INFORMATION PROVIDED BY POLYMET REGARDING WASTE ROCK CLASSIFICATION AND MANAGEMENT

1.0 Introduction

The waste rock management plan for the NorthMet Project[1] (Project) incorporates a waste rock segregation strategy that is designed to mitigate potential impacts to surrounding water resources, while minimizing the need for long-term mechanical treatment of mine-impacted water. This plan segregates waste rock into three different categories, each reflecting the different potential of the rock to result in acidic drainage and/or drainage with elevated metals. This waste rock classification system uses the following sulfur contents as cut-off criteria:

- Category 1: sulfur content less than or equal to 0.12%
- Category 2/3: sulfur content greater than 0.12% and less than or equal to 0.60%
- Category 4: sulfur content greater than 0.60%

This memo describes the development and implementation of the waste rock classification system for the Project, specifically: 1) the methodology used for the development of the waste rock classification system; 2) how this waste rock classification system is implemented within the Project's current waste rock management plan; and, 3) a comparison between the waste characterization program used to develop the classification system for the Project with guidance provided by a variety of recognized sources.

2.0 Development of Waste Rock Classification System

The majority of the technical basis for the Waste Rock Classification System, and the resulting sulfur cut-off criteria, is documented in "RS53/RS42 - Waste Rock Characteristics/Waste Water Quality Modeling - Waste Rock and Lean Ore – NorthMet Project – DRAFT."[2]

2.1 Objectives for RS53/RS42 Waste Rock Classification System

The waste rock classification system defined in RS53/RS42 was developed to identify one or more parameters that could be easily measured during mine operation and would correspond to the quality of drainage associated with waste rock likely to be managed at the Project site.

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[1] The NorthMet Project Description and the Waste Rock Management Plan have evolved during the iterative processes of mine planning, water quality modeling, and environmental impact assessment. References to the "NorthMet Project" in this memo refer to the current Project, as of July 2014, unless otherwise noted. The project description is detailed in:

PolyMet Mining Inc. NorthMet Project Project Description (v5). March 2013.

Citations for specific Project documents are provided in footnotes throughout the text.

[2] SRK Consulting Engineers and Scientists. RS53/RS42 - Waste Rock Characteristics/Waste Water Quality Modeling - Waste Rock and Lean Ore – NorthMet Project - DRAFT. [RS53/RS42 Draft-01]. March 2007

Criteria using the parameter(s) were proposed with the objective of defining categories of waste rock that would exhibit the following distinct sets of geochemical characteristics:

A. "Non-reactive" waste rock suitable for construction with negligible potential for acid rock drainage (ARD) and metal leaching; expected to produce component concentrations in drainage below water quality objectives.
B. Waste rock with negligible potential to produce ARD but likely to have drainage with component concentrations exceeding water quality objectives.
C. Waste rock with potential to produce ARD, but with significant delay. Component concentrations are expected to exceed water quality objectives by a wide margin.
D. Waste rock with potential to produce ARD immediately. Component concentrations are expected to exceed water quality objectives by a wide margin.

The development of the waste rock classification system led to the conclusion that none of the recognized categories of waste rock would entirely fulfill the criteria for "non-reactive" rock. The system did define categories of waste rock that fulfilled the other three sets of geochemical characteristics (B, C and D, above).

2.2 Design Basis for RS53/RS42 Waste Rock Classification System

2.2.1 Geochemical Background Material

Identification of potential parameters that could be used for waste rock classification was made with the aid of an extensive body of research conducted by scientists at Minnesota Department of Natural Resources (MDNR) on environmental behavior of Duluth Complex rocks. This research also provided corroborative lines of evidence for classification cut-off criteria. The following MDNR work was identified as geochemical background material for the development of the waste rock classification system:

- **AMAX Shaft:** Six approximately 1000-ton field leach piles were constructed using Duluth Complex rock from the Babbitt Deposit that was excavated during the development of an exploratory shaft by AMAX in 1977. MDNR studied the physical characteristics of these piles and monitored the drainage from 1977-1994.

- **AMAX Drill Core Tests:** Parallel to the field leach piles, MDNR conducted 24 weathering experiments on 75-g samples of AMAX drill core that had been crushed and sieved to -100+270 mesh. These experiments were run from 30 to 49 weeks.

- **AMAX Particle Size Experiments:** An additional set of parallel 75-g sample weathering experiments were conducted on size segregated samples from one of the AMAX Field Leach Piles. Approximately 10 years of leachate data from these experiments was included within the geochemical background material for RS53/RS42.

- **Dunka Pit Stockpiles:** Eight stockpiles containing primarily Duluth Complex rock were constructed in order to access iron formation ore at Dunka Mine, beginning in the 1960s. MDNR has conducted a number of field studies on drainage from these stockpiles and treatment approaches. Due to the origin of the stockpiles, there is considerable uncertainty in their rock and chemical composition. While these studies are acknowledged in RS53/RS42, they are not considered to be appropriate analogues for future NorthMet waste rock stockpiles.

