

Information Request 6

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IR 6 – Geochemistry – Metal Leaching / Acid Rock Drainage Characterization

References:

EIS Guidelines, Sections 2.2.5, 2.7.2.1 and 2.8.1
EIS, Section 2.7.2.1

Related comments:

CEAR # 272 (Natural Resources Canada)

Rationale:

According to Natural Resources Canada (NRCan), metal leaching/acid rock drainage (ML/ARD) resulting from the proposed project operations is not expected to cause significant impacts, provided that the Proponent is committed to:

- Applying criteria put forward for the separation of PAG and non-PAG materials (i.e. $(NP-10)/AP < 2$); and
- Executing planned adaptive management measures upon observing upsetting monitoring results.

However, NRCan notes that the determination of carbonate-NP and time of onset for acid generation is not clearly presented. In particular, the calculation of the inorganic carbon contained in calcium and magnesium carbonate minerals (ICCaMg), as an indicator of effective carbonate neutralization potential involves what NRCan considers questionable assumptions.

NRCan further notes that the development of the equation for delay to ARD onset (p. 487) is not clearly described, and the assumption of a direct linear relationship between oxidation rate and sulphur content is not satisfactorily substantiated. These should be addressed.

Information Requested:

The Panel requests that Taseko:

- a. Justify assumptions made in Section 2.7.2.1 of the EIS regarding the calculation of the inorganic carbon contained in calcium and magnesium carbonate minerals, as an indicator of effective carbonate neutralization potential.
- b. Clarify development of the equation to determine the delay to ARD onset and the assumption of a direct linear relationship between oxidation rate and sulphur content.

Information Request #6a

Justify assumptions made in Section 2.7.2.1 of the EIS regarding the calculation of the inorganic carbon contained in calcium and magnesium carbonate minerals, as an indicator of effective carbonate neutralization potential.

Response Summary

The assumptions used in the calculation of inorganic carbon contained in calcium and magnesium carbonate minerals are justified based on mineralogical and chemical work detailed below. They are based on sound science and result in a conservative indicator of effective carbonate neutralization potential.

Discussion

The primary assumptions that relate to using the approach described in the EIS to quantify effective carbonate neutralization potential are:

1. The carbonate grains examined in the supporting mineralogical characterization are representative of the waste rock.
 - Table 2.7.2.1-8 in the EIS indicates the combination of alteration types and rock types that were evaluated mineralogically. Review of the summary of waste tonnages by alteration type in EIS Table 2.7.2.1-16 shows that the mineralogical characterization samples represent the great majority of the waste rock that the project will produce.
 - It should be noted that the carbonate mineral compositions identified in the study were typical compositions for the individual carbonate species.
2. That geochemical conditions in the full-scale waste rock dump will promote oxidation of iron and manganese released through carbonate dissolution.
 - This assumption requires that sufficient oxygen is available throughout the dump to cause iron and manganese to oxidize from the respective reduced forms which are released during carbonate dissolution to the respective oxidized forms. When the reduced forms of iron and manganese oxidize, protons (H⁺) are generated; these protons offset the alkalinity that is generated by the carbonate dissolution, with the result that (under oxidizing conditions) there is no net neutralization potential from pure iron and manganese carbonate minerals. If conditions within the dump are not sufficiently oxidizing, the reduced forms of iron and manganese will not fully oxidize, and to the extent that reduced forms of iron and manganese exit the waste rock dump via seepage pathways, the protons generated during oxidation will not deplete neutralization potential within the dump itself.

The basic method of calculating the inorganic carbon contained in calcium and magnesium carbonate minerals (ICCa,Mg) for each sample was as follows:

- Bulk mineral composition was determined by x-ray diffraction with Rietveld refinement (QXRD), including the proportions of the carbonate minerals calcite, dolomite-ankerite, and siderite;
- Microprobe analyses on carbonate grains that were identified via optical petrography were carried out to define the proportions of each cation (calcium, magnesium, iron or manganese) in each grain probed;
- Average cation content for each mineral was calculated and used to define a representative stoichiometry for each type of carbonate mineral (provided in Table 2.7.2.1-9 of the application);
- The calcium and magnesium carbonate content was then calculated based on the representative stoichiometry by the method summarized on p. 462-463 of the application.

It should be noted that the adoption of ICCa,Mg as a measure of neutralization potential ignores the contributions of other neutralizing minerals to the actual capacity of New Prosperity waste rock to neutralize acid; this approach is considered to be appropriate, but it does contribute to the conservative nature of the approach to ARD classification.

Figure 2.7.2.1-34 in the EIS illustrates that the mineralogically-determined neutralization potential due to calcium and magnesium carbonates correlates well with the neutralization potential determined via routine titration tests. As presented in the EIS, the estimation of the quantity of PAG waste rock assumed 10 kg CaCO₃ equiv./tonne of titrated NP rock would not be available- the mineralogical study demonstrated that this approach was conservative.

Information Request #6b

Clarify development of the equation to determine the delay to ARD onset and the assumption of a direct linear relationship between oxidation rate and sulphur content.

Response Summary

The equation to estimate the delay to ARD onset was developed by estimating the rate of depletion of calcium and magnesium carbonate neutralization potential ($R_{IC\ Ca,Mg}$) due to sulfide oxidation under neutral pH weathering conditions, and then calculating the time required to deplete the calcium and magnesium carbonate content (t_{onset}) in individual samples and allow the development of acid weathering conditions.

The assumption of a linear relationship between oxidation rate and sulfur content assumes that oxygen concentrations are not limiting and that sulfide minerals are exposed to oxygen rather than being occluded by either primary minerals or by weathering rinds. Provided oxidation is not limited by lack of oxygen or lack of sulfide grain exposure, the bulk rock oxidation rate (and therefore the acid production rate) of a waste rock mass will be a function of the sulfide mineral content of that rock.

It should be noted that the estimates of delay to ARD onset are not particularly critical for PAG waste rock that will be saturated within 2 years after being mined, given that the lag time is expected to be considerably greater than the exposure period. For the final pit walls, delay to ARD onset will be more material, and monitoring of development of acid weathering conditions will be necessary to validate the pre-production assessment.