GRADE CONTROL BLENDING AND SELECTIVITY FOR OPTIMAL PROCESS PERFORMANCE AT THE SKORPION ZINC MINE, NAMIBIA

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ABSTRACT

The Skorpion Zinc Mine and Refinery is situated approximately 25 km north of Rosh Pinah, south-western Namibia. The supergene zinc oxide deposit at Skorpion is hosted in a volcano-sedimentary succession within the para-autochthonous Port Nolloth Zone of the Gariep Belt. Rock types hosting the ore deposit include altered and metamorphosed volcaniclastic and clastic sediments, limestone and rhyolite.

At Skorpion, the metallurgical process is unique and the plant design requires minimal fluctuations within a selected feed grade. In addition, the presence of limestone inter-fingered with ore in some areas of the deposit results in dilution problems which may increase gangue acid consumption and therefore processing costs. Hence, selective mining is necessary to ensure the delivery of suitable ore to the processing plant, in order to keep the overall operating costs at a minimum.

A complex control system is in place and is capable of a high degree of selectivity. The paper describes the grade control system in place at Skorpion Mine which ensures that the qualities of the blocks planned for mining and the material being mined meet the stringent process requirements of the refinery, i.e zinc grade, gangue acid consumption and deleterious elements that may impact on the efficiency and costs of the metallurgical process.

Keywords: Skorpion zinc, zinc oxide, supergene, volcano-sedimentary, grade control

1. INTRODUCTION

The Skorpion Zinc Mine is situated approximately 25 km from Rosh Pinah, Namibia (Figure 1). The supergene zinc oxide deposit at Skorpion is hosted in Late Proterozoic altered and metamorphosed volcaniclastic and clastic sediments, limestone and rhyolite of the Port Nolloth Zone of the Gariep Belt (Borg et al. 2003). The supergene deposit is thought to have formed primarily from the oxidation of a sulphide-bearing precursor and carbonate wall rock replacement (Hitzman et al., 2003).

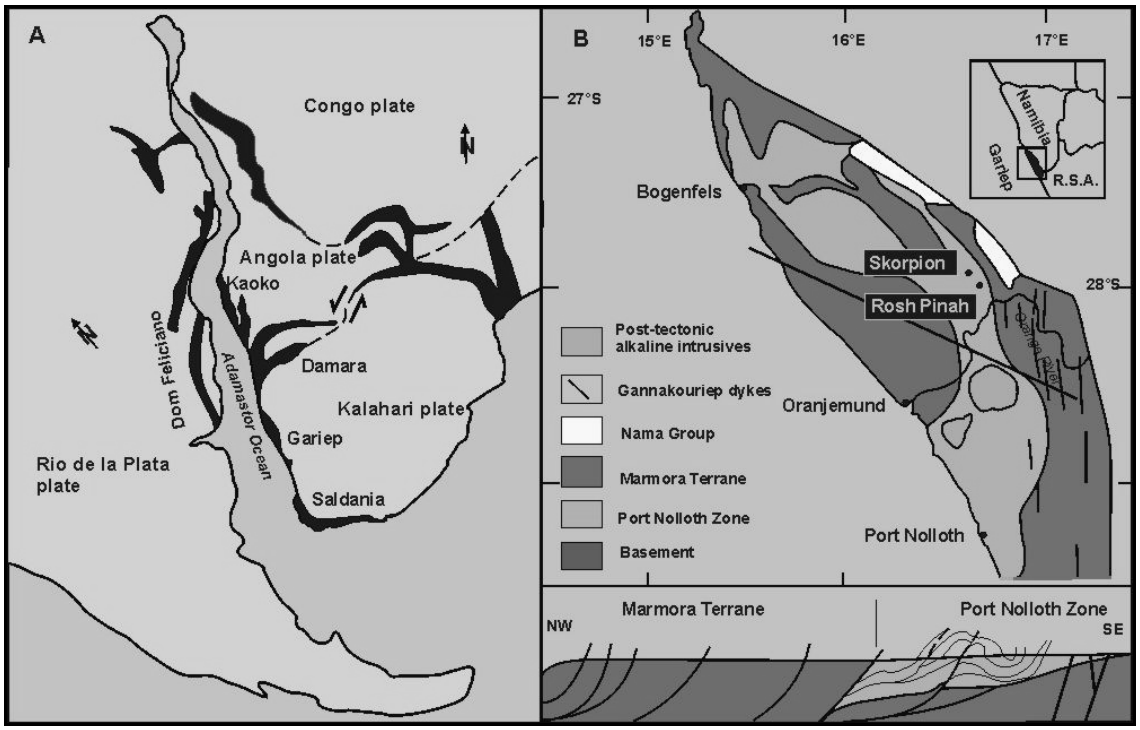

Figure 1. Location and structural setting of the Skorpion non-sulphide zinc deposit.

