ARD/ML MONITORING AND MANAGEMENT PLAN FOR EXPLORATION DRIFT DEVELOPMENT

12/4/2018

Palmer Project, Alaska

Report prepared for:

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LISTS OF ACRONYMS

ABA	Acid-Base Accounting
AP	Acid Potential
ARD	Acid Rock Drainage
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
ML	Metal Leaching
MPA	Maximum Potential Acidity
Non-PAG	Non-Potentially Acid Generating
NP	Neutralization Potential
QA/QC	Quality Assurance/Quality Control
QEMSCAN	Quantitative Evaluation of Minerals by Scanning Electron Microscopy
TIC	Total Inorganic Carbon
SFE	Shake Flask Extraction
VMS	Volcanogenic Massive Sulfide

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PALMER PROJECT, ALASKA

1.0 INTRODUCTION

The Palmer Volcanogenic Massive Sulfide-Sulfate (VMS) Project is a copper-zinc-gold-silver (barite) project located 55 km northwest of the town of Haines in Southeast Alaska, USA. The project is being advanced as a joint venture partnership between Constantine North Inc. (Constantine) incorporated in Alaska (a wholly owned subsidiary of Constantine Metal Resources Ltd.) and Dowa Metals & Mining Alaska Ltd. (Dowa) incorporated in Alaska (a wholly owned subsidiary of Dowa Metals and Mining Co. Ltd. of Japan) with Constantine as operator.

Constantine is evaluating continued exploration of the South Wall mineral resource at the Palmer Project via an underground drift for the purpose of resource definition and exploration drilling.

pHase Geochemistry Inc. (pHase) has been retained by Constantine to prepare a monitoring and management plan to address any unexpected potential acid rock drainage/metal leaching (ARD/ML) and water quality issues associated with development of the proposed underground exploration drift. This plan is based on the findings and conclusions from a geochemical characterization program conducted on potential waste rock from the proposed underground drift (pHase, 2018a). This plan describes the operational monitoring and management of waste materials and drainage associated with the proposed underground drift development.

The ARD/ML monitoring and management plan is structured as follows:

Section 2 – **Overview** presents the operational, geological and current ARD/ML information relevant to the Project.

Section 3 – **Development Waste Rock** outlines the operational monitoring and management plan for development waste rock.

Section 4 – **QA/QC Program** outlines the quality assurance/quality control (QA/QC) program for waste rock and site drainage during underground development.

2.0 OVERVIEW

2.1 Proposed Operational Context

The proposed underground exploration drift, identified as Option 7 and referred to herein as such, would consist of a portal, access ramp and exploration drilling drift as shown in Figure 1. The portal is located in the area immediately southeast of the terminus of the Saksaia Glacier, referred to as the Terminus Area. From the portal, the proposed access ramp (5m-wide by 5m-tall and 1.6 km length) would pass under the Saksaia Glacier before turning to the northeast and extending to the South Wall area, where an exploration drift (5m-wide by 5m-tall and 400 m in length) would extend away from the access ramp to serve as a platform for drilling.

A geological cross-section in the area of the proposed exploration drift development is shown in Figure 2. The proposed exploration drift is designed to stay entirely within the hanging wall sequence of rock units. The access ramp would pass through hanging wall basalts (and subordinate intercalated limey sediments) in the Jasper

Mountain Area for most of its length, before passing through limey argillites near the Kudo Fault area and then back into hanging wall basalts of the South Wall area near the intersection of the access ramp and exploration drift (Core Geoscience, 2018). The exploration drift will not encounter VMS mineralization or the footwall sequence. Approximately 95% of the development drift rock is expected to be basalt with the remaining 5% to be limey argillite.

Much of the excavated development drift rock will be used for constructing avalanche berms & mounds, road surface and building flat laydown areas. Three areas have been selected as potential rock dump sites to store excess waste rock, each with a capacity to store 20,400 to 38,600 cubic meters (Figure 3). Any seepage from the development drift rock will infiltrate to groundwater.

The project design includes a Land Application Disposal (LAD) system of buried pipes. All portal discharge water will be directed to the LAD and also report to groundwater. There is no expected discharge from the mine facilities to surface waters.

A lined temporary waste rock storage site (Figure 3) has been included in the engineering designs that could be used for storage of any unexpected mine rock with the potential for ARD/ML. Seepage from that storage site would be collected in a sediment pond.

