Predicting ML/ARD from Low Sulphide and Low Neutralization Potential Waste Rock; Baffinland Iron Mines Mary River Project, Nunavut, Canada

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Abstract

Baffinland Iron Mines (Baffinland) is developing an iron ore mine on northern Baffin Island, Nunavut, Canada. Mining, currently scheduled to commence in 2016/2017, is expected to generate some 570 Mt of waste rock. The footwall to the deposit mainly consists of gneiss with minor schist, psammitic gneiss and amphibolite. The hanging wall is primarily composed of schist and volcanic tuff with lesser amounts of amphibolite and metasediment. From an ML/ARD perspective, the waste rock at the site is broadly characterized as having low contents of sulphide and low neutralization potentials that are dominated by non-carbonate minerals. All rocks have low to moderate NP, mean value of 22 kg $CaCO_3$/t with only a fraction of this attributed to carbonates. Mean sulphide content of the samples tested was 0.2% leading to some 13% of samples having a neutralization potential ratio (NPR) < 2. Prediction of the ML/ARD potential of low sulphide, low NP material is often challenging. Therefore prediction of the long term behavior of these materials has been a focus of the Baffinland project in order to optimize the waste management and mitigation plans for the development.

Key Words: low carbonate neutralization potential, ABA, humidity cells

Introduction

Baffinland Iron Mines (Baffinland) is planning to mine iron ore at their Mary River site located on the northern half of Baffin Island (Figure 1), in the Qikiqtani Region of Nunavut, approximately 160 km south of Pond Inlet (Mittimatalik), 270 km south-east of Nanisivik, 300 km north of Hall Beach, and 1000 km north-west of Iqaluit, the capital of Nunavut Territory, Canada. This area experiences a mean annual temperature of approximately -12ºC and monthly averages below -20ºC from December to March. Above freezing temperatures occur only from June to August, with an average high of 4.4ºC in July. There are currently five deposits of potential economic interest that have been well defined near the Mine Site area. The most advanced mining exploration development relates to Deposit No.1, which is currently the largest and best known of the economic deposits at the site.

The current projected life of mine is about 21 years based on reserves in Deposit No.1. The proposed mine will include the open pit, crushing and screening facilities, and the ore and waste rock storage facilities. The dimension of the ultimate open pit will be approximately 2,000 m in length, 1,200 m in width and range from 195 m on the south side to 465 m on the north side in depth (Aker Kvaerner, 2008). A railway will be constructed to connect the Mary River site to Steensby Port, where ore from the operation will be shipped year round and loaded on ore carriers year round (Baffinland, 2008).

The economic iron deposits at the Mary River project represent high-grade examples of Algoma-type iron formation. Approximately 365 Mt of ore will be produced at the Mary River Project (Aker Kvaerner, 2008). Deposit No. 1 ores contain magnetite and hematite in different proportions. About 570 Mt of waste rock are anticipated to be produced during the life of the mine.