- **Dunka Blast Holes Samples:** A set of 20 samples total of Duluth Complex and Virginia Formation rocks collected from blast holes at Dunka Pit were subject of weathering experiments in MDNR-style 75-gram reactors. These experiments began to be initiated in 1989 and were terminated at various times with select experiments ongoing. During the development of the RS53/RS42 waste rock classification system, leachate data was available for experiments with durations ranging from 78 to 923 weeks.

- **Babbitt and Dunka Road (NorthMet) Deposit Samples:** A program was initiated in 2003 to compare weathering tests conducted using MDNR 75-g reactor and ASTM humidity cell test designs. In this program, 10 Duluth Complex samples were tested (7 from the Babbitt Deposit and 3 from Dunka Road, the same area as NorthMet deposit) using both reactor types. During development of RS53/RS42 Waste Classification System, 170 weeks of data from these experiments were provided.

In light of this geochemical background material, the following potential parameters for waste classification were identified:

1) silicate mineralogy (corresponds with rock type);
2) sulfur content and sulfide mineralogy;
3) copper and nickel content; and
4) particle size of potential future waste rock.

In order to identify which of these parameters might be useful for waste classification, an evaluation was conducted to assess relationships between these parameters and sulfide oxidation rate[3] (the primary driver for ARD potential), and release rates for copper, nickel, and cobalt.

The evaluation for the first three factors listed above was made by comparing the release rates from Project humidity cell tests (HCT) and bulk mineral and chemical characteristics measured for these HCT samples. The evaluation of the fourth factor was conducted by comparing the release rates from five Project experiments using size-segregated samples.

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[3] Sulfide oxidation rate is reflected in HCT data as sulfate release rate.

2.2.2 Humidity Cell Test Program

The release rate data from the Project HCT program form a large portion of the technical basis for both the selection of appropriate classification parameters and the identification of classification criteria.

2.2.2.1 Sample Selection for Humidity Cell Tests

The samples used for the HCT program were selected to be representative of the range in characteristics of potential future waste rock that would be managed during operations. Prior to initiation of the kinetic testing program for the Project in August 2005, a sampling matrix was developed through a series of discussions between MDNR, SRK, and Poly Met Mining Inc. (PolyMet), and evaluation of available data, including the December 2004 PolyMet geologic and assay database and the February 2005 Block Model (matrix is included as Appendix A). The selection of HCT samples was conducted by querying the drill core database to identify drill core intervals that fulfilled bulk chemical and lithological characteristics targeted by the sampling matrix.[4] Because the HCT sample selection process in 2005 proceeded the development of the waste rock classification system, rocks were designated according to provisional segregation criteria into the following categories: “non-reactive” (sulfur less than 0.05%); “reactive” (sulfur greater than 0.05% but not likely ore grade); and “lean ore” (rock with marginal ore grade, that may or may not be used as ore, depending on the Net Metals Value). These categories were intended to facilitate sample selection and then later be replaced by site-specific criteria through evaluation of the HCT data.

This process resulted in the selection of 82 unique waste rock samples for humidity cell testing. An additional 7 duplicate HCT were run, for a total of 89 waste rock HCT. Three samples representing ore composites were also submitted for HCT at approximately the same.

2.2.2.2 HCT Sample Characterization

Samples selected for humidity cell testing were subjected to the following physical, mineralogical, and chemical tests:

- Specific gravity
- Particle size distribution
- Optical mineralogy
- Microprobe analysis
- Total sulfur and carbonate

[4] HCT sample selection process is documented in Appendix A of RS53/RS42.

- Four-acid digestion followed by ICP analysis on 27 elements
- Aqua regia digestion followed by ICP analysis of 34 elements
- Whole rock oxides

In addition, five size fragments of each sample were individually subjected to total sulfur analysis and four acid digestion, with the digestate analyzed by ICP for 27 elements.

2.2.3 Static Test Program

The igneous Duluth Complex rock at Project does not contain significant carbonate minerals. Instead, neutralization potential is provided through kinetically-controlled dissolution of silicate minerals, in particular, Ca-rich plagioclase. Therefore, traditional acid-base accounting which balances the acid-generating potential (as represented by the total amount of sulfide sulfur) against the neutralizing potential (represented by the total amount of carbonate carbon in the sample) to determine whether the rock is potentially net acid-generating is not meaningful for predicting field conditions. As indicated in Section 2.2.2, the samples used in the 87 waste rock HCT (including splits for duplicates) and the 3 ore samples were analyzed for total carbonate carbon and total sulfur. Total sulfur is also measured as part of routine drill core chemical analysis. As of 2007, the Project drill core database contained at least 19,661 analyses for total sulfur.[5] By attributing no neutralizing potential to carbonate carbon, the waste classification system effectively assumes that there are no carbonate minerals in the rock. This assumption was confirmed for the HCT samples by traditional acid-base accounting techniques and optical mineralogy.

2.3 Waste Rock Classification System Methodology

The comparison of potential parameters that could be used for waste classification with HCT data indicated that sulfide mineralogy (specifically, whether the dominant sulfide mineral was pyrrhotite or chalcopyrite), total sulfur content, and particle size could all be correlated with sulfide oxidation rate (and, therefore, ARD potential). Of these three parameters, waste rock classification on account of sulfide mineralogy and total sulfur content could be best implemented during operations.