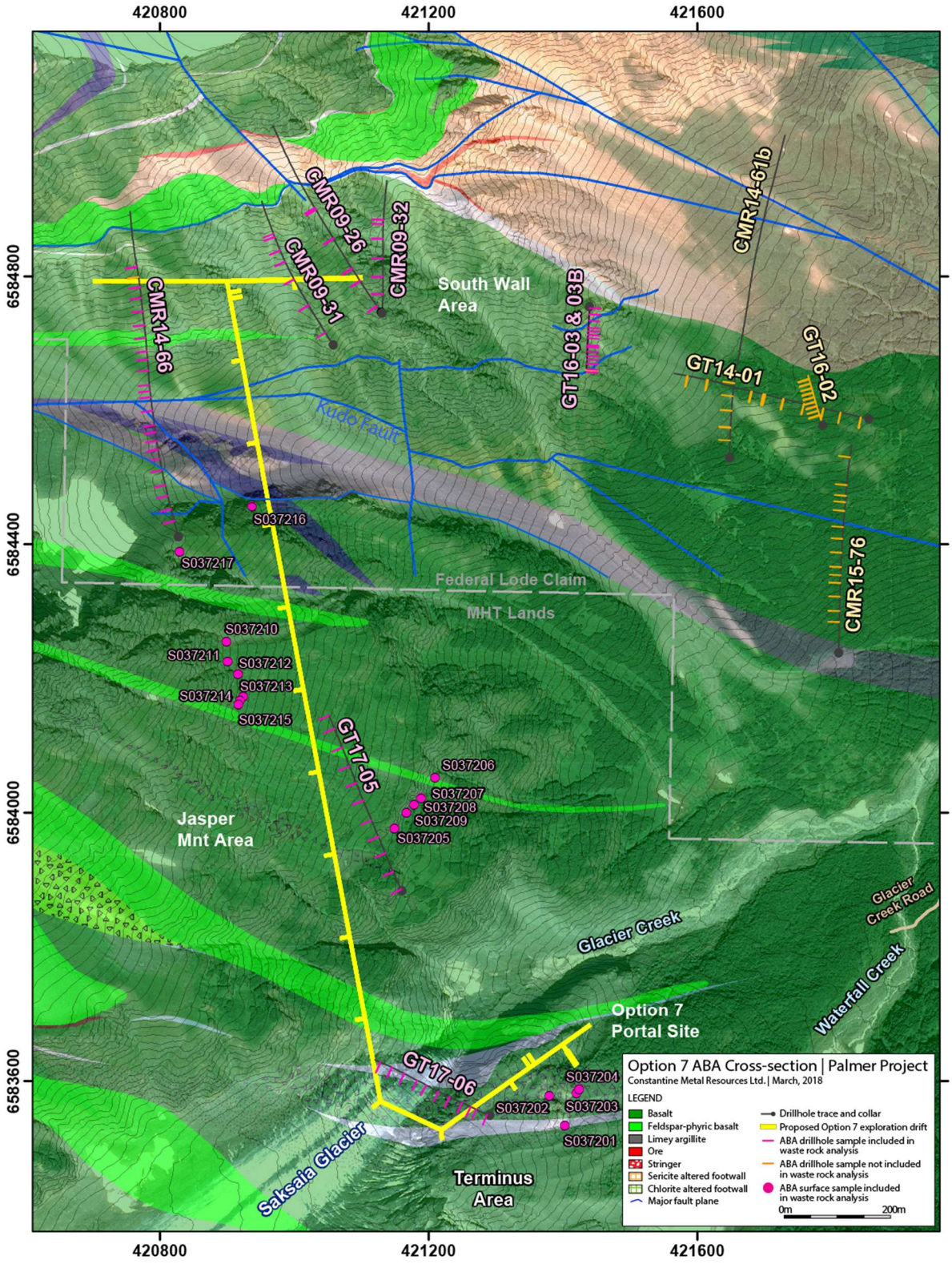

FIGURE 1. PROPOSED EXPLORATION DRIFT.

