



**Appendix J Mine Rock Adaptive Management Plan**

# Memo

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**To:** Dave Brown, Steve Woolfenden (IAMGOLD)

**Date:** December 20, 2018

**From:** Steve Walker (Wood)

**cc:** Don Carr, Steve Sibbick, Debbie Dyck (Wood)  
Stephan Theben (SLR)

**Ref:** TC180501

**Re:** Updated Mine Rock Adaptive Management Plan  
Côté Gold Project, Ontario

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## 1. INTRODUCTION AND BACKGROUND

Wood Environment & Infrastructure Solutions, a division of Wood Canada Limited (Wood, formerly Amec Foster Wheeler), was retained by IAMGOLD Corporation (IAMGOLD) to conduct a geochemical characterization study of the future open pit mine rock in support of the Côté Gold Project Federal and Provincial Environmental Assessments (AMEC 2013, AMEC 2014).

The results of previous geochemical characterization studies for the Côté Gold Project open pit identified that most mine rock had a low sulphide content with a low potential for metal leaching / acid rock drainage and an overall excess of neutralization potential (NP) over acid potential (AP). The average neutralization potential to acid potential ratio was 19. More than 93% of samples were classified as non-potentially acid generating (NPAG) based on an NP to AP ratio >2.

In addition, distribution of potentially acid generating (PAG) rock based on an NP to AP ratio <2 appeared to be largely random and not localized within the future pit. PAG sample distributions were sparse, but some apparent visual clustering of data was observed in certain regions. The apparent visual clustering of PAG samples had no geological basis and the cluster volumes appeared to contain dispersed rather than continuous PAG rock with a clear overall excess of NP. Planning for segregation of PAG material based on such distributions was not considered to be feasible and/or beneficial from a mine waste management and mine water quality perspective.

In January 2017, the Provincial environmental assessment (EA) process for the Côté Gold Project was successfully concluded, subject to various terms and conditions listed in the EA approval. Condition 12.1, of the Provincial EA approval requires a mine rock adaptive management approach proposal, and is described below:



12.1 *The Proponent shall submit to the Environmental Compliance Approval Director a waste rock adaptive management approach proposal, prepared to the Ministry's satisfaction, which outlines the Proponent's strategy for ensuring that waste material that is potentially acid generating (based on geochemical monitoring) will ultimately be randomly distributed in the waste rock area during Construction, operations and closure phases of the Undertaking. The Proponent shall submit its waste rock adaptive management approach proposal with its industrial sewage Environmental Compliance Approval application and in its Closure Plan submission to the Ministry of Northern Development and Mines.*

This memo has been prepared to address Condition 12.1. This adaptive management proposal will be built in to the Côté Gold Project environmental management system. The initial characterization measures described herein will be executed and further adaptive management plans as described will be implemented as needed.

This adaptive management proposal includes the following:

1. Basis of Leco C and Leco S as suitable analogues for neutralization potential (NP) and acid potential (AP) respectively.
2. Supplemental Côté Gold Project open pit PAG rock continuity assessment, and
3. Adaptive mine rock management approach.

## **2. BASIS OF LECO ANALYSES AS SUITABLE ANALOGUES FOR NP AND AP**

For the EA, static testing of drill core samples for acid base accounting (ABA) was completed for 236 archived drill core samples (reference sample set) and an additional 912 archived pulverised (pulp) samples were analysed for carbon/sulphur by Leco induction furnace for use as proxies for NP and AP. The proxy approach is supported and described by analyses and interpretation as reported in AMEC (2013) and summarized as follows.

The total sulphur content was compared to the sulphide sulphur content and a positive correlation trend in the data shows that sulphur was largely in the form of sulphide sulphur in the mine rock samples. This is particularly evident for samples with total sulphur content greater than 0.1%. Values for AP (calculated from sulphide sulphur) ranged from 0.3 to 45 kg CaCO<sub>3</sub>/tonne, with a median AP value of 1.1 kg CaCO<sub>3</sub>/tonne. By using MPA (calculated from total sulphur and consistent with proxy sulphur analysis by Leco induction furnace) AP values were in the same range but had a higher median value of 1.8 kg CaCO<sub>3</sub>/tonne. Therefore, use of total sulphur as a proxy measure of AP may slightly over estimate AP from sulphide especially at values below about 0.1% total sulphur; however, this will lead to a conservative estimate of AP for those samples.

The total carbon content was compared to the carbonate carbon content for the ABA data set and also provided a strong positive correlation. The relationship indicates that the majority of carbon is inorganic, and that total carbon content is a reasonable measure of carbonate content overall. A small excess of total carbon can be observed in some samples below about 0.1% total carbon. This may lead to a slight over-estimate of NP; however, the number of samples in this range is small. More generally, the modified Sobek NP of the mine rock samples ranged from 0.6 to 450 kg CaCO<sub>3</sub>/tonne, with a median value of 31 kg CaCO<sub>3</sub>/tonne. The carbonate NP was calculated from the total carbon and ranged from 1.3 to 413 kg CaCO<sub>3</sub>/tonne, with a median value of 31 kg CaCO<sub>3</sub>/tonne. Therefore, total carbon (as measured by Leco



induction furnace) provides an estimate of available NP in the ABA sample set and is suitable for use as a proxy measure of NP in the samples.

For reference, approximately 94% of the drill core pulp mine rock samples had proxy carbonate NPR (based on total carbon and total sulphur) values greater than 2 which was comparable to findings from the full ABA testing (~ 93%) which further supports the suitability of Leco carbon and sulphur as a proxy for NP and AP determination.