Based on the above findings, a method was used to develop criteria that would allow an initial level of classification into low-ARD potential and high-ARD potential categories. Details of the method used to define segregation criteria for this initial level of classification are provided in

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[5] A summary of sulfur analyses from the drill core database available at the time that the waste classification system was developed and a comparison to HCT samples and anticipated waste rock is presented in:
PolyMet Mining, Inc. RS78-Block Ore and Waste Surface Waste. [RS78-Draft 01]. March 2007.
The analytical methods used for characterization of drill core sample are described in:
PolyMet Mining Inc. ER03 - Geology Report. March 2007.

Appendix B. Generally, site-specific experimental and solids characterization data, as well as background geochemical information available at the time of RS53/42 development (approximately 2007), indicated that low level generation of alkalinity by silicate weathering should offset similarly low levels of acid generation by oxidation of sulfide minerals. Because oxidation rates are correlated with sulfide content, the critical level of oxidation at which alkalinity from silicate mineral weathering exceeds acid generation can be related to sulfide content, a measurable parameter during mine operation. The method used to develop criteria for low and high-ARD potential was:

1. Estimate bicarbonate generation rate from silicate minerals using samples containing low levels of sulfur and exhibiting lowest levels of alkalinity
2. Convert alkalinity generation rate to equivalent acidity generation rate expressed as sulfate generation
3. Determine regression relationships between oxidation rate (sulfate generation rate) and sulfur content

Humidity cell test data indicated that samples where chalcopyrite was the primary sulfide mineral (reflected in whole rock chemistry by Cu/S>0.3) were more reactive than samples where pyrrhotite was the primary sulfide mineral (whole rock chemistry with Cu/S<0.3). Therefore, the sulfur cut-off criteria for rocks dominated by chalcopyrite would be lower than those for which pyrrhotite dominated. For step 3, above, two regression relationships were developed, one for the chalcopyrite-dominated waste rock (Cu/S>0.3), the second for the pyrrhotite-dominated waste rock (Cu/S<0.3). These regressions are shown in Appendix B. The results are two categories of low-ARD risk waste rock (Category 1 and Category 2), shown in Table 2-1.

Table 2-1 Segregation Criteria Based on Initial Level of Evaluation (Modified from Table 6-2, RS53/RS42)

Cu/S Criteria	S Criteria		
	S<0.12%	0.12%≤S<0.31%	S≥0.31%
Cu/S<0.3	Low ARD risk (Category 1)	Low ARD risk (Category 2)	High ARD risk
Cu/S≥0.3	Low ARD risk (Category 1)	High ARD risk	High ARD risk

A second level of evaluation was used to separate rock that is expected to produce severe ARD rapidly from rock that will likely produce ARD at some in the future. The NorthMet kinetic test database, at the time of RS53/RS42 development, indicated that rapid (<1 year) onset to ARD can be expected for rock containing more than 1.7% sulfur. HCT leachate for samples with lower sulfur concentrations did not go below the pH of de-ionized water during that time period. The AMAX field leach piles, constructed out of Duluth Complex rock from a different site (Babbitt Deposit) and studied by MDNR, showed that rock with sulfur content of 0.79% and 1.4%

developed ARD, with pH less than 5, in about 1 year, whereas rock containing 0.64% sulfur took 6 to15 years. These findings have been used to propose a sulfur criterion of 0.6% to separate waste rock that will likely produce severe ARD rapidly (Category 4) from waste rock that will likely produce ARD at some point in the future (Category 3).

2.4 Comparison of Waste Rock Classification Criteria between RS53/RS42 and Current Project

The waste rock categories and classification criteria that result from the analysis in RS53/RS42 are:

Category 1: Sulfur content less than or equal to 0.12%S. This material will not generate ARD but may leach metals

Category 2: Sulfur content is greater than 0.12%S but less than or equal to 0.31%S with a Cu/S ratio of less than or equal to 0.3. This material will not generate ARD but may leach metals

Category 3: Material with greater than 0.12%S with a Cu/S ratio of more than 0.3 or a sulfur content greater than 0.31%S but less than or equal to 0.6%S. This material may eventually generate ARD and may leach metals

Category 4: Material with greater than 0.6%S and all Virginia Formation rock which will generate ARD rapidly and leach metals

Category 3 and Category 4 were further subdivided into waste rock and lean ore with the criteria for lean ore being economic rather than geochemical. Lean ore is material that is not economic at the time of mining but could become economic in the foreseeable future.

Criteria were re-considered in light of an additional 70 weeks of HCT data in RS82[6]. This analysis found that sulfide oxidation rates for lower sulfur samples had decreased somewhat, but the rate of alkalinity generation remained the same. This implies that the sulfur cut-off criteria developed in RS53/RS42 are slightly higher than they would be if the analysis were done using data from longer test durations in RS82; however, the criteria were not re-defined.