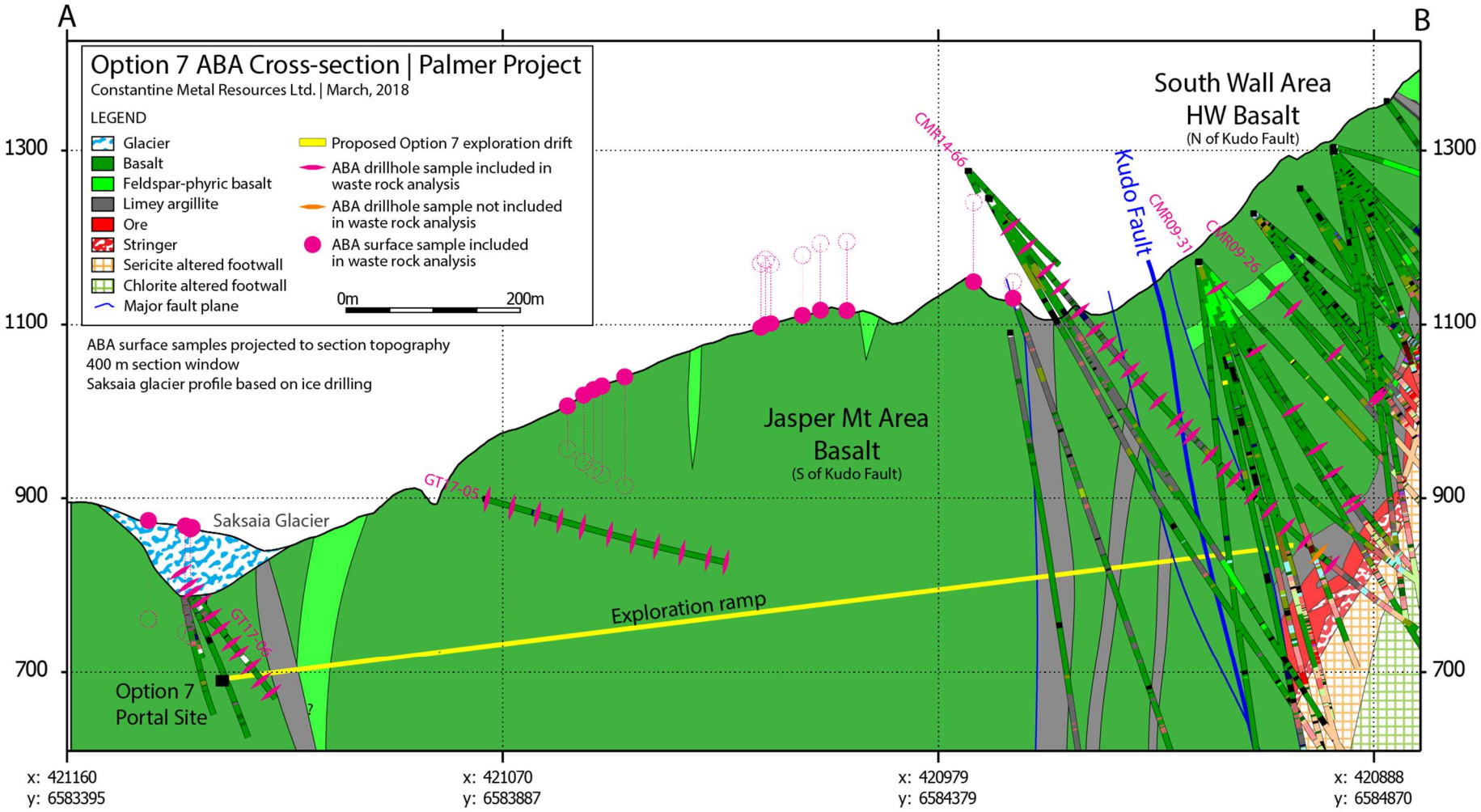

FIGURE 2. CROSS-SECTION IN THE AREA OF PROPOSED EXPLORATION DRIFT DEVELOPMENT.

