Amsterdam '14

WS5-A04

Seismic Exploration for Volcanogenic Massive Sulphides - The DeGrussa Copper-gold Mine, Western Australia

J. Kinkela* (HiSeis Pty Ltd), S. Ziramov (Curtin University), A. Dzunic (HiSeis Pty Ltd), M. Urosevic (Curtin University) & P. Hilliard (Sandfire Resources NL)

SUMMARY

Traditional geophysical prospecting techniques used for mineral exploration rarely provide the resolution required to accurately target orebodies at depth. Based on this, the seismic reflection method was trialled over a known VMS orebody at the DeGrussa copper-gold mine, Western Australia, in the hope of providing a viable exploration tool for deeper depths of investigation. However, a structurally complex geologic setting and a thick, highly variable regolith caused significant challenges in the processing of the seismic data. This paper addresses these challenges and looks at strategies used to overcome them eventually leading to the direct imaging of the orebody.

Introduction

The DeGrussa orebodies of the Bryah Basin, Western Australia, have yielded some of the richest copper-gold deposits in recent times for the region. Located 900 km NE of Perth, the Volcanogenic Massive Sulphide (VMS) mineralisation style has turned the Bryah Basin into '…an area of renewed exploration vigour, and potentially the host of a significant new VMS camp for Western Australia' (Bamforth, 2011). However, significant exploration challenges exist due to the structural complexity of the geologic setting and the thick, highly variable regolith known to cover the area. The seismic reflection technique is currently being trialled in the hope of providing a viable exploration tool for deeper depths of investigation.

Experimental seismic surveys

Rock property measurements showed that while the P-wave velocity contrast was not distinct, the density values of the massive sulphide orebodies were significantly higher compared to that of the surrounding rock units. Therefore, it was determined that the orebody should be easily detectable by surface seismic methods.

Based on this petrophysical analysis a trial 3D test survey was designed to image a known orebody in order to verify the seismic reflection technique in this area. Unfortunately access restrictions resulted in less than optimal coverage and illumination of the underground structures. A complex regolith profile comprising 0 – 40 m of transported alluvial cover underlain by 25 – 300 m of variably oxidised in-situ material challenged data processing. Indeed, initial processing results of the 3D volume failed to map the ore body with any certainty, mainly due to geometrical constraints that resulted in insufficient offsets available for imaging. First order processing issues included the quality of first break picks for entry into the refraction static calculation as a significantly thicker regolith profile than anticipated resulted in a lack of recorded offsets to adequately sample the base of oxidation (BOX). Strong velocity changes observed both laterally and with depth negatively impacted velocity analysis and subsequent imaging. Finally, velocity jumps from 3000 m/s to 5000 m/s at the BOX caused significant amounts of wavelet stretching and loss of data through stretch muting.

Along with the acquisition of 3D seismic, a zero-offset VSP survey was also collected down a drillhole which intersected the target orebody. The quality of the VSP data was considered very high for a hard-rock dataset. Subsequent processing of this showed unambiguously that reflections from the massive sulphides were transmitted back to the surface and should therefore produce a reasonably strong seismic reflection detectable by surface methods. The results of the VSP provided the impetus to pursue the further acquisition of seismic data to address issues in the original 3D survey.

A short 3 km 2D line was subsequently acquired to investigate why the 3D failed to clearly image the target orebody. The main areas to be addressed were a lack of source-receiver offsets to properly sample the deeper BOX interface and the suitable placement of receivers to record reflections from the steeply dipping portion of the orebody. Therefore, the 2D line utilised larger offsets in the down-dip direction. The simple processing and decimation of the 2D seismic was enough to demonstrate that the initial 3D geometry was insufficient to image the steeper part of the orebody (Figure 1). However, standard hard rock 2D processing consisting of DMO and post stack migration resulted in the orebody being severely misplaced (Figure 2 left panel). This was due to strong lateral velocity variation brought about by the heterogeneous oxidised zone. Tomographic velocity analysis followed by Kirchhoff migration addressed this problem and produced outstanding results (Figure 2 right panel).