The major zinc-bearing minerals present at Skorpion are generally smithsonite (zinc carbonate), sauconite (zinc clay) and hemimorphite (zinc silicate). Minor ore minerals include tarbuttite, chalcophanite and zinalsite. Other minerals present in the deposit include copper "oxide" minerals like malachite, digenite, chalcocite and chrysocolla, as well as copper sulphide minerals like pyrite, sphalerite, and chalcopyrite have been reported (Borg et al. 2003).

Estimated resources are of the order of 18 million tonnes at an average grade of 11.3 % Zn and a 14 year life of mine. The mineralised ore body extends to a depth of 420m. U-Th/He thermochronometry dating of the zinc phosphate mineral, tarbuttite, constrains the time of oxide mineralisation at Skorpion to between 42 Ma and 70 Ma. Ar-Ar step-heating age data for K-bearing romanechite from the Skorpion deposit yielded two clusters of middle Miocene to upper Eocene ages (Gutzmer, 2006).

2. THE IMPORTANCE OF GRADE CONTROL AT SKORPION

The Skorpion Zinc mining and refinery operations present a different paradigm, because metallurgical processes are not designed around expected variations in the feed grade from the open-pit where mining costs are conventionally kept low. Skorpion operations are such that the mining costs are relatively low compared to the metallurgical processing costs. The metallurgical process is unique and the plant design requires a feed grade within a narrow range, typically 10 -12 % Zn. Within a selected feed grade, the requirement is that fluctuations must be minimal.

In addition, the presence of limestone inter-fingered with ore in some areas of the deposit results in dilution problems which may increase gangue acid consumption and therefore processing costs. Hence, selective mining is necessary to ensure the delivery of suitable ore to the processing plant, in order to keep the overall operating costs at a minimum.

Grade Control, together with operational management and mine planning ensures that the qualities of the blocks planned for mining and the material being mined meet the stringent process requirements of the refinery, in terms of zinc grade, gangue acid consumption and deleterious elements that may impact on the efficiency and costs of the metallurgical process.

3. THE GRADE CONTROL PROCESS

A complex system is in place that is capable of a high degree of control and selectivity. A dedicated team of grade control operators undertake blast hole sampling, spot grade perimeters in the open-pit and control loading and dumping of material to and from low-, medium- and high-grade ore stockpile destinations. Waste and marginal ore are also separated to different destinations. The degree of selectivity in the open-pit serves to minimise dilution and allows for blending from a range of stockpiles. A tracking database monitors ore tonnes and grades on stockpiles to enable optimal blending for the required plant process performance.

The grade control process is described below:

DRILLING: Drill burden and spacing are based on the rock types present at Skorpion , e.g. 4 m x 4 m in ore and 6 m x 6 m in waste material (Figure 2).

SAMPLING: Samples and drill chips are collected over intervals of 2.5m, 5m or 10m. Large samples (>5kg) are riffle split at the drill rig (Figure 2).

Figure 2. Blast-hole drilling and grade control sampling at the DM45 drill rig.

ASSAYS: Routine XRF analysis of Zn, Ca, Fe, Mn and Cu concentrations in pressed powder pellets are performed by the on-site Skorpion Laboratory.

QUALITY CONTROL: The Quality Control Procedure specifies the use of quality control (QC) samples to track laboratory performance. At least 5% of the grade control samples are submitted for analysis comprises QC specimens. The QC samples used for this purpose include matrix-matched certified reference material (MM-CRM), rig duplicate samples, internal geology blanks, laboratory replicates and laboratory blank samples.

The purpose of quality control is to minimise biases, confirm whether laboratory assays are correct to within a defined degree of accuracy and precision and to detect the presence of "carryover" contamination between samples.

BLASTING: Blast designs and techniques are based on the different rock and alteration types. Fragmentation versus minimum movement of material is optimised when a particular powder factor is selected.

MODELLING: Survey borehole collar co-ordinates, geology (rock types, "ZincZap" and HCl reactions) and assay results are captured in a database. Block modelling is undertaken over appropriate levels (smu = 5m x 5m x 2.5m) depending on continuity of geology and grade, using a customised DATAMINE Grade Control System developed by Bloy Mineral Resource Evaluation (BMRE) software. Mining perimeters are delineated based on assay results and gangue acid consumption calculations. Grade and tonnage evaluation reports and loading plans outlining mining perimeters in the open-pit are then generated.

ORE TRACKING: Mining equipment implemented for ore extraction is optimal for selective mining. Material from the pit is transported to various stockpile destinations. These include high-grade (>13% Zn), medium-grade (9 - 13% Zn), low-grade (4 - 9% Zn) and marginal (1 - 4% Zn) ore stockpiles. Limestone (Ca >28%) from the pit is mined for plant acid neutralisation purposes. Material with Zn <1% is designated for the waste stockpile.

