THE IMPORTANCE OF MINERALOGICAL CHARACTERISATION IN MINE PIT LAKE WATER QUALITY PREDICTIONS: COPPER FLAT PROJECT, NEW MEXICO

R.Warrender[1], R.J.Bowell[1], A.Prestia[2], C.Brough[1]

[1] SRK Consulting (UK) Ltd., Churchill House, 17 Churchill Way, Cardiff CF10 2HH, UK

[2] SRK Consulting (US) Inc., Suite 300, 5250 Neil Road, Reno, Nevada, 89502, USA

Introduction

The Copper Flat project is a porphyry copper-molybdenum deposit located on the western margin of the Rio Grande Rift in South Central New Mexico. The deposit is hosted by a small quartz monzonite stock that intrudes a sequence of andesitic volcanic rocks. Copper exploration at the Copper Flat site began in the 1950s and continued to the early 1980s, when Quintana Minerals Corporation defined 60 Mt of reserves sufficient to operate for a 10 year mine life at an extraction rate of 15,000 tons per day (tpd). Operations included the development of the open pit, waste rock piles and tailings storage facility, but mining stopped after 3 months due to low metal prices. No commercial mining activities have occurred at Copper Flat since 1982; however during the late 1980s and 1990s a pit lake has developed in the existing pit

New Mexico Copper Corporation (NMCC) is currently undergoing permitting activities with the aim of re-opening and expanding the project facilities. As part of the rigorous environmental studies being undertaken for the permitting process, an extensive geochemical characterisation program was undertaken, including the development of a predictive geochemical model to assess potential future pit lake chemistry for the project.

The existing pit lake at Copper Flat provides a valuable analogue of likely future pit lake chemistry. Evaluation of the existing pit lake chemistry does not indicate the presence of a chemocline or any chemical stratification in the lake although a seasonal thermocline does develop. The pit lake itself is circum-neutral pH at surface and close to gypsum saturation in terms of calcium and sulfate concentrations. Precipitated mineral salts are present along the lake shore and characterisation of these precipitates allows for a more detailed understanding of mineral precipitation and adsorption processes within the existing lake. These findings can then be incorporated into the pit lake geochemical predictions to provide a more accurate prediction of likely future pit lake chemistry.

Methodology

A predictive geochemical model for the future Copper Flat pit lake was developed using the results of geochemical and mineralogical testwork and was calibrated to the existing pit lake to ensure all active geochemical mechanisms could be accounted for. In order to develop representative pit wall rock source terms for input to the geochemical model, a total of 32 humidity cell tests (HCT) were run for between 28 and 122 weeks. The HCT results were coupled with mine plan, geologic, hydrogeologic, climate and hydrogeochemical information to develop numerical predictions of future pit lake water quality using the USGS software PHREEQC.

To support the geochemical modelling, a detailed mineralogical study was undertaken on 28 samples of representative pit wall rock material, including optical microscopy, scanning electron microscopy (SEM) and X-Ray Diffraction (XRD). The purpose of the mineralogy work was to assess the controls on acid generation and solute release from the pit wall rocks and to identify secondary minerals that may influence future pit lake chemistry. The results of the mineralogy study were used to define appropriate mineral equilibrium phases for input to the PHREEQC model.

Results

The results of the pit lake geochemical prediction model showed good calibration for pH, alkalinity, calcium, cadmium, cobalt, copper, magnesium, manganese, sodium, zinc, sulfate and TDS within the existing pit. This demonstrates that these constituents can be predicted with reasonable accuracy for the future pit lake. However, a number of trace constituents showed either positive or negative bias in the pit lake calibration model, indicating that there may be additional geochemical or mineralogical processes that were not fully accounted for in the model.

In order to better define mineral precipitation and adsorption processes within the existing lake, an additional seven mineralogical samples were collected from precipitated salts around the rim of the existing pit. These samples were collected from transects through the different coloured mineral salts that had precipitated over time above the water line, representing changes in lake level. The mineralogy and geochemistry of these samples were assessed by XRD, multi-element assay and leach tests.

The results of the mineralogy work confirmed that copper, cadmium, and selenium are significant trace elements in the gypsum crust surrounding the existing pit lake at Copper Flat, present to varying degrees in all of the observed layers. In addition minor amounts of lead, zinc, manganese, iron and molybdenum are also present in different layers of the salts. Although gypsum was identified as the major mineral in the crust, minor amounts of brochantite, epsomite, halotrichite, langite, pickeringite and Na-metaschoepite were also observed. From electron microscopy, goethite and malachite also appear to be present. Colouration differences of the gypsum crust were related to varying trace metal content, reflecting changes in the lake chemistry and levels. Analysis of these precipitates reveals variable enrichments of several elements, particularly copper. Copper also showed mobility during the leach tests, indicating it may be rinsed from the precipitated salts. Precipitation of these salts forms an important attenuation mechanism for trace elements and represents a major control on pit lake chemistry at Copper Flat. However, flushing of the pit walls by meteoric water could also release these elements back into the pit lake. In order to account for these mechanisms in the PHREEQC predictive calculations it is justified to include the sulfate minerals or compounds of the trace elements as potential saturated solids in the pit lake modelling. The precipitation of these salts is important in pit lake geochemical predictive calculations as it represents a potentially significant control on pit lake water quality.