For the current Project, the classification system has been modified to not include the distinction between chalcopyrite or pyrrhotite dominated sulfide mineralogy (reflected by Cu/S ratio of rock). The resulting waste rock classification system is based entirely on sulfur content and, in

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[6] SRK Consulting Engineers and Scientists. RS82 - Update on Use of Kinetic Test Data for Water Quality Predictions – DRAFT 02. [RS82, Draft-02]. February 2009.

effect conservatively assumes that all sulfide minerals may be as reactive as chalcopyrite-dominated (most reactive) sulfide minerals. The current classification criteria[7] are:

Category 1: Sulfur content less than or equal to 0.12%. Material will not generate acid but may release metals

Category 2: Sulfur content greater than 0.12% and less than or equal to 0.31%. Material may generate acid and consequently release metals at higher rates than Category 1

Category 3: Sulfur content greater than 0.31% and less than or equal to 0.60%. Material will eventually generate acid and consequently release metals at higher rates than Category 2

Category 4: Sulfur content greater than 0.60%. Material will rapidly generate acid and consequently release metals at higher rates than Category 3

3.0 Implementation of Waste Rock Classification System

The overall objective of the NorthMet Project Rock and Overburden Management Plan[8] is to "provide stable and safe storage of the mine's waste rock and overburden in a manner that results in compliance with safety and environmental regulations". While specific aspects of the waste rock management plan have changed during the years of Project development,[9] the plan has always relied on the strategy of segregation of waste rock according to anticipated geochemical behavior of the rock, with engineered systems designed to meet water quality objectives for each waste rock type. During Project development from the years 2007 to 2014, the trend has been to incorporate additional mitigation measures in the management of all categories of waste rock and to streamline the classification system to facilitate implementation during operations.

The current Project proposes to segregate waste rock into three waste rock stockpiles: Category 1 Waste Rock stockpile, Category 2/3 Waste Rock stockpile, and Category 4 Waste Rock stockpile. The Category 2/3 and Category 4 Waste Rock stockpiles are backfilled into the East

[7]PolyMet Mining Inc. NorthMet Project Waste Rock Characterization Data Package (v10). March 2013.
[8]PolyMet Mining Inc. NorthMet Project Rock and Overburden Management Plan (v5). December 2012.
[9] Previous plans include the "Proposed Action" and "Reasonable Alternative 1" from the modeling of water quality impacts in:
PolyMet Mining, Inc. RS74A Surface Waste and Groundwater Quality Modeling: Mine Site Draft 02. [RS74-Draft 02]. September 2008.
Both plans use the waste rock classification system and criteria established in RS53/RS42 and propose to store waste rock in five stockpiles during operations. For the Proposed Action, the five stockpiles are: the Overburden and Category 1/2 Waste Rock Stockpile, the Category 3 Waste Rock Stockpile, the Category 3 Lean Ore Stockpile, the Category 4 Waste Rock Stockpile, and the Lean Ore Surge Pile. At closure, the lean ore stockpile would be removed, leaving four stockpiles remaining. In the Reasonable Alternative 1, the rock is segregated differently, so that Category 2 waste rock is managed with Category 3 rock, and not Category 1 rock. The Category 1 Waste rock stockpile is the only one that would remain on the surface post-closure; all other waste rock would be backfilled into the East Pit for subaqueous disposal in the latter years of operation.

Pit during operations for subaqueous disposal. The Category 4 Waste Rock stockpile is relocated first, a reflection of the anticipation that this rock category will produce ARD more quickly than Category 3 rock. The Category 1 Waste Rock stockpile is the only waste rock stockpile that will remain at the surface post-closure. This stockpile will be progressively reclaimed during operations. An engineered geomembrane cover will be implemented progressively starting in Mine Year 14 and will be fully installed by Mine Year 21.

4.0 Comparison of Waste Rock Characterization Program with Recognized Guidance

4.1 Industry Guidance for Waste Rock Characterization

In practice, the number of samples required to adequately characterize waste rock for a given project is site-specific and depends on the size and variability of the deposit, the statistical degree of confidence required, and the overall risk for ARD and/or drainage with elevated metals to occur on the site. Furthermore, geochemical testing refers to a host of techniques, and may be executed using a phased approach, with the first phase of geochemical investigation being a broad application of quick and relatively inexpensive tests on samples throughout the deposit, and subsequent phases consisting of more targeted, detailed analyses and involved test work on representative samples.

While a site-specific sampling plan is almost always recommended,[10] guidance has been provided by a variety of sources on recommended sampling frequency for geochemical characterization of mine waste, summarized in Table 4-1. Even for the references noted in Table 4-1, it should be noted that the numbers provided are offered as general rough guidelines, to be superseded by site-specific considerations. Alternatively, or as a supplement, information pertinent for waste rock characterization—such as percent sulfur, alteration, mineralogy—can be collected as part of the exploratory drilling program conducted for resource definition and block modelling.[11] In this case, as long as waste rock units are sufficiently included in the drilling program, geochemistry of the waste rock will be characterized with a similar level of confidence as the ore units.