"Spotting" and recording of ore types and tracking of tonnages and grades, according to mining perimeters and loading plans, is undertaken in-pit by a dedicated team of geology operators. A stockpile "tallyman" records material delivered to the correct stockpiles.

DATA MANAGEMENT: The ore tracking data are captured in a Tallies Database. The database is important for calculating the grade and tonnage of material tipped onto the various stockpiles. A well-managed tallies database is important for effective grade control and blending. This allows for a continuous feed through elimination of fluctuations resulting in homogenised feed grade.

STOCKPILE MANAGEMENT AND BLENDING

Stockpile tipping and reclaiming faces are strictly monitored and surveyed (Figure 3). Ore is reclaimed perpendicular to the tipping direction. The average grade of a particular stockpile is the average grade of ore mined during a certain stockpile building period. Ore from the stockpiles is blended to the required grade before feeding to a stacker-reclaimer for further homogenisation.

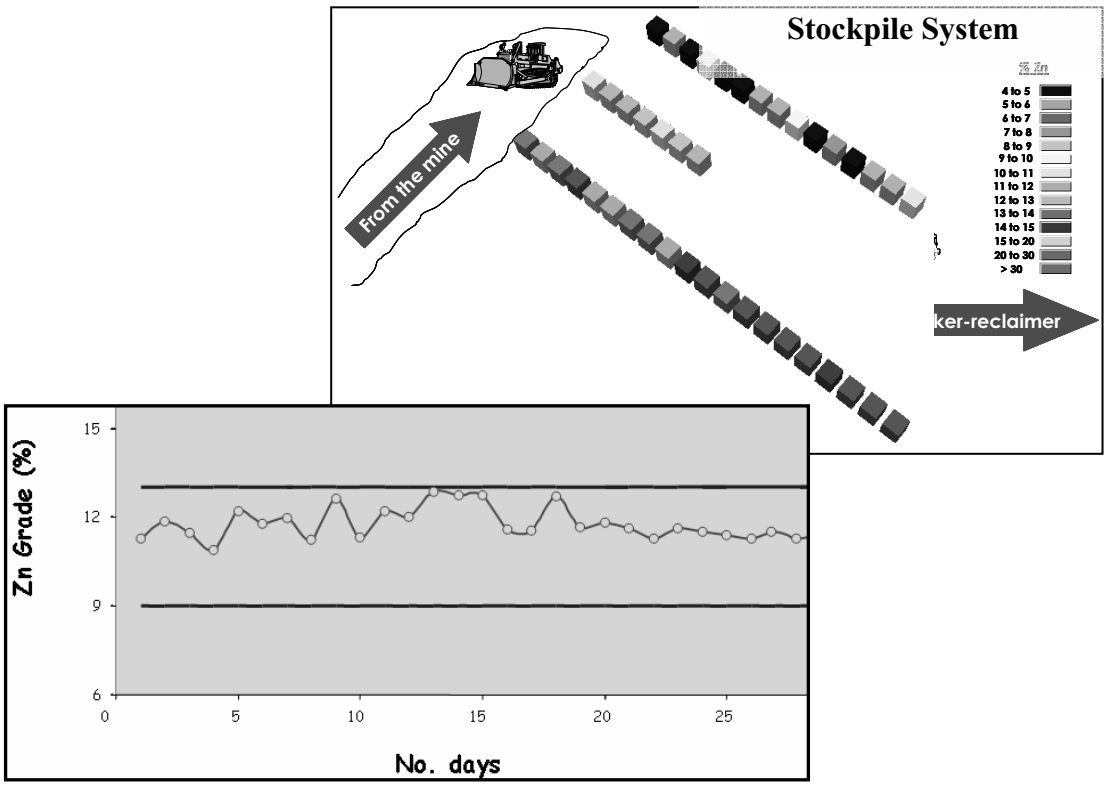

Figure 3. Ore is tipped at stockpiles (high-, medium- and low- grades) from which it is reclaimed and blended for the metallurgical plant.

4. CONCLUSIONS

The operational requirements at Skorpion mine are such that a complex system is in place that is capable of a high degree of control and selectivity.

A dedicated team of grade control operators undertake blast hole sampling, spot grade perimeters in the open-pit and control loading and dumping of material to and from low, medium and high grade ore stockpile destinations.

Quality control ensures that grade control samples are representative and laboratory biases are minimised. Laboratory assays are confirmed correct to within a defined degree of accuracy and precision and the presence of "carryover" contamination between sample is monitored.

Mining equipment implemented for ore extraction is optimal for selective mining. Disciplined blasting, loading and hauling of material from the pit to various destinations and recordings in a well-managed tallies database are important for effective grade control and blending. This allows for a continuous feed through elimination of fluctuations resulting in homogenised feed grade.

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