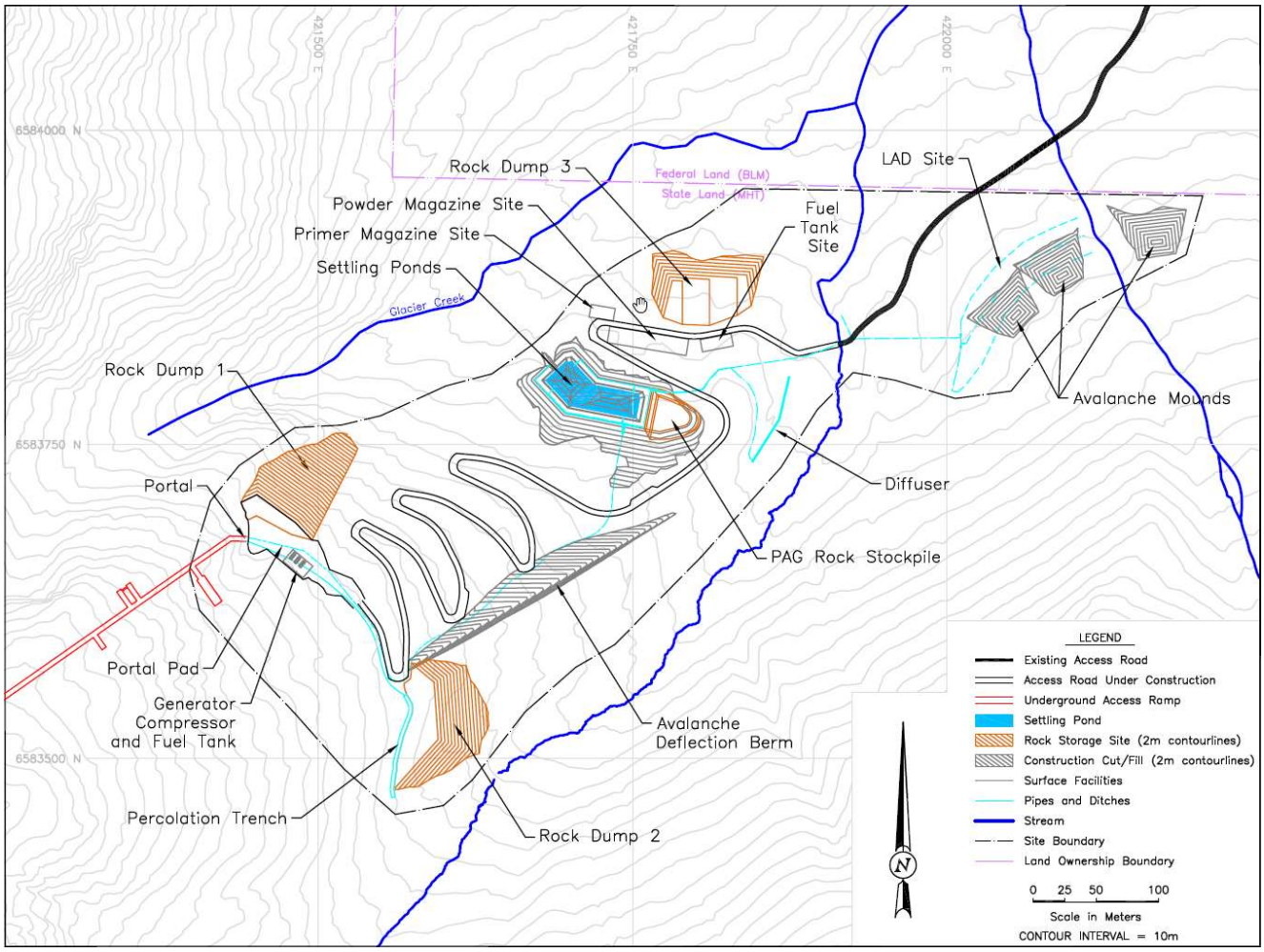

FIGURE 3. SITE PLAN SHOWING PROPOSED MANAGEMENT OF WASTE ROCK.

2.2 Assessment of ARD/ML Potential

A geochemical characterization program to assess the ARD/ML potential of waste rock that would be generated as part of a proposed exploration drift at the Palmer Project was reported by pHase Geochemistry Inc. (pHase) in their report "Geochemical Characterization in Support of a Proposed Exploration Drift" (pHase, 2018a) and summarized here.

The characterization program consisted of geochemical testing on 101 samples sourced from surface outcrops and drill core that were geologically representative of the Option 7 exploration drift and the three principal units that will be intersected along the access ramp: Japer Mountain Basalt (most volumetrically significant), Limey Argillite (those interstitial to basalts, and from the unit near the Kudo Fault) and the Hanging Wall Basalt in the South Wall area within the vicinity of the access ramp and exploration drift.

