WASTE MATERIAL MANAGEMENT AT THE KEMESS SOUTH MINE TO CONTROL ENVIRONMENTAL IMPACTS

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ABSTRACT

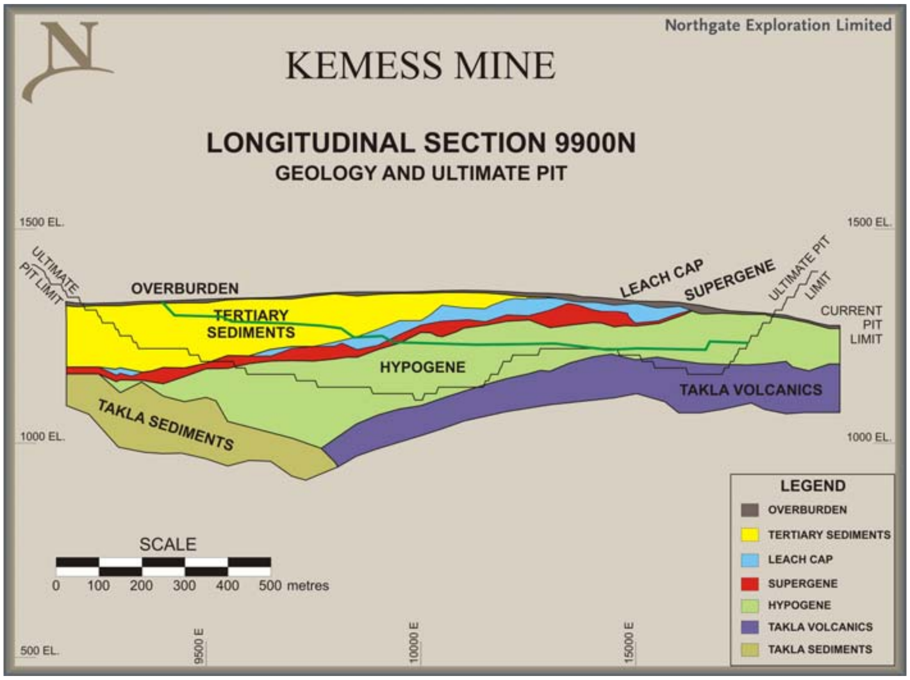
The ore and waste rock at Kemess Mine are highly variable and range from having high acid generation potential to high neutralization potential and some of the materials may also leach metals, notably selenium, at neutral pH. The potential environmental impact caused by the storage of ore and waste rock has been reduced to acceptable levels by the integrated materials management program. Management techniques include the ongoing sampling and classification of all rock types on site into 11 categories and the segregation of potentially problematic materials. This segregation requires a considerable effort on the part of mining operations to schedule and monitor waste placement. The materials management program has been successful largely due to the cooperation between the relevant departments at the mine, including Environment, Engineering and Geology, and the level of awareness of operating personnel.

This paper provides details on the procedures developed at the Kemess Mine to control impacts. Included are details on the Acid Rock Drainage and metal leaching prediction methods employed and the material handling and segregation procedures use to achieve the required objectives.

INTRODUCTION

Kemess Mine is an open-pit gold-copper mine located 10 kilometres east of Thutade Lake, in the northern Omineca Mountains of north central British Columbia. The minesite is approximately 300 km northwest of Mackenzie, B.C. The ore and waste rock at the mine range from having high acid generation potential to high neutralization potential and some of the materials have demonstrated the ability to leach metals, such as selenium, at neutral pH conditions. In addition, the physical characteristics of some of the unconsolidated materials can result in the release of high total suspended solids concentrations and therefore, requires additional control efforts during periods of high runoff. Because of this high variability in the rock types in the area, and the need to control impacts, the rock has been divided into 7 waste rock categories and 4 ore types, which have been based on the potential to recover economic value and on the potential to impact the environment. The material is handled and stored based on these categories. The complexity of the ore body is illustrated in the following Longitudinal Section of the open pit area.

