POST-MINING RECONCILIATION OF BHR PREDICTED RESOURCE ELEVATION MODELS

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INTRODUCTION
The Snap Lake Mine near Yellowknife in the Northwest Territories of Canada goes into production during 2007 (Figure 1). In preparation for this, two Test Mining Panels were designed and developed in order to establish a range of geotechnical and ore extraction parameters. Before development commenced, Borehole Radar (BHR) surveys were conducted over these two areas to assess the feasibility of using BHR to delineate the resource and to provide information on structural and geological conditions ahead of mining.

The first BHR surveys, conducted over Test Panel 1 in August 2004, proved the concept of imaging the three dimensional shape of the ore-body over the Test Panel area, and established the feasibility for continuing with the evaluation and development of the technique. The BHR surveys conducted over the second Test Panel aimed at obtaining a more direct correlation between the measured radar time sections and the mapped geology in the panel drifts. The borehole layout was designed to evaluate the optimum layout required to protect mining panels in a production environment.

The dielectric properties of the dominant granitic host, hosting roughly 80% of the orebody, are very good and offer high transluence to VHF wave propagation (est. $Q \geq 35$). A typical range of 75m is achieved with slimline (31mm OD), bistatic borehole radars with a bandwidth of 10-125MHz. All data acquisition was performed with Geomole borehole radar instruments.

Figure 1: Map of Canada showing the location of the Snap Lake mine near Yellowknife in Northwest Territories.
GEOLOGY AND MINING BACKGROUND
The orebody is a shallow dipping (-15°) diamondiferous kimberlite dyke that intruded into a series of Achaean granite-gneiss and metavolcanic rocks. The dominant type of kimberlite is a macrocrystic hypabyssal kimberlite, abbreviated as HK. Locally a number of subordinate units, such as veined hypabyssal kimberlite and kimberlitic breccias are identified (Mogg, 2003). The average thickness of the dyke is 2.5m.

The morphology of the dyke is not a uniform sheet. McCallum (2006) suggested that the emplacement was controlled by sets of pre-existing low angle fractures. The dyke contains ramps, steps and branches or bifurcations, such as schematically illustrated in Figure 2 (adapted from SRK, 2006). Many of the irregularities occur at a 1m to 5m scale, which makes them critical to planning, but difficult to predict and in fact impossible to predict from the historic 150m node surface drilling results.

Production will be from a modified room and pillar underground mining method. Figure 3 shows a schematic illustration of the Mine Block and Panel design. To smooth the flow of ore and ensure the production call is met, short-term mine planners require high resolution information to make on-time adjustments and to productively move resources around the mine.

SURVEY DESIGN – TEST PANEL 1 & 2
Figure 4 shows a fan of four coplanar, near horizontal boreholes, that covers the Test Panel 1 area. The holes range in length from 90m to 125m, and were drilled into the hanging wall approximately 10m above the expected plane of the dyke. The development (planned and completed) shown in Figure 4 was the status at August 2004, after completion of the BHR surveys.

The mine plan design for Test Panel 2 was similar to that of the first Test Panel, with the exception that it was orientated with the panel drifts extending in the opposite direction; towards the south as illustrated in Figure 5. The panel is located approximately 50m further West along the same ore ramp. The borehole configuration used for this survey was changed from the fan design, to being parallel to the panel drifts. The holes were placed in such a manner that they would provide optimum cover for the Test Panel, i.e. along the drifts on the edges and in the centre. The holes were drilled at an inclination of -12°, into the foot wall.
Single hole reflection surveys were conducted in all of the holes, moving the bistatic radar (with a fixed Tx-Rx offset of 4.5m) along the hole at a constant speed of 10m/min. The radar time sections acquired from these boreholes, after the application of band-pass and automatic gain control (AGC) filters, are displayed in the following sequence of figures. Data processing and interpretation is performed in Seiswin, software proprietary to Geomole.

**BHR RESULTS – TEST PANEL 1**

Figure 6 shows the radar time sections acquired over Test Panel 1. The plots show the distance along hole from left (collar) to right, and time/range increases from top to bottom. The geological logs from each hole are displayed along the top of each section. Fault and contact planes intersected by the borehole appear as inverted V’s in the time section, due to the omni-directional nature of the instrument.

**Figure 6**: BHR time sections of the 4 holes surveyed (clockwise from Top Left, Hole-179 to 182). The main arrivals are identified on each section. The green solid line represents the top dyke horizon and the light blue dashed line the lower horizon. Fault planes are shown as inverted V’s.
Instead of the expected single, shallow dipping reflector associated with the dyke, two distinctly separate reflectors are observed, being associated with the upper and lower horizons or planes of a split or step in the dyke. The two dyke horizons are linked by a fault plane dipping at roughly 35°, and the dykes step repeatedly at 1.6m offsets. The fact that both horizons step in the same direction, is an indication that both horizons are on the same side of the borehole, i.e. below.

The interpreted reflector horizons are digitised and, with the underlying assumption that the dyke is smooth and continuous from hole to hole, a surface is created through interpolation between the profiles. The results were ground-truthed by analysis of its deviation from the geological model on completion of Panel development. Figure 7 shows the surface constructed from the BHR interpretation of the lower dyke horizon, overlying the dyke model of the Test Panel. The BHR surface is coloured by the distance between the two surfaces. The average difference between the BHR surface and the mapped hanging wall contact is 1.5m. Spatial sampling rates are high NW-SE, along the borehole axis, but poor normal to this axis.

**Figure 7**: Test Panel 1: Correlation of the BHR interpreted surface and the modelled dyke surface (red). The BHR surface is coloured by the distance from the modelled dyke surface.

**Figure 8**: Test Panel 2: 3D Model of the dyke surface interpreted from the BHR survey data. The existence of the fault was proved during mining of the ore drifts.

**BHR RESULTS – TEST PANEL 2**

Figure 8 shows the final model constructed from the BHR survey results over the Test Panel 2 area. All available borehole information in the area are displayed in the figure. The interpreted location of the dyke from the Borehole-517 data correlates extremely well with the dyke intersection from a vertical surface borehole at this location. The model illustrates a fault scarp offsetting the dyke with a maximum of 20m. Subsequent mining confirmed the existence of the fault when development along Panel Drift 40 encountered a 5m throw of the dyke into the hanging wall. Developments in the other drifts were halted and the design of the panel modified to accommodate the structure.

**CONCLUSIONS**

Propagation conditions in the granite host at the Snap Lake mine favours high-resolution BHR imaging to a range of approximately 75m. Geological structures at a scale of >1m can be accurately mapped, providing mine planners with the information required to ensure on-time evaluation of geological risk and a smooth flow of ore to the plant.
REFERENCES