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[10] For example:

Kentwell, D., Garvie, A., Chapman, J., Adequacy of Sampling and Volume Estimation for Pre-mining Evaluation of Potentially Acid Forming Waste: Statistical and Geostatistical Methods. Report by SRK consulting based on a paper presented in: Proceedings of Life-of-Mine Conference, 10-12 July 2012, Brisbane, Australia (The Australasian Institute of Mining and Metallurgy: Melbourne). Accessed online 22 July 2014 at: http://www.na.srk.com/files/File/papers/adequacy_of_sampling_for_acid_mine_drainage.pdf>.

US Environmental Protection Agency (USEPA) - Technical Document, Acid Mine Drainage Prediction (EPA 530-R-94-036 NTIS PB94-201829) December 1994. Available from: http://water.epa.gov/polwaste/nps/upload/amd.pdf>.

Clifford, S. R., 2010. How many samples are enough? Explore. Issue 148. September 2010.

[11] Bennett, M.W., Kempton, J.H., and Maley, P.J., 1997. Applications of geological block models to environmental management. In: Proceedings of the Fourth International Conference on Acid Rock Drainage (ICARD), Vancouver, B.C., Canada, May 31-June 6, 1997, p. 293- 303.

Table 4-1 Summary of Guidance on Waste Characterization Sampling Frequency

Recommended Approximate Sample Frequency	Notes:	Reference
8-12 Samples per significant rock type or 1 sample for each 1 million tons minimum	Guidance for "Descriptive Baseline Testing" (static test program, multi-element geochemistry) with a need to characterize population distribution, mean, and variance and direction that the sample number should produce a statistically valid population	Schafer, W M, 1993. Design of Geochemical Sampling Programs, presented at Mine Operation and Closure Short Course, Helena, Montana, USA, April 27-29
1 sample (1500 grams) per 20,000 tons, or about 50 samples per 1 million tons		Farmer, G., 1992. A Conceptual Waste Rock Sampling Program for Mines Operating in Metallic Sulfide Ores with a Potential for Acid Rock Drainage. USDA, Forest Service, Ogden, Utah.
3/ <10,000 tons 8/ <100,000 tons 26/ <1,000,000 tons 80/ <10,000,000 tons	"Number of samples for preliminary static testing based on experience with a limited number of mining projects in British Columbia. However, the empirical and preliminary nature of the curve indicates that it should only be used as a guideline..." Widely cited in various forms (For example, Price, 1997; Maest, 2005)	Steffen, Robertson and Kirsten, Inc. (B.C.), in association with Norecol Environment Consultants and Gormely Process Engineering, 1989. Draft Acid Rock Drainage Technical Guide. Volumes I and II. Prepared for British Columbia Acid Mine Drainage Task Force.
Same as above	"... arbitrary recommended minimum number of samples from each rock unit or a mine component based on tonnage of disturbed rock is provided for use in the first phase of testing, in the rare case where no other guidance is available of initial sampling."	Price, W.A., 1997. Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia. Reclamation Section, Energy and Minerals Division, Ministry of Employment and Investment, Smithers, B.C. Canada.
Cites above, but emphasizes need for site-specific determination	"The variability in the potential to impact the environment should be examined initially by extensive geologic and mineralogic analysis of all mined materials and wastes. The extent of geologic and mineralogic sampling should be commensurate with the extent of sampling for ore characterization. The observed degree of geologic and mineralogic variability should then dictate the extent of sampling for environmental characterization. Fewer samples should be required for tailings than for waste rock, wall rock, and other types of heterogeneous material."	Maest, A.S., Kuipers, J.R., Travers, C.L., and Atkins, D.A., 2005. *Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties, and State-of-the-Art.*
Several hundred representative samples for static testing, 1-2 representative kinetic tests for each material type	"Where required, the number of samples must be sufficient to populate a "resource" block model of the ore and host rocks that will be affected by mining with a reliable distribution of NAPP[1] data (e.g., acid producing potential (APP), sulphur and acid neutralizing capacity (ANC) (or NPR data) on ore, waste rock and wall rock."	GARDGuide, 2014. Chapter 4: Defining the Problem-Characterization. INAP. Accessed online 22 July 2014 at: http://www.gardguide.com/index.php?title=Chapter_4>

4.2 Comparison of NorthMet Program to Guidance

A comparison of the sulfur content between waste characterization samples and drill core database for each waste rock category, along with the number of samples and anticipated tonnages, is shown in Table 4-2.[12] The number of analyses shown here includes those collected after the development of the waste rock classification system (24,861 analyses in 2011 compared to 19,661 analyses available for RS53/42 in 2007). The number of waste rock analyses exceeds guidance summarized in Table 4-2. Furthermore, because chemical analysis has been incorporated into the exploration drilling (and populated into the drill core database), a similar level of consideration has been given to deposit variability for the sulfur characterization as for the resource modeling.