Figure 1: Longitudinal Section Through Kemess Pit



The potential of environmental impact due to the storage of waste rock and ore at the minesite caused some concern early in the operation of Kemess Mine, however, this impact has been reduced to acceptable levels by the successful management of those materials. The management techniques employed at Kemess Mine include the continued sampling and characterization of all waste rock types on site and the segregation of potentially problematic materials based on the potential to cause impact. This segregation requires a considerable effort on the part of mining operations to schedule and monitor waste placement and control drainage. The program has been successful largely due to the high level of cooperation that exists between the relevant departments at the mine, including Environment, Engineering and Geology, and the high level of awareness of operating personnel.

All rock types mined at the Kemess Mine are sampled and tested prior to excavation. The Metal Leaching and Acid Rock Drainage (ML/ARD) program at Kemess Mine is designed to characterize the samples defined as waste to ensure that they are disposed of in a suitable manner. The waste rock is transported to designated areas based on geochemical/geological characterization

The frequency of the waste rock sampling is dependant upon the rock type. Non-lithified surficial materials, such as till, talus and glaciofluvial materials, and Toodoggone Tuffs have been classified as non-acid generating (NAG) and are not sampled as sufficient information on this rock type has been collected. The samples are sieved into fine and coarse fractions and each fraction is submitted for Acid Base Accounting (ABA) analysis and selected samples are submitted for ICP analyses with other samples retained for future shake flask testing, if required.

All other rock types (Leach Cap, Supergene, and Hypogene) are characterized using both pre-blast and post-blast coarse and fine fractions. Every fifth pre-blast holes are sampled, which represents 20,000 tonnes mined, and a post-blast samples are collected from every 20,000 tonnes of blasted rock. The only exception to this is the Asitka PAG (potentially acid generating) lithology in which a preblast samples are collected every 30,000 tonnes, within the PAG outline defined by drilling, and postblast samples are collected every 20,000 tonnes. For Hypogene material, one post-blast sample is collected for every 100,000 tonnes mined. Sampling is most intense for materials with uncertain chemistry or that have greater potential for impact. Physical and geological descriptions are recorded for every sample taken.

ROCK TYPES

The rock types present at the Kemess Mine have been classified into 7 types of waste and 4 types of ore. The individual materials and their area of concern are listed in Table 1 below and the following Plate 1 illustrates the segregation and temporary storage of the PAG waste materials.

Plate 1: Low Permeability Ex-Pit PAG Dump (Showing Drainage Control And Collection Pond)

Table 1 Ore and Waste Rock Classifications

Material	*Nature*	*Concerns*	*Test Method*
Overburden	Waste	None	
Toodoggone Sediments	Waste	None	
Asitka Group NAG	Waste	Metal Leaching	Shake Flask, Field Test
Asitka Graphitics	Waste	Acid Generation, Metal Leaching	Shake Flask, ABA, Humidity Cell, Field Test
Asitka Group PAG	Waste	Acid Generation, Metal Leaching	Shake Flask, ABA, Humidity Cell, Field Test
Hypogene PAG	Waste	Acid Generation, Metal Leaching	Shake Flask, ABA, Humidity Cell, Field Test
Leach Cap Waste	Waste	Metal Leaching	Shake Flask, Field Test
Transition Ore	Ore		
Leach Cap	Ore		
Supergene	Ore		
Hypogene	Ore		

MATERIALS HANDLING AND WASTE DISPOSAL DESTINATIONS

Following is a summary of the materials handling and waste disposal management systems at Kemess Mine.

Waste Rock and Ore

The Kemess Geology Department uses stakes, banner boards and flagging tape to mark the different kinds of ore and waste for the operators in the open pit. In addition, the pit foreman and shovel operators are given maps showing the geological boundaries. The shovel operator informs the haul truck operator either by horn blasts or radio where the load is to be deposited. Where the geologic boundaries are difficult to define (e.g. cross contamination of material near rock type boundaries), the pit geologist will be called in to help differentiate.

The waste materials classified at Kemess Mine are disposed of based on their geochemical classification. All material that has been classified as PAG are placed on the Ex-pit PAG dump, which is separate from the NAG waste dump. The Ex-pit dump is a temporary storage location and these materials will ultimately be re-handled and permanently stored under water in the exhausted open pit upon cessation of mining. Routine monitoring ensures the acid generation processes have not initiated and if ARD onset to is noted the material will be moved and placed underwater. This material could be relocated to the tailings impoundment for permanent subaqueous disposal or into the exhausted eastern portion of the open pit.

