Geophysical Exploration for Gold: A Major Company Perspective

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Barrick Gold is the world's leading gold producer, with reserves of 139.8 Moz (2009). Barrick is the gold industry leader, with interests in 25 operating mines and a pipeline of projects located across five continents, in addition to large land positions on some of the most prolific mineral districts. Barrick produced 7.42 Moz of gold in 2009 and is expected to produce between 7.65 and 7.85 Moz in 2010. Our exploration goal is to find new ounces and grow production. Barrick focuses on world-class deposits with long lives, high production rates and good economics.

Barrick has a proven track record in both brownfields and greenfields exploration. The geophysical group, an integral part of the exploration team, has an average age of 34, is strong in geology and mostly has honours degree or equivalent. The Barrick geophysical group has directly supported 9 honours/masters projects and one PhD in the last 10 years. Four honours students are now employed as Barrick geophysicists. In addition, Barrick has employed 14 student interns over the past 10 years and is directly associated with KEGS, SEG, ASEG (Research Foundation), Curtin University of Technology (CUT), University of Western Australia (UWA), Centre for Exploration Technology (CET), University of British Columbia (UBC), University of Utah (UoU), Montana Tech (MT), CRC for Deep Exploration Targeting (CRC) and AMIRA International (AMIRA).

Barrick focus on deposit types that give best chance of success at finding world-class examples. That is, types represented by largest number of deposits (greenstone, porphyry Cu-Au, epithermal); large percentage of population >10 Moz (greenstone, porphyry Cu-Au, epithermal); and, ones with good economics (Carlin, epithermal–alkalic, greenstone). Direct detection of these gold deposits using geophysics is possible (porphyry Cu-Au), but not common. Therefore, the focus is on petrophysics and understanding how it relates to geology, alteration and geochemistry for targeting. Barrick utilize current best practices and support research for development of new technologies and innovations. Recent geophysical applications on selected deposit type follows.

A recent application of geophysics in the search for Carlin-style mineralization is (hardrock) seismic. Seismic technique is well-suited for the low-angle carbonate stratigraphy and fold-and-thrust architecture of Nevada, with good acoustic impedance contrasts between lithologies and deposition facies. There are specific acquisition and processing considerations for hardrock seismic, requiring a lot higher resolution than softrock (oil and gas) seismic (10m receiver, 20m shot spacing) and higher fold (120+). In previous surveys at Barrick these data are integrated with drilling data to construct comprehensive interpretation of structure on 2D sections. In 2011 Barrick are moving to 3D acquisition and interpretation. Hardrock seismic is an order of magnitude cheaper and can provide more information than a fence of drilling. Hardrock seismic data can validate and improve geologic models, leading to better drill targets.

Airborne EM has been applied to exploration for greenstone gold mineralization. More typically, the sediment hosted sulphide-rich greenstone deposits are better suited to electromagnetic (EM) techniques as apposed to lode gold style mineralization. Tight line spacing (50m) is better suited to map the sulphide variation in these systems. Where sulphide alteration is associated with mineralization, the most conductive near-surface response usually identifies the centre of these systems. Typically there are many other barren sulphide accumulations proximal to know mineralization. An example of 3D inversion of helicopter time domain EM data will be presented over a sediment-hosted greenstone deposit.

A variety of geophysical techniques can detect alteration associated with Cu-Au rich porphyry style mineralization. Alteration mapping using magnetics/ radiometrics to map potassic alteration is well documented. The potassic core can be either conductive in sulphide-rich systems, or resistive in sulphide-poor systems, but ultimately it depends on the host rock (contrast and reactivity). The outer phyllic/ propylitic alteration is chargeable, magnetite destructive and is often resistive. Airborne and ground data will be shown over a Cu-Au rich porphyry deposit.

Geophysical methods can also be applied to alteration mapping of near-surface high sulphidation (HS) epithermal deposits, where the upper part of a mineralized system is associated with vuggy silica alteration (high resistivity). Resistivity data can effectively map the typical alteration zonation (from centre outward) of advanced argillic with vuggy silica (resistive), to advanced argillic with quartz alunite (moderate resistor), to argillic with intense clay (conductive, chargeable). Ground resistivity data is shown mapping alteration zonation over a near-surface HS epithermal deposit.

Barrick's investments in geophysical research have led to the development of practical tools for exploration. One example is the development of an algorithm with the CET at UWA to recognize the footprint of near surface porphyry Cu-Au responses in magnetic data. The result was a fast, effective reconnaissance porphyry mapping tool from magnetic data. Examples showing results of this algorithm versus mapped porphyry systems will be presented.

Geophysics will play an increasingly important role as near surface exploration opportunities decrease and focus is shifted deeper into bedrock and in covered areas. Understanding petrophysics and how it relates to geology, alteration and geochemistry of giant gold deposits will help us select the best future exploration opportunities. To better realize these opportunities, Barrick geophysicists are embedded in regional exploration offices, promoting maximum interaction and impact on the exploration teams.