Integrated multidisciplinary high resolution 3D geophysics in brownfields and in-mine exploration: New successful approaches in gold, nickel and uranium districts

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The greenstone belts of the Yilgarn craton, Western Australia host numerous Archaean gold, nickel and iron ore deposits. These deposits are typically found in complex geological structures associated with crustal scale shear zones. In this respect they have similarities with many other commercial mineral deposits. The complex structures of the greenstone belts are commonly hidden by a deep, heterogeneous and often conductive regolith profile consisting of totally weathered rocks and transported colluvial and alluvial deposits. This give rise to added complexity in successful application of surface transient electromagnetic (TEM) and seismic methods.

Exploration in Western Australia has entered its mature phase and future discoveries of large deposits at greater depths will depend on focussed exploration programs where there is little or no exposure of Archaean geology. Consequently the traditional prospecting will have to be complimented with smart, effective and efficient exploration techniques. Williams (2005, 2007) gave details how smarter exploration for Komattite hosted nickel sulphide mineralisation, using 3 component TEM surveying, could be done in an underground mine environment. These techniques have now given rise to 2 commercially significant brownfields discoveries (McLeay and Moran Deposits, Kambalda, Western Australia) in the last 4 years. However these techniques need to be in turn complimented by other applicable techniques.

An initial 2D seismic reflection exploration experimental program, which started in 2004, included investigations over more than 10 mine sites (mainly gold deposits, some nickel and iron). High quality seismic images produced enabled precise targeting, resulting in new discoveries. Perhaps even more importantly, obtained seismic images provided much improved understanding of both shallow and deep complex geological structures. In the initial stage seismic results were exclusively aimed for precise structural interpretation which was subsequently used to improve inversion of the potential field data. In the later stage we used seismic data to detect various lithologies, including direct detection of ore surfaces in contact through seismic inversion.

While 2D hard rock exploration program in Yilgarn craton proved successful it became clear that 3D images are necessary to fully resolve complex structures and in that way assist underground mine planning and developments. The most recent 3D seismic exploration program included several mine sites in difficult terrains. Severe environmental restrictions required deployment of light, low impact, portable equipment and modified 3D layouts. The target depths were in the range from 150 m (iron ore) to 600 m (gold) and over 1000 m depth for nickel sulphide exploration. Application of lowpower sources and low to moderate CMP fold resulted in generally low signal-to-noise (S/N) ratio. However initial 3D images proved superior over existing 2D images which were recorded with much better initial S/N ratio. Improvements in instrumentation and field deployment has significantly decreased the cost of deployment of such a technique.

Several case histories of the application of high to very-high 3D reflection seismic methods for mineral exploration in all-out hard rock environment will be presented and discussed. Relevant commodities include nickel sulphide (Komatiite hosted), lode and shear gold related, unconformity and paleochannel uranium related.