All drainage from the Ex-pit dump is collected and monitored before being discharged to a central collection pond. This allows the determination of the drainage water quality from the different rock types, which will indicate the early onset of ARD or metal leaching. All drainage from the collection pond is directed to the TSF. No discharge from the collection pond is released to the receiving environment.

NAG material is placed in the main NAG waste dump. Toodoggone Sediments, the single largest volume of all waste rock types, are used to build the base pad for the NAG dump, as these materials are chemically inert and do not have a metal leaching concern. The Asitka NAG material is disposed of on top of the base pad. At the end of mine life the rock dump will be covered with overburden material to facilitate final closure and reclamation of the rock dump.

Leach Cap Waste has been found to have metal leaching potential and is therefore hydrologically isolated within the NAG waste dump to prevent the release of metals. The leach cap portion of the NAG dump, already in place, has surface grading and till cover engineered to control and shed water. The Leach Cap portion of the dump is planned to be completely encapsulated within the NAG Dump to minimize water from leaching metals from this material.

Tailings

Tailings are pumped via a slurry pipeline to the Tailings Storage Facility (TSF), which is a constructed dam facility. The upstream portion of the facility consists of a beach area and pond. The objective is to maintain the tailings in flooded or permanent state of saturation. In addition, PAG waste rock was permanently stored in the facility during the early days of mine operation, prior to the construction of the aforementioned Ex-Pit PAG Dump.

The original construction method for the TSF was an “earth-filled” dam. In 2002 the construction method was modified to include placement of desulphurized cyclone sands as downstream buttress zone material. As with the waste rock area, an inventory is maintained of each rock and waste type placed in the dam and in the tailings impoundment. The following information is recorded: type and mass of material disposed; disposal site, elevation and predicted time to flooding; present height of the water table; geological and ML/ARD characterization data; and water quality data.

As noted above, Kemess Mine uses desulphurized and cycloned tailings sands for the construction of a downstream buttress on the tailings dam. The only material permitted for construction, following desulphurization and cycloning, are hypogene tailings. A comprehensive testing program was conducted of this material to show that it is not acid generating and does not pose a metal leaching risk. In order to ensure that the material has no long term risk, Lysimeter Testing has also been conducted on the material.

Ongoing testing continues on the material for buttress building prior to deposition to ensure that it continues to be suitable for construction purposes. Following are details of the general sampling procedure and ABA material characterization for the cyclone sands material.

- The minimum allowable NPR for construction sand use on the downstream of the dam is an NPR_{CarbNP} of >2.
- The minimum allowable NPR for the material used to build the exposed tailings beach upstream of the tailings dam at the end of mining is an NPR_{CarbNP} of >2.
- The plant feed and secondary cyclone underflow are sampled every three hours.

MATERIALS CHARACTERIZATION TESTING

A comprehensive test program is conducted at Kemess Mine to determine the potential of the materials to cause an environmental impact. The results of the program are used to ensure that the materials moved do not cause an impact. Tests that are conducted include lab and field scale static and kinetic tests. These tests include: ABA tests, Shake Flask Tests, Laboratory Leach Cell Tests, Humidity Cell Tests and Field Lysimeters. Following are summaries of the methods employed for the individual test.

Acid Base Accounting Tests

ABA tests are conducted in the analytical laboratory at Kemess Mine and are designed to measure the balance between potentially acid-generating potential and acid neutralizing potential in samples. The ratio between the two values is the Net Potential Ratio (NPR), which determines whether a particular sample may generate acid over time.

In standard acid based accounting, the maximum potential acidity (MPA) is calculated using the Total Sulphur result, assuming that all sulphur present is in the sulphide form and potentially convertible to sulfuric acid. The neutralizing potential (NP) is determined by treating the sample with an excess of standardized hydrochloric acid, heating to ensure complete reaction, then titrating the unconsumed acid with standardized base to a pH of 7.0.