Table 4-2 Comparison Between Waste Rock Samples and Waste Rock Anticipated to be Managed During Operations

		Category 1	Category 2	Category 3	Category 4	Category 4 Virginia Formation
Stockpiles – Block Data	Tons of Rock	216,694,700	73,328,300	9,454,000	3,084,500	5,552,100
	Min % S	0.01	0.13	0.32	0.61	0.33
	Avg % S	0.06	0.18	0.42	0.93	2.43
	Max % S	0.12	0.31	0.6	3.04	4.94
Humidity Cell Tests (does not include duplicates)	Number of Samples	38	16	9	16	3
	Min % S	0.02	0.14	0.32	0.68	2
	Avg % S	0.05	0.2	0.44	1.44	3.82
	Max % S	0.12	0.3	0.59	4.46	5.68
Drill Core Database (2011)	Number of Samples	16,127	4,389	1,656	1,429	1,260
	Min % S	0.01	0.13	0.32	0.61	0.01
	Avg % S	0.05	0.2	0.43	1.5	1.67
	Max % S	0.12	0.31	0.6	7.93	8.29
Sulfur Analyses per 10,000,000 tons of rock		744	599	1752	4633	2269

[12] All sulfur data in the table, as well as, the number of samples for the humidity cell tests and drill core database, are from Table 2.2 in:

PolyMet Mining Inc. NorthMet Project Block Model (v1). November 2011.

Note, the data for the drill core database is not weight averaged. The tonnages of anticipated waste rock are from Table 4.3 in:

PolyMet Mining Inc. NorthMet Project Mine Plan (v2). December 2012.

Because the tonnages in Table 4.3 are not broken down between Duluth Complex Category 4 and Virginia Formation Category 4 rock, the total Category 4 tonnage is apportioned using the "% of rock" data from Table 2.2.

APPENDIX A

Table 1: Matrix for Sample Selection in Waste Rock Types

Unit	Rock Type	Non-Reactive	Reactive	Approximate sulfur contents																					Reactive Rock
				Non-reactive[1]			Reactive[1]									Lean Ore[1]								P size
		M. tons	M. tons	NR1	NR2	NR3	P10	P25	P50	P75	P80	P85	P90	P95	P100	P10	P25	P50	P75	P80	P85	P90	P95	
1	Anorthositic	0.57	0.99				0.08	***0.1***	***0.15***	***0.29***				***1.09***	1.09	0.11	0.26	***0.36***	***0.93***				***1.95***	***4***
1	Gabbroic	0	0.68				0.06	0.07	0.07	0.08				0.19	0.5	0.09	0.1	0.18	0.37				0.5	
1	Sedimentary hornfels	0	1.6				***0.08***	***0.35***	***0.69***	***2.2***	2.32	***2.81***	3.38	3.5	3.78	0.34	1.37	***1.58***	1.76				***4.91***	
1	Troctolitic	17.2	40.1	***0.01***	***0.03***	***0.05***	0.06	0.07	***0.1***	0.18	***0.21***	0.26	***0.34***	***0.62***	***1.97***	0.08	***0.15***	***0.24***	0.42	0.49	***0.55***	0.68	***0.98***	***4***
1	Ultramafic	0.21	1.1				0.07	***0.08***	0.1	0.13	0.2*	0.3*	0.5*	0.8*	1.35	0.07	0.09	***0.14***	***0.33***	0.55	***0.56***	0.65	***0.81***	
1	Vein	0.055	0.022				0	0	0	0				0										
2	Anorthositic	2.4	0.56	***0.01***	***0.03***	***0.05***	0.06	0.06	0.08	0.11				0.19		0.09	0.12	0.17	0.21				0.25	
2	Basalt inclusions	0.28	0													0	0	0	0				0	
2	Gabbroic	0	0.082				0	0	0	0				0										
2	Troctolitic	16.9	9.7	***0.01***	***0.03***	***0.05***	0.06	0.06	0.07	0.09	0.09	0.1	0.11	0.12	0.25	0.05	0.07	0.12	0.18	0.2	***0.22***	0.26	***0.32***	
2	Ultramafic	0.38	0.25	***0.03***	***0.04***	***0.05***	0	0	0	0				0		0.04	***0.05***	0.07	0.12	***0.14***	0.16	0.19	***0.23***	
3	Anorthositic	9.4	1.2	***0.01***	***0.03***	***0.05***	0.07	0.08	0.08	0.12				0.14		0.06	0.08	0.12	0.27				0.38	
3	Fault-Breccia	0	0.055				0	0	0	0				0										
3	Gabbroic	0.2	0.72				0.09	0.15	0.18	0.27				0.29		0	0	0	0				0	
3	Noritic	0.11	0																					
3	Sedimentary hornfels	0.38	0.46				0.12	1.42	1.67	1.97				2.22		1.66	1.77	1.85	2.43				3.26	
3	Troctolitic (augite)	41.2	12.5	***0.01***	***0.03***	***0.05***	0.06	0.06	***0.08***	0.1	0.11	***0.12***	0.14	***0.19***	0.36	0.05	0.13	0.19	***0.32***	0.35	0.45	0.48	***0.52***	***4***
3	Ultramafic	0.24	0.071				0	0	0	0				0		0	0	0	0				0	
4	Anorthositic	0.16	0.055				0	0	0	0				0										
4	Sedimentary hornfels	0	0.055				0	0	0	0				0										
4	Troctolitic	7	2.2	***0.01***	***0.03***	***0.05***	0.06	***0.07***	0.09	***0.18***	0.19	0.19	***0.48***	***0.92***	1.53	0.09	0.15	0.22	0.47				***1.52***	***4***
4	Vein	0.055	0																					
5	Troctolitic	2.5	2	***0.01***		***0.05***	0.07	0.09	0.11	0.16				0.22	0.22	0.12	0.17	0.26	0.37				***0.45***	
6	Chlorite	0.16	0													0	0	0	0				0	
6	Fault-Breccia	0.055	0.055				0	0	0	0				0										
6	Troctolitic	6.8	0.59	***0.02***	***0.04***		0	0	0	0				0		0.01	0.01	0.03	0.07				***0.19***	
6	Ultramafic	0	0.11				0	0	0	0				0										
7	Ultramafic	0.082	0													0	0	0	0				0	
20	Troctolitic	0	0.27				3.18	3.45	3.76	4.3				4.31										
20	Virginia	0	10.4				0.59	***1.25***	2.98	***4.15***	4.49	4.85	5.07	***6.06***	7.45	0	0	0	0				0	***4***