It is expected that confirmation and further refinement of the above proxy relationships (should it be necessary) will follow from on-going data collection and checks as included in this management plan.

### **3. SUPPLEMENTAL OPEN PIT PAG ROCK CONTINUITY ASSESSMENT**

Existing information has identified that a low fraction of PAG rock is expected to be present within the Côté open pit with sufficient excess NP such that net acid generating conditions are unlikely for unsegregated Côté mine rock. In order to guide the level of additional mine rock management and monitoring that is appropriate for the project, Wood is recommending execution of a more detailed assessment of NP and AP distribution at the mine block scale. The program will include the following additional sampling and analysis.

- Select approximately 30 PAG rock target intervals for a more detailed spatial assessment of ARD risk at the mine block scale.
  - The target intervals will be distributed across the open pit in order to cover the range of mine rock lithologies
  - The current geological model, geochemistry results and drill-hole database will be utilized to select the intervals for assessment in consultation with IAMGOLD geologists where necessary.
- Assess the continuity of PAG rock materials along each target interval and also the net balance of NP and AP at the mine block (10m) scale rather than individual sample scale.
  - Assessment will include analysis of a continuous set of 1 to 2m rock core sample intervals approximately 10m above and 10m below the target sample (20 m interval in total) for Leco carbon and sulphur as a proxy for NP and AP as applied in previous studies.
  - Analysis of approximately 20% of samples for i) full acid base accounting (ABA) including modified NP determination and carbon and sulphur speciation and ii) ICP metals including sulphur determination.
- Assessment of the results to determine the presence of any notable continuous PAG zones at the 10m scale.
- Determination of the net balance of NP and AP at the 10m scale in the segments analysed.

The results of this analysis are expected to confirm the discontinuous nature of PAG rock and the lack of net acid generating conditions within the future planned unsegregated waste rock stock pile. Results of



this analysis will also be used to guide the level and approach for waste rock monitoring during operations as detailed in the following section.

#### **4. ADAPTIVE MINE ROCK MANAGEMENT APPROACH**

The results of the above described continuity assessment will be used to guide mine waste management in terms of monitoring and screening of mine rock during operations. Where the spatial PAG assessment described above identifies no concerns for net acidic drainage from an unsegregated mine rock stockpile, a verification sampling and monitoring program will be implemented as described in Section 4.1. Should the spatial PAG assessment identify any zones of concern for ARD that when placed within the planned unsegregated waste rock stock pile pose a risk of ARD, an updated waste rock management plan will be developed as described in Section 4.2 below.

##### **4.1. Low Risk of ARD Confirmed by Spatial Assessment**

Where no net acid generating zones are identified by the above spatial PAG assessment, a low risk of ARD should be considered confirmed and verification level ABA screening program will be implemented for open pit mine rock. This verification program would include the following approach.

- Periodic analysis of blast hole cuttings for Leco carbon and sulphur to determine analogue NP and AP. Initially, one random sample of blast hole cuttings for every 30,000 tonnes of mine rock for verification purposes. Sampling frequency is expected to decrease as monitoring progresses and geological experience is gained.
- Sample location and predominant lithology or lithologies for the sample to be recorded.
- One in 10 samples to be analysed for full ABA including modified NP determination, total carbon and total sulphur, HCl leachable sulphate sulphur and sulphide sulphur by difference (total sulphur less sulphate sulphur).
- Evaluate data as received. If PAG results are identified conduct a visual inspection of suspect lithology and region within the open pit and carry out additional sampling as appropriate. Evaluate need to adjust mine rock management plan.
- Any localized PAG material identified for placement in the mine rock area (MRA) will be documented by tonnage and tracked to identify location of placement in the MRA. Placement of such PAG materials will be randomized within the MRA to avoid inadvertent co-location of the material with previously placed PAG material.
- Evaluate data annually by a qualified professional. Recommendation to reduce or otherwise adjust sampling frequency may be made at that time, where appropriate.

##### **4.2. Risk of ARD Identified by Spatial Assessment**

Where potential for ARD is identified based on the above spatial PAG assessment, a revised mine rock management plan will be prepared. Additional investigation and consultation with IAMGOLD staff may be the appropriate first steps to guide the understanding of the specific rock volume(s) requiring



management. The updated mine rock management plan will be scaled to the nature and volume of PAG material expected; however, based on overall characterization work to date, any such PAG volumes, should they be identified, are expected to be small.

An updated mine rock management plan could range from implementing geological controls to segregate localized volumes of previously unidentified PAG material to conducting systematic blast-hole sampling with on-site Leco carbon and sulphur analysis to identify segregable PAG volumes for management in previously unidentified zones of concern. An appropriate management/storage plan for any PAG rock volumes, if required, would also be developed. Such a plan may include proven strategies such as encapsulation (within mine rock stock pile or tailings), blending within the NPAG stockpile, relocation to the pit prior to flooding, or an alternate approach deemed suitable at that time. The updated plan will be added to the Côté Gold Project environmental management system and submitted to MNM for approval.

## **5. INTEGRATION WITH OTHER SITE MONITORING ACTIVITIES**

Though not specifically integrated herein, it is assumed that regular water quality sampling of open pit and waste rock dump run-off will be completed as part of other operational site monitoring programs. If notable degradation in water quality is observed, investigation of mine rock as a potential source should be completed. Adjustment of mine rock management plans following an approach similar to that described in Section 4.2 above would be considered, if appropriate.

## **6. REFERENCES**

- AMEC Environment and Infrastructure (AMEC). 2013. Côté Gold Project Geochemical Characterization Report.
- AMEC Environment and Infrastructure (AMEC). 2014. Addendum to Appendix E – Geochemical Characterization Report.