Finding Gold – Time for a Seismic Shift in Exploration Thinking

Introduction

At shallow depths, gold explorers have a broad arsenal of targeting tools and drill testing is relatively cheap. At greater depths, where each drillhole represents a substantial expense, the effectiveness of most current targeting tools is greatly reduced. Reflection seismic is one geophysical tool which retains its resolution, and therefore effectiveness, as a function of depth.

Reflection seismic operates by transmitting vibrational waves into the ground (see Figure 1). These waves propagate until there is a change in the elastic properties (e.g. lithological boundaries, alteration zones, faults and shears). At each boundary a small portion of the energy is reflected whilst the majority of the energy is transmitted down to the next boundary where the process is repeated - and so forth. The reflected signals are measured by an array of sensors on the surface and can be used to provide a detailed image of the subsurface. The sensor array can be along a single line (2D survey) or a grid (3D survey). Surveys are built up by transmitting the vibrational waves into the ground at multiple locations.

The key parameter that determines the strength of reflections is the acoustic impedance. This is equal to the product of density and seismic velocity. Geological features are imaged both directly by reflections off specific boundaries and by interruptions to the reflections and changes in texture of the reflections.

Reflection seismic is a critical component of almost all oil and gas exploration projects and its use has massively improved drill success rates (Aylor, 1999). With some exceptions (e.g. Stevenson and Durrheim, 1997), reflection seismic has rarely been used in mineral exploration. In the past this was for both technical and financial reasons. Significant developments on both fronts mean that seismic surveys can now offer substantial benefits to gold explorers. Our presentation will show the results of recent seismic surveys to assist exploration for high-grade gold in terranes with known gold endowment.

Case History 1 – Epithermal Gold

In July and August 2013 2D seismic surveys were completed at Cracow and Pajingo to assist with exploration for epithermal gold deposits. The mineralisation at both Cracow and Pajingo occurs as thin (1-15m) structurally controlled, steeply dipping quartz veins. Both surveys identified multiple sub-vertical structures interrupting reflections from andesitic lavas, tuffs and fragmentals. The survey also provided much greater detail on the structural architecture of the regions. Figure 2 shows a structural interpretation from the 2D seismic data and other available information from drilling, mining and potential field data.

Drilling showed these structures to be coincident with veins some of which contained gold. Based on the success of these surveys, Evolution initiated 3D surveys at each of the 2 sites in May and June 2014. Figure 3 shows an initial depth slice...
through the 3D data cube with the interpreted location of faults some of which correspond to the location of known faults and epithermal orebodies.

**Case History 2 – Orogenic Gold**

A significant benefit of seismic reflection imaging is not only the ability to detect structures which may be difficult to detect via sub-vertical drilling but to provide a continuous map of these structures. In many gold deposits high grade zones occur in dip or strike flexures of host structures (see for example Figure 4). Seismic surveys can potentially map these structures whilst they can be difficult to detect by drilling particularly at larger depths. Two 2D surveys at Tropicana in December 2012 and July 2013 demonstrated the ability of seismic surveys to image the structures controlling mineralisation. Figure 5 shows the seismic sections from these two surveys. As a result of the success of the 2D seismic surveys, AngloGold Ashanti and the Independence Group decided to proceed with a 3D seismic survey to image the 3D geometry of these structures down dip from the existing ore reserves. The 3D survey covered an area of approximately 10 square kms (see Figure 6) and was completed in July 2014.

**Conclusion**

Surface based reflection seismic can provide continuous 3 dimensional images of prospective geological terranes. Its strengths are:

- its ability to provide images over depth ranges from less than 100m to many kilometres;
- its high resolution; and
- that the high resolution is essentially independent of depth.
Thus reflection seismic provides gold explorers with a way to develop a full 3-dimensional understanding of their mineral prospects and therefore rapidly focus in on the most prospective areas. Recent results indicate that this can provide a new highly cost-effective approach for gold exploration.

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References

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Biography

GREG TURNER’s previous roles have included being Geoscience Manager for WMC’s Technology Group and a co-founder of the Geoforce geophysical service company.

He is currently Director New Business Development at HiSeis which is a company that uses seismic methods to fast-track exploration and improve mine planning.