Testwork included static and kinetic testing. Laboratory static tests included acid-base accounting (ABA), total inorganic carbon (TIC) and trace element analyses on all samples, as well as mineralogical analysis via QEMSCAN and particle size analyses on a subset of samples. Kinetic tests included field barrel tests and parallel laboratory humidity cell leach tests on three composite samples representing the three main rock types expected in drift

development (Jasper Mountain Basalt, Limey Argillite and Hanging Wall Basalt). The humidity cell tests were terminated after 40 cycles and the field barrel tests (initiated summer 2017) are still in progress.

An overview of the findings of the geochemical study is summarized as follows:

- Rock expected to be encountered in underground drift development has abundant neutralization potential and thus buffering capacity, primarily in the form of calcite.
- Sulfur content in samples tested was generally low ranging from 0.01% to 1.09% and typical of trace to minor amounts of sulfide mineralization in the rock, primarily as pyrite. Total sulfur content was slightly higher in the Limey Argillite (median=0.6%) than the Jasper Mountain Basalt (median=0.12%) and Hanging Wall Basalt (median=0.05%) samples.
- All rock samples tested classified as non-potentially acid generating (non-PAG).
- Kinetic test results to date have yielded leachates with alkaline pH and are not expected to generate acid.
- The potential for metal leaching from the Jasper Mountain Basalt and Hanging Wall Basalt is low.
- Leach tests on Limey Argillite indicated an initial flush of marginally elevated selenium at neutral pH. Selenium in the humidity cell test steadily declined to lower levels as testing progressed. Marginally elevated selenium levels have continued in the Limey Argillite field barrel leachate.

Overall, the geochemical characterization study indicated that no PAG rock is anticipated during underground drift development.

Despite marginally elevated selenium concentrations in leachate from the Limey Argillite unit, source term water quality predictions for portal drainage and waste rock (pHase, 2018b) indicate that predicted concentrations for selenium are expected to be low. Overall, the prediction results indicate that all contact water will remain pH neutral to slightly alkaline with low to moderate sulfate concentrations and negligible trace metals, with concentrations generally similar to groundwater monitored in the area. Nitrogen species are expected to be low to moderate in contact water but will decrease over time as the explosive residues flush from rock surfaces (pHase, 2018b).

3.0 DEVELOPMENT WASTE ROCK

Although no PAG or ML rock is anticipated during underground drift development at the Palmer Project, an ARD/ML management plan will be implemented at the Palmer Project to identify waste rock with higher potential to generate ARD/ML, should it be encountered, and ensure that it is handled and placed in appropriate disposal locations. The strategy for the ARD/ML monitoring and management of waste rock excavated from underground development will be based on visual inspection, routine ARD/ML sampling and testing, and comprehensive record keeping of waste rock management. The plan is outlined as follows:

1. Visual Inspection

On-site visual inspection and assessment of the degree of sulfide mineralization in the waste rock by qualified personnel will be conducted for each blast round. The objective will be to identify any visible increase in sulfide content in the rock. Underground faces and blast round materials will be visually examined for sulfide content.

Blast rounds of development rock will be field-confirmed as non-PAG and placed directly in the surface waste rock piles if they meet the following criteria:

- contain <2% visible sulfides.

Blast rounds of development rock that do not meet this criteria will be either:

- conservatively managed and placed directly in the lined waste rock storage pile, or
- segregated and placed in a temporary pile where a composite sample will be collected and sent to an off-site lab for analysis to determine acid generating potential prior to appropriate disposal

The basis for 2% visible sulfides is derived from a total sulphur cutoff of 1%, which was the approximate cutoff for uncertain (UC) or PAG samples, for all samples in the Palmer Project geochemical database (i.e. samples relevant to Option 7 drift as well as lithologically relevant samples from previous drift options) as shown in Figure 4. In addition, visible sulfide content less than 2% may be hard to quantify in the field.