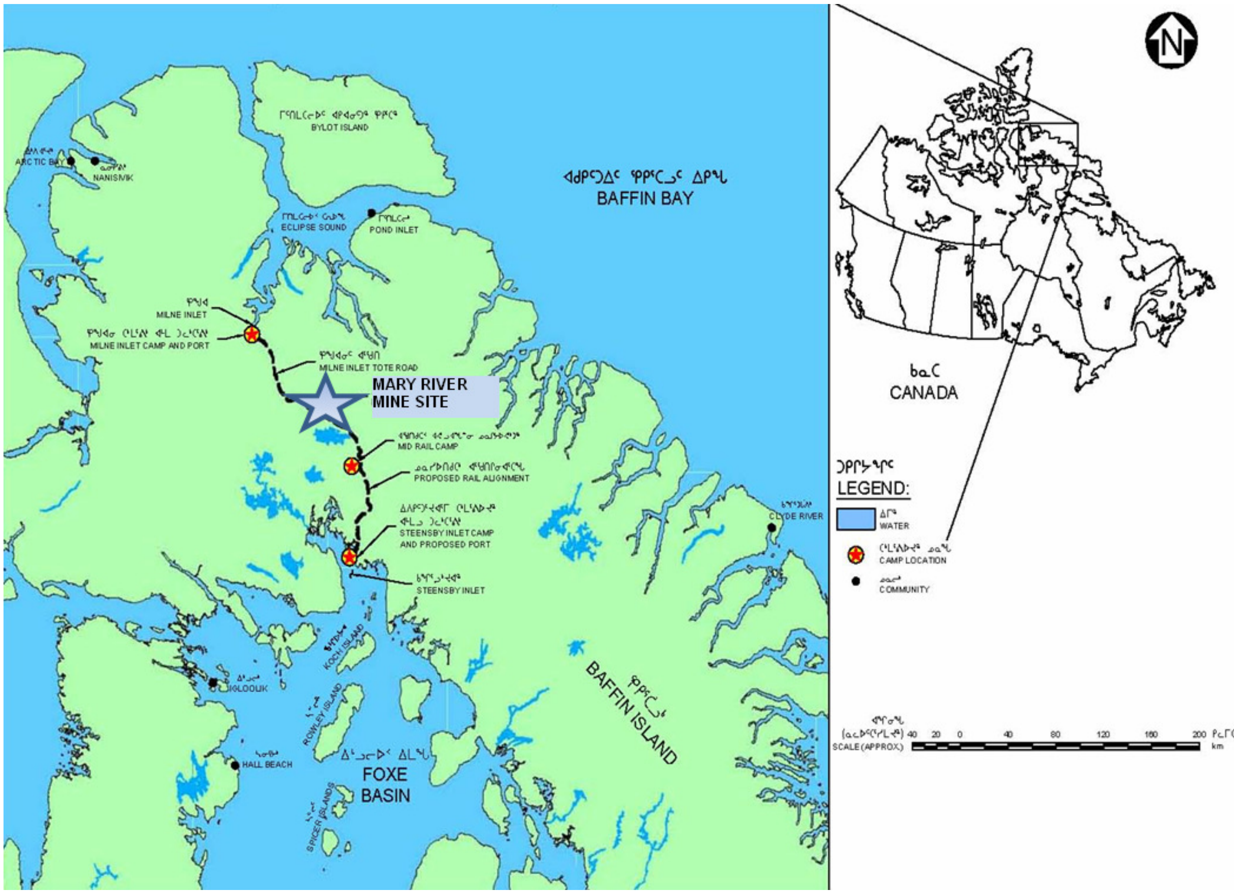

Figure 1. Site Location

From an ML/ARD perspective, the waste rock at the site is broadly characterized as having low sulphide and low neutralization potentials that are dominated by non-carbonate minerals. Some of these materials have been identified as being potentially acid generating (NPR < 2). Prediction of the ML/ARD potential of low sulphide, low NP material is often challenging. Therefore prediction of the long term behavior of these materials has been a focus of the Baffinland project in order to optimize the waste rock management and mitigation plans for the development.

Geology

Regional Geology

The northern part of Baffin Island consists of the ca. 3.0-2.5 Ga Committee Fold belt which lies within the Rae domain of the western Churchill Province (Jackson and Berman, 2000). The Committee belt extends north-east for around 2000 km from south-west of Baker Lake, Nunavut Territory to northwestern Greenland. Four major assemblages of Precambrian rocks have been identified within the Committee Belt. The iron ore deposits occur as part of the supra-crustal rocks of the Neoarchean aged (2.76-2.71 Ga) Mary River Group in the region. The Central Borden Fault Zone passes within 1 km to the south-west of the site. This fault separates the highly deformed Precambrian rocks to the north-west from the early Paleozoic relatively flat lying sedimentary rocks to the southwest.

