ATTACHMENT 1
RESPONSES TO NMED
CONDITIONAL APPROVAL LETTER,
CONDITION NO. 85, DP-1403

1.0 INTRODUCTION

Cobre Mining Company (Cobre) has received comments from the State of New Mexico Environment Department (NMED) on the Continental Mine Pit Lake Formation Model (Condition No. 85, DP-1403). The comments were provided in a letter from Kurt Vollbrecht (NMED) to Timothy Eastep (Cobre) dated July 5, 2006, granting conditional approval of Condition No. 85. The NMED comments are provided in Section 2.0 (shown in italics) with Cobre's responses immediately following the comment in plain text.

2.0 COMMENTS AND RESPONSES

*1) **Section 4.0, Continental Pit Conceptual Model**: The conceptual model in the Plan ignores limnological effects, such as pit lake stratification, oxidation-reduction, and overturning. The conceptual model should address the likely pit lake chemistry including the expected chemical evolution during filling, solubility limits on water chemistry, likely precipitates, pH and redox state.*

The conceptual model now includes an analysis of how the Continental pit lake will stratify and turnover, as well as the effect of stratification on oxygen dynamics and oxidation-reduction potential. The analysis of stratification, oxygen dynamics and oxidation-reduction potential is discussed in detail in Attachment 2.

The conceptual model for the evolving chemistry of the lake is described in detail in Section 2.2 of the report. A discussion of how the gross inputs of chemicals to the pit from all sources are calculated on a daily basis is presented in section 4.1.1. The report includes a discussion (Section 4.2) of the assumptions made (e.g., oxidation-reduction potential, allowed precipitates, and pH) to take the gross chemical composition to a net chemical composition using a thermodynamic equilibrium model, at various times while the lake is developing.

*2) **Section 4.6.1, Rate and Mass of Constituent Release:** a) In determining wall rock oxidation rates from humidity cell tests and transferring that data to the field setting, uncertainties related to the following should be addressed in the conceptual model:*

extent of weathering of the sample and how that compares to waste or wall rock, how much the sample was crushed, how long the test was run, and whether there was an initial flushing.

The laboratory humidity cell test procedure, as well as results and how they are interpreted and applied to the field setting is discussed in Section 3.2.4. This section has a detailed discussion of how disparities between laboratory and field conditions are accounted for in the model.

(b) Test results are usually reported as mg solute/kg of sample per week. Results in the report are presented as mg solute/kg of sample (the rate must be implied in the workplan, but not given). Often a scaling factor is used to account for the differences in reactive surface area between the HCTs and waste or wall rock. The plan does not mention any such scaling factor.

The initial test results were plotted as mg solute/kg of sample/week, however, the cumulative quantities were then calculated and plotted in order to calculate mg solute/kg sample at any future time. A new approach to quantifying the rate of rock weathering was developed that not only accounts for the differences in reactive surface area between the HCTs and wall rock, but also avoids the need for adding a scaling factor. This is discussed in detail in Section 3.2.2. Essentially, the HCT data are interpreted as a reaction front velocity that penetrates the exposed/reactive surfaces of rocks. The velocity from the HCTs is applied directly to the surface area of wall rocks to determine the volume of rock oxidized. The surface area of wall rock includes internal cracks. So instead of using a surface area scaling factor to adjust the reaction rate, the approach developed uses the same reaction rate for both HCT material and wall rock and applies it to the available surface area. Using a scaling factor would result in the same predictions, however, the approach developed here is mechanistically more accurate.

To account for the disparity in the frequencies of wetting and drying cycles (oxidation cycles) between the HCT field, the climate data for the site was evaluated and a scaling factor was introduced. This is discussed in Section 3.2.5.

c) To determine the average oxidation (sulfate release) rate in the pit, a better procedure may be to weight the average oxidation with the fraction of surface area exposed for each formation in the submerged pit wall at a given time.

Agreed. However, instead of using an average oxidation rate for the whole pit that is weighted by the fraction of area of each formation exposed on the pit wall, the model now uses individual oxidation rates for each formation and applies that rate to the fraction of each formation exposed on the pit wall. The approach is discussed in detail in Section 3.2.2 and 4.1.1.

*3) **Section 4.6.2, Extent of Wall Rock Oxidation:** a) It is not clear from the Plan if the Davis-Ritchie model of sulfide oxidation kinetics is to be handled numerically or if an analytical approximation is to be used (although as only the average thickness of the oxidized wall rock seems to be required, one will assume the latter will be used). The Plan should explicitly list the model equations to be solved, assumptions implicit in the applicability of the equations, and should include preliminary results and a sensitivity analysis of the various parameters (particularly the diffusion coefficient within the particles, D_2).*

The model no longer uses calculations from the Davis-Ritchie model. Attachment 3 discusses why the Davis-Ritchie model is not applicable.

b) The estimation of wall rock oxidation introduces an inconsistency in the modeling results: the Plan proposes use of the Davis-Ritchie model to estimate the amount of advancement of oxidized wall rock zones, and then use of HCT results to yield the amount of oxidized reaction products from the overall volume of oxidized wall rock.

Agreed. Please refer to attachment 3 for a detailed discussion of these issues.

c) As above, the release rates of metals should reflect the actual surface and volumes of formations submerged by the rising pit lake level, and not a simple numerical average of HCT results presented in Table 4.

Agreed. The model now uses the specific release rate (oxidation rates) for each formation and applies that rate to the actual area of that formation submerged in that time step. This is discussed in more detail in Section 3.2.2.

4) 4.7 Geochemical Modeling Procedures: a) The Plan should indicate what database and activity coefficient model will be used in the PHREEQC modeling and describe how oxidation/reduction processes will be handled.

The pit lake model utilizes the MINTEQ database which was developed by the U.S. Environmental Protection Agency (Allison and others, 1991). The MINTEQ database was used for this study because it represents an extensive compilation of thermodynamic data adequate for addressing a broad range of geochemical conditions involving metals. Activity coefficients for ion pairs and complexes uses the Davies Equation which is valid to ionic strengths up to approximately 0.5 molal.

b) The Plan should indicate whether the DSM is linked to the PHREEQC output or if the DSM will be run first, and then fed to the PHREEQC model.

The DSM and chemical equilibrium models are used in sequence. First, the DSM calculates the gross amount of solutes that enter the pit to yield unequilibrated concentrations. Then, at several points in time while the pit is filling, the unequilibrated concentrations are entered into PHREEQC and equilibrated with the wall rock and atmosphere. This is discussed in more detail in Section 4.2.

c) The Plan should indicate whether the surface area of ferrihydrite available for metal adsorption will change with time or remain at some constant level characteristic of the initial amount.

A surface area of 100,000 m^2/g was used for ferrihydrite. In the model, the total surface area available for adsorption changes dynamically and is proportional to the mass of ferrihydrite predicted to precipitate. The model does not include aging of ferrihydrite to reduce its specific surface.

d) The Plan should indicate whether other minerals, if determined to be supersaturated by the modeling, will be permitted to precipitate, rather than restricting precipitating phass to those mentioned in Table 6.

Thirteen minerals were permitted to precipitate and these are listed in Table 12 of the report. The PHREEQC input file is provided as attachment 4.

3.0 REFERENCES

Allison, J.D., D.S. Brown, and K.J. Novo-Gradac. 1991. MINTEQA2/PRODEFA2, A Geochemical Assessment Model for Environmental Systems. Version 3.0 User's Manual. Environmental Research Laboratory, Office of Research and Development, U.S Environmental Protection Agency, Athens, Georgia. 106 pp.

Cobre Mining Company   5   *Telesto Solutions, Inc.*

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