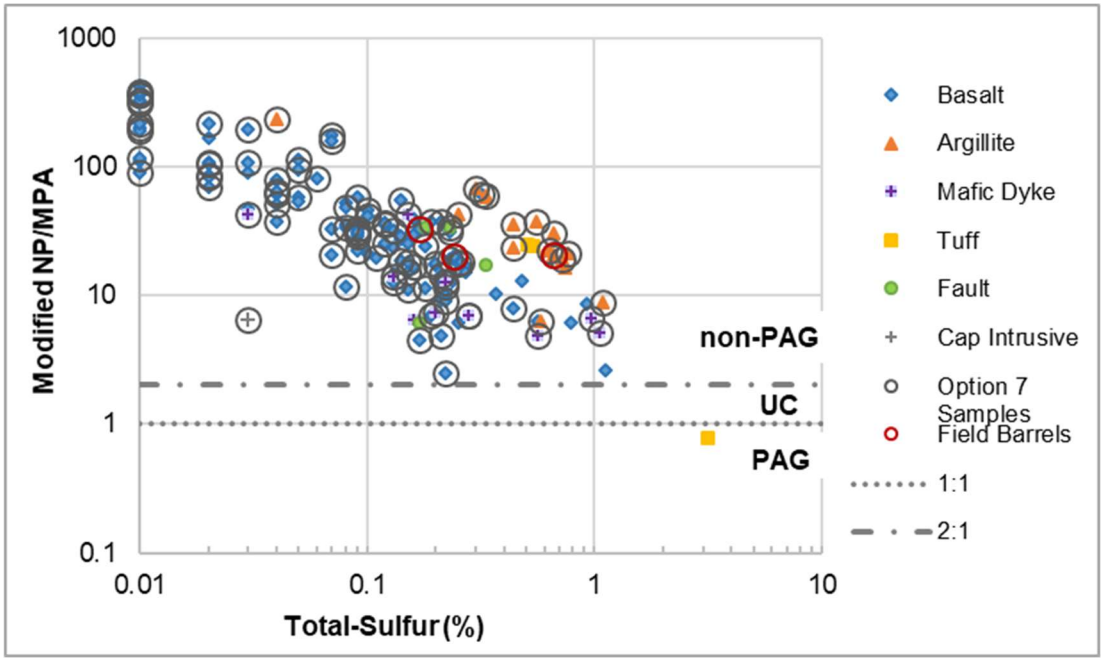

FIGURE 4. RATIO OF MODIFIED NEUTRALIZATION POTENTIAL TO MAXIMUM POTENTIAL ACIDITY VERSUS TOTAL SULFUR FOR ALL PALMER PROJECT SAMPLES.

Any blast round that is not field-confirmed as non-PAG should be sampled to determine appropriate disposal location. Samples will comprise a representative composite of the fine waste rock fraction (i.e. <2mm fraction) of the blast pile. Typically, the <2 mm fraction is considered to be the most reactive fraction of the waste rock (MEND, 2009).

Samples will be shipped off-site to an accredited external commercial laboratory for confirmation testing. Analyses will be consistent with those described below for routine testing.

Sample descriptions, record keeping of ARD samples and waste material placement are also described in the sections below.

2. Routine ARD/ML Sampling and Testing

In addition to samples not field-confirmed as non-PAG, routine ARD/ML sampling and testing will be implemented to verify the previous geochemical characterization study conclusions and classification based on visual quantification of sulfide content. The routine ARD/ML sampling will consist of a sample collected every 10th blast round (i.e. every 2700 tonnes of waste rock), where there is a significant change in rock type, and

where an increase in visible sulphides is noted. Each sample will comprise a representative composite of the fine waste rock fraction (i.e. <2mm fraction) of the blast pile. The routine sampling will be conducted throughout development of all underground workings including the access ramp, exploration drift, muck bays and underground shop.

Each ARD/ML sample will be accompanied by a location/coordinates and geological description. The description will include the sample's rock type, sulfide mineralogy and quantity, carbonate mineralogy and quantity, fizz test rating with hydrochloric acid, alteration, texture and any other diagnostic features significant to ARD/ML. Further detail on the geological descriptions is summarized in Table 1.

ARD samples will be shipped off-site to an accredited external commercial laboratory for rinse pH, acid-base accounting (ABA) and shake flask extraction (SFE) leach tests. Rinse pH will be conducted on the as-received, uncrushed waste rock sample to quantify the current pH of the sample at the time of testing. Acid-base accounting tests will include paste pH, total sulphur, sulphate sulphur, Modified NP, fizz rating and total inorganic carbon (TIC) to determine the acid-generating potential of the sample, whereby a sample with a neutralization potential to acid potential ratio less than 2 (NP/AP<2) will classify as potentially acid generating (PAG). SFE leach tests will be conducted at a 3:1 liquid to solid ratio and analysis of leachate by ICP-MS to assess for metal leaching potential.