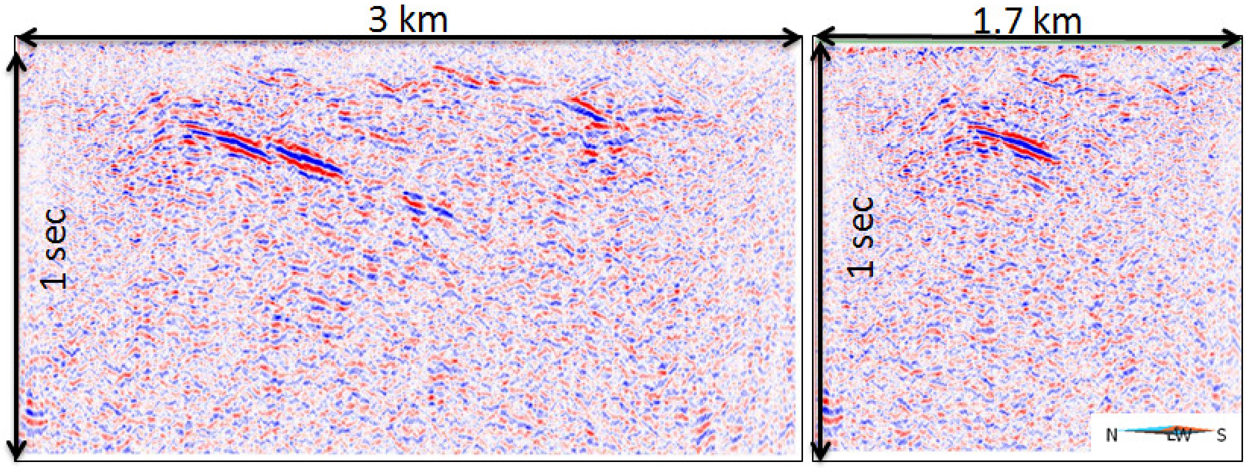

Figure 1 *Stack with full 2D geometry (left) and stack using line length and maximum offset as in the 3D survey (right) in time. The down-dip component of the high amplitude reflection is only imaged with the full 2D geometry.*

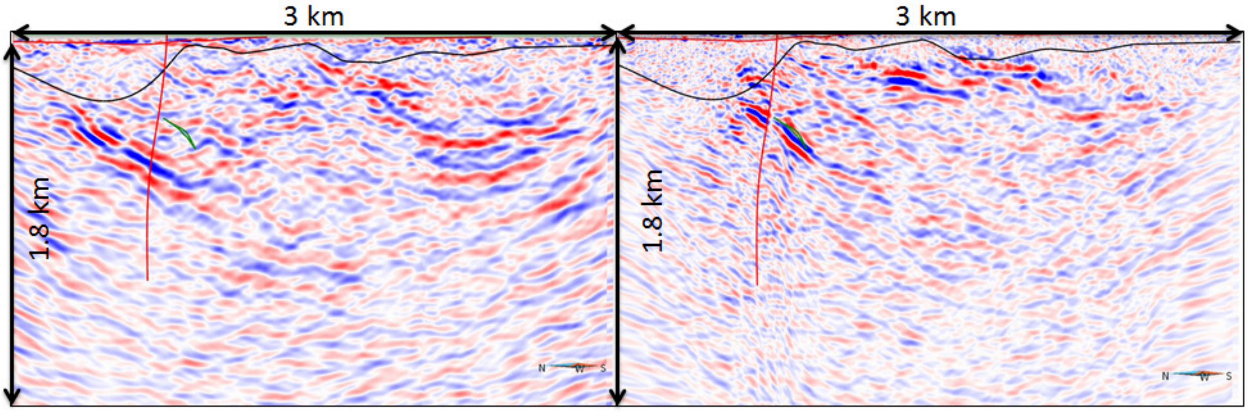

Figure 2 *2D migrated sections using the standard (left) and tomography driven approach (right) in depth. Sub-vertical red line and dipping green line represent a major fault and massive sulphide respectively. Both are accurately imaged using the tomography driven approach.*

Conclusions

The seismic reflection technique was trialled over a known VMS orebody with an initial 3D survey having limited success. A complex regolith profile with strong velocity changes both laterally and with depth caused significant challenges during the processing stage. Numerous tests and extensive data analyses revealed that an extended receiver geometry and a tomographic inversion were required to unambiguously image the massive sulphide. This therefore validated the seismic technique for exploration in this region.

Acknowledgements

We thank Sandfire Resources NL for providing permission to publish this data and continued support throughout the project.

References

Bamforth, S. [2011] The DeGrussa Project; A new generation of Exploration in the Bryah Basin: Presented at the Mining and Exploration Discussion Group Western Australia (MEGWA) Seminar Series, Australian Institute of Geoscientists.