Notes:
1. Non-reactive rock categories (lower, medium and higher sulfur contents).
2. Sulfur percentiles for reactive rock types calculated by PolyMet are shown. "*" indicates approximate percentiles.
3. Grey – sampling plan.
4. Bold and italic – samples obtained.
5. Bold border – duplicate cell in operation.

APPENDIX B

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Memo

To:	Tamara Diedrich, Barr Engineering	**Client:**	PolyMet Mining
From:	Stephen Day	**Project No:**	1UP005.001
Cc:		**Date:**	July 21, 2014
Subject:	Requested Detail on Derivation of Sulfur Thresholds for Waste Rock Classification, NorthMet Project - DRAFT		

1 Background

This memorandum provides a response to your request for more detail on the derivation of sulfur thresholds for classification of waste rock reactivity at the NorthMet Project (Table 6-2 of SRK (2007)). The method was described in Section 6.4.3 of SRK (2007) and is reproduced below:

- Estimate bicarbonate generation rate for silicate minerals using samples containing low levels of sulfur and exhibiting lowest levels of alkalinity. The rate used in the calculation is the lower 95% confidence limit on the average of measurements toward the latter part of the test.
- Convert alkalinity generation rate to equivalent acidity generation rate expressed as sulfate generation.
- Determine regression relationships between oxidation rate (sulfate generation rate) and sulfur content. One regression relationship was calculated for the straight line trend represented by the chalcopyrite-dominated waste rock and lean ore (Cu/S>0.3). The second relationship was calculated for the pyrrhotite-dominated waste rock (Cu/S<0.3). For each regression relationship, the lower regression envelope was calculated. The predicted sulfur content equivalent to the sulfate generation rate determined above was calculated using the lower regression envelope (95% confidence limit). This resulted in the lowest equivalent sulfur for the oxidation rate that would balance alkalinity generation.

2 Calculation Detail

2.1 Alkalinity Generation and Acidity Equivalent

The average alkalinity generation rate was determined to be 3.3±0.4 $mgCaCO_3$/kg/week. The 5th to 95th percentile range was 2.1 to 5.3 $mgCaCO_3$/kg/week. The rate used in the subsequent calculations was 2.9 $mgCaCO_3$/kg/week. The equivalent acid generation rate was set to 2.8 $mgSO_4$/kg/week (ie. 2.9x(96/100)).

2.2 Regression Equations

Figure 1 (top) compares sulfur content with sulfate release rate for waste rock and lean ore, and shows two regression relationships for samples classified according to Cu/S ratio. The threshold selected to separate data according to Cu/S ratio was chosen to be 0.3 mg/mg. The regression equations were calculated excluding three data points at higher total sulfur contents that were showing unstable sulfate release.

The regression equations were:

$$Cu/S<0.3: \text{Total } S = 0.40\, R_{SO4} - 0.70 \ (n=15, r=0.98)$$

$$Cu/S>0.3: \text{Total } S = 0.046\, R_{SO4} - 0.010 \ (n=37, r=0.93)$$

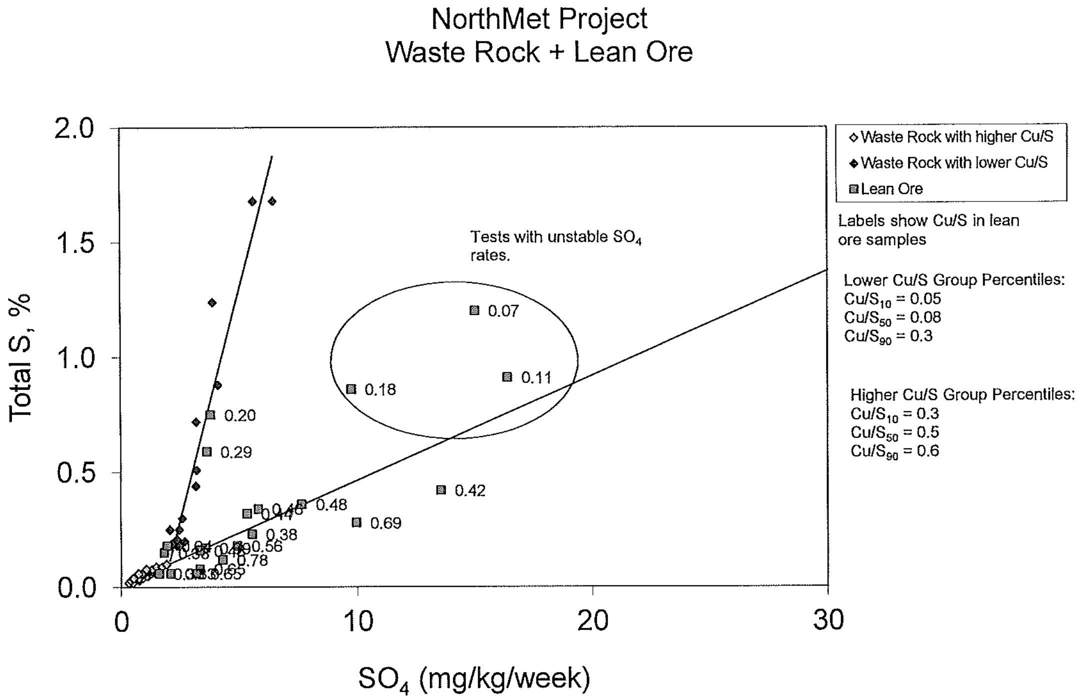
In both cases, the linear correlation coefficients were strongly significantly different from zero, and therefore, the regression relationships can be used to calculate total S equivalents to sulfate release rates. The confidence limits on estimates of total S ($\hat{y}$) (i.e., the regression envelope) were calculated using:

$$\hat{y} \pm t.s_e.\sqrt{(1/n+(x-x_{mean})^2/S_{XX})}$$

where t is the student t statistic at the selected significance level ($\alpha=0.05$), s_e is the standard error, n is the number of measurements, x is the SO_4 rate used for which total S is to be calculated, x_{mean} is the mean of all SO_4 rate data, and S_{xx} is the sum of the squares for the SO_4 data used to calculate the regression equation. Figure 1 (bottom) shows the use of the regression equation envelope to calculate the two total sulfur thresholds provided in Table 6-2 of SRK (2007).

3 References

SRK Consulting. 2007. RS53/RS42 – Waste Rock Characteristics/Waste Water Quality Modeling - Waste Rock and Lean Ore – NorthMet Project – DRAFT. Report Prepared for PolyMet Mining Inc. SRK Project 1UP005.001. February 2007.



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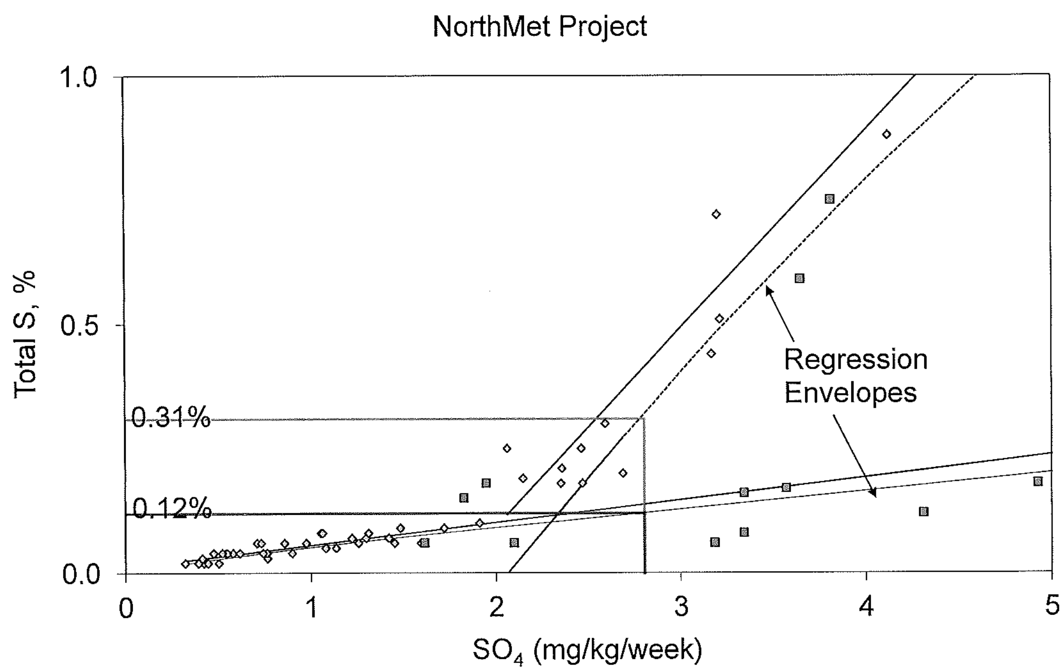

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Figure 1. Sulfate Release Compared Total Sulfur.