As noted above, any samples from blast rounds of development rock that classify as potentially acid generating (PAG) will be either:

- conservatively managed and placed directly in the lined waste rock storage pile, or
- segregated and placed in a temporary pile where a composite sample will be collected and sent to an off-site lab for analysis to determine acid generating potential prior to appropriate disposal

TABLE 1. ARD SAMPLE DESCRIPTIONS.

Field	Input
Sample ID	Sample identification such as sample number or sample name
Sample Date	Date of sample collection
Sample Location	Location such as access ramp, exploration drift, etc., as well as sample interval (i.e. 100m along access ramp), coordinates (northing/easting) and linked to location map.
Rock Type	Predominant rock type such as Jasper Mountain Basalt, Limey Argillite, Hanging Wall Basalt etc.
Alteration Type	Predominant alteration type such as carbonate, quartz-sericite-pyrite, iron-oxide, unaltered etc. and intensity (strong, moderate weak)
Alteration Minerals	Alteration minerals present such as sulphides, carbonate, clay, mica etc.
Sulphide - Mineralization	Sulphide minerals present such as pyrite, sphalerite, chalcopyrite etc.
Sulphide - Quantity	Estimated quantity of sulphide mineralization by volume (i.e. trace, 1%, 5% 10 % etc.)
Sulphide - Style	Style of sulphide mineralization such as disseminations, veinlets, blebs, massive, crystalline etc.
Carbonate - Mineralization	Carbonate minerals present such as calcite, dolomite, siderite, ankerite etc.
Carbonate - Quantity	Estimated quantity of carbonate mineralization by volume (i.e. trace, 1%, 5%, 10% etc.)
Carbonate - Style	Style of carbonate mineralization (i.e. veinlets, stockwork, alteration, cement, cavity-filling etc.)
Fizz Test Rating	Rating when sample reacted with 10% dilute HCl (i.e. none, slight, moderate strong)
Texture	Prominent textures, if any (i.e. blocky, gouge, high fractured, coarse-grained, fine-grained etc.)
Other/comments	Note any other diagnostic features relevant to ML/ARD such as the presence of graphite, quartz veins etc.

3. Mapping of Underground Workings

An ARD/ML monitoring program for the underground workings will also be implemented to support reclamation and closure of the underground workings. This will consist of wall mapping that will be undertaken during development work. Due to the routine ARD/ML sampling and analysis program to be conducted on the blast piles during development as described above, sampling of the underground wall rock will not be required, and wall rock properties will be extrapolated from the assessment of the routine ARD/ML sampling and analyses. The composition of the walls in the workings is expected to be similar to that of the waste rock, although there is much lower surface area. Additional sampling may be conducted, if considered appropriate, to assess major structural features, and lithologic features of interest that are smaller than blast lengths, i.e. areas of quartz veining and/or localized mineralization, should they be detected.

4. Record Keeping

All ARD/ML sample descriptions and lab results during underground development will be compiled into a geochemical database. The database will be updated by qualified personnel as ARD samples are collected and lab results returned. A digital map showing all ARD sample locations and geology in the underground development workings will also be compiled.

Routine record keeping on waste rock tonnages hauled from underground development and the locations the material is placed will be undertaken in a structured manner such that the management of waste rock can be accurately tracked. The waste rock inventory would include composition, volume, storage location, history and timing of excavation, and monitoring.

4.0 QA/QC PROGRAM

The ARD/ML monitoring plan will be accompanied by an effective QA/QC program. This program will include field and laboratory duplicate and blank samples in order to identify potential contaminants, achieve reproducible results and to guarantee high quality results. A field duplicate sample will be collected for every 10% of samples collected during routine ARD/ML sampling/testing.

This report titled "**ARD/ML Monitoring and Management Plan for Exploration Drift Development, Palmer Project"** was prepared by pHase Geochemistry Inc. for Constantine to address potential acid rock drainage/metal leaching (ARD/ML) and water quality issues associated with development of the proposed underground exploration drift at the Palmer Project.

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