The generalized stratigraphic sequence of the Mary River group from top to base according to Young *et al.* (2004) and Johns and Young (2006) is:

- interbedded ultramafic and intermediate volcanic rocks;
- quartzite;
- algoma–type oxide– and silicate–facies iron formation;
- amphibolite; and
- psammite and sedimentary migmatite.

The thickness of individual units varies considerably across the area. Ultramafic and gabbroic intrusions in the form of small sills and dykes (<10 m in thickness) may occur within the sedimentary rocks, iron formation and amphibolite units (Johns and Young, 2006). Locally these intrusions have been observed to contain thin sulphide veinlets and disseminated sulphides. At the deposit scale, the overall sequence can be complicated by inferred early isoclinal folds and ramp and flat thrust faults (Young *et al*., 2004) which create complex and variable stratigraphic relationships. The contact between the Mary River group and gneiss basement rock is generally not directly exposed, being obscured by younger granitic intrusions.

Iron formation within the Mary River Group occurs as an oxide- and silicate- facies unit. Oxide facies iron formations vary from lean magnetite-chert to iron-ore quality deposits of magnetite and hematite (Johns and Young, 2006). Genesis of high grade iron ores is the result of the Hudsonian age deformation and metamorphism of enriched Archean Banded Iron Formation. The silicate–facies iron formation is generally thin and found in association with the oxide–facies, although it also occurs on its own. It commonly contains coarse garnet, anthophyllite, cummingtonite, and actinolite porphyroblasts.

Deposit Geology

Deposit No.1 occurs at the nose of a syncline plunging steeply to the north-east (Aker Kvaerner, 2008). The iron formation occupies the nose and two limbs of this feature with an ~1300 m long northern portion and an ~700 m long southern portion. The footwall to the iron formation mainly consists of gneiss with minor schist, psammitic gneiss (psammite) and amphibolite. The hanging wall is primarily composed of schist and volcanic tuff with lesser amphibolite and metasediment.

The hanging wall primarily encompasses chlorite–actinolite schist and garnetiferous amphibolites. Meta-volcanic tuff is also a significant lithology identified in the hanging wall. The footwall mainly consists of quartz-feldspar-mica gneiss with lesser meta-sediment (greywacke) and quartz-mica schist. Microcline and albite are the predominant feldspar within the gneiss and biotite is generally more abundant than muscovite.

The iron ore deposits at the Mary River project represent high-grade examples of Algoma-type iron formation and are composed of hematite, magnetite and mixed hematite-magnetite-specular hematite varieties of ore (Aker Kvaerner, 2008). The iron deposits consist of a number of lensoidal bodies that vary in their proportions of the main iron oxide minerals and impurity content of sulphur and silica in the ore. The massive hematite ore is the highest grade ore and also has the fewest impurities, which may indicate it was derived from relatively pure magnetite or that chert, quartzite and sulphides were leached and oxidized during alteration of the iron formation.

Intense deformation and lack of outcrop limit the ability to subdivide by lithology on the basis of future mined tonnages. Rather, the waste material has been subdivided on the basis of zonal relationships around the iron ore as described in Table 1.

Table 1. Summary of Waste Types and Tonnages

Waste Type	In-Pit Tonnage (t)	% of Waste	Lithologies (in approximate order of abundance)
Hanging wall (HW)	114,506,831	20.0	meta-volcanic (tuff); greywacke; amphibolite; chlorite, mica or amphibole schist; ultramafite; and gneiss
Hanging wall schist (HWS)	103,479,188	18.1	chlorite, mica, or amphibole schist; amphibolite; greywacke; and meta-volcanic (tuff)
Internal waste (IW)	2,982,893	0.5	schist; amphibolite; and meta-volcanic (tuff)
Deleterious ore (DO)	13,672,193	2.4	High grade iron formation (elevated Mn, S or P); and banded iron formation
Footwall schist (FWS)	45,917,213	8.0	chlorite, mica, or amphibole schist; gneiss; greywacke; amphibolite; and meta-volcanic (tuff)
Footwall (FW)	291,226,388		