack time-migrated seismic section for Line #2. Depth conversion is poorly constrained due to lack of drill control.

Preliminary Interpretation

The regionally significant North-trending faults of the Emu corridor dip inwards at a steep angle to form an asymmetric graben. The host shale sequence is identifiable as a characteristic low-reflectance layer between two strong reflectors (dolostone units), and can be traced with confidence across the project area. The host (Barney Creek Fm) is confirmed to occur at a range of depths between 500 metres and 1,500 metres.

The sub-basin formed by the Emu corridor is asymmetric, with maximum throw and sediment growth on the western side. This interpretation will allow us to select discrete areas for follow-up exploration.

CONCLUSIONS

Seismic reflection surveys have been utilised at an early stage in the exploration process at the Yalco project. The 2D seismic surveys have been invaluable in characterising the architecture of the basin for target generation. The high resolution of the seismic data has allowed us to interpret stratigraphy with confidence, and to effectively determine depth to the potential host stratigraphy.

The Yalco project has not been drill tested yet, but the geophysical surveys have identified prospective geological targets for follow up. The strategy of using seismic methods in the initial stages of exploration has been successful in reducing technical risk associated with deep exploration for SHMS systems in this area.

The constraints on depths and geometry provided by seismic data will contribute to more effective and efficient testing. This has the potential to substantially decrease exploration costs and to increase the effectiveness of exploration.

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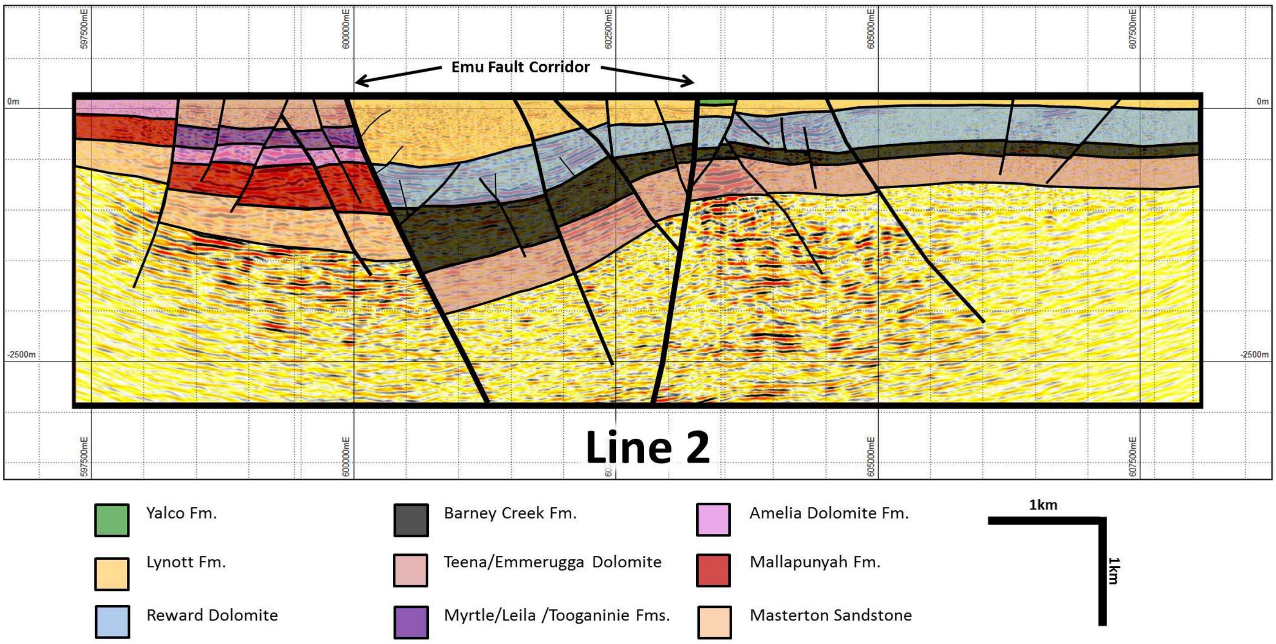

Figure 5: Interpreted seismic section (PSTM) for Line 2.