ABA Analyses at Kemess Mines is carried out according to the methods outlined in the "Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and ARD", and include paste pH, rinse pH, Total-S%, Sulphate, Total-C%, Total Inorganic-C%, and Sobek bulk NP determination. The only approved departure from the above noted method is the fizz test procedure and the rational for the change and details of the procedure are outlined below.

The MPA is determined using a Leco Sulfur Analyzer to determine Total Sulphur, which is converted stoichiometrically to sulphide. Previous testing has shown that neither sulphate nor barite minerals are a significant source of sulphur at Kemess.

If there are no Fe-Mn carbonates or no sources of organic-C present in the material being tested then a Total-C% assay is used to determine NP, using a Leco Carbon Analyzer. If there is Organic-C present (i.e. graphite), then a Total Inorganic–C% (TIC) is measured. TIC is derived by the difference of Total-C minus Organic-C. If there are Fe-Mn carbonates present, the standard Sobek procedure for determining bulk NP is also used.

The Sobek Method is dependent on the fizz test, and as the standard fizz test is very subjective and can vary from assayer to assayer, Kemess has developed a procedure to quantify the visual Sobek fizz test by indirectly measuring CO_2 through gravimetric measurements. The procedure involves measuring the difference in sample weight following the addition HCl and mixing using a vortex. The basic assumption with the test is that the gas evolved is $CO_{2,}$ caused by the reaction of HCL and reactive carbonate minerals present, which represents the readily available NP component of the rock. The Kemess Vortex procedure has accomplished 2 key objectives: (1) successfully eliminated the subjective component of the standard ABA procedure, and (2) created a procedure that is readily "repeatable" thereby minimizing operator-induced variability.

Shake Flask Tests

Shake Flask Test are conducted at the Kemess minesite and the purpose of the test is to obtain information on the mobility of metals from rock samples when exposed to water. The Shake Flask test is conducted by placing 250g sample of material, (particle size <2mm) with 750mL of distilled or deionized water into a 1000mL container. The mixture is gently agitated on a shake flask table for 24 hours. On completion of the 24 hour agitation, the samples are allowed to settle and 250mL of the supernatant are decanted and analyzed for dissolved metals, pH, conductivity, and sulphate.

Laboratory Leach Cell Tests

Laboratory Leach Cell Tests are conducted at Kemess Mine and are used to evaluate the potential for dissolution and mobility of metals from rock samples during exposure to percolating water. The tests are generally conducted using 500 g charges of material leached with 500 ml of distilled water in PVC columns, which are 20 cm tall and 15 cm in diameter. The tests are conducted include: Flooded Procedure, Trickle Leach Procedure and Recirculating Procedure.

During the Flooded Procedure, the water is added to the material in the cell and allowed to soak for one hour. The cell is then allowed to slowly drain over 24 hours and the liquid is collected for analyses. For the Trickle Leach Procedure, water is added to the cells over a 24-hour period, the leachate is then collected and analyzed. The Recirculating tests are conducted using a method similar to the Trickle Leach Procedure, where 1000mL of leach water is continuously re-circulated through the column. Analyses conducted samples may vary depending on the purpose of the test, however, analyses are generally conducted for pH, conductivity, alkalinity, sulphate and metals.

Humidity Cell Tests

Humidity Cell Tests are conducted by contract environmental laboratories as required, using standard methodologies.

Field Lysimeters

Kemess Mine currently has twelve field test pads, four of which have been in operation since 1999, two in operation since 2000, three in operation since 2002 and three that were commissioned in 2003. The types of materials stored in these pads are shown in Table 2 below and the following Plate 2 shows examples of the Field Lysimeters..

Table 2: Field Test Pad Materials and Date Installed

Pad Number	Material	Installed
LTP 1	Hypogene Waste Rock	1999
LTP 2	Leach Cap Rock	1999
LTP 3	Asitka Chert Rock	1999
LTP 4	Asitka Graphite Rock	1999
LTP 5	Leach Cap Rock	2000
LTP 6	Leach Cap Rock	2000
LTP 7	Hypogene AG	2002
LTP 8	Hypogene AG	2002
LTP 9	Hypogene AG	2002
LTP 10	Asitka Chert Talus	2003
LTP 11	Asitka Chert Talus	2003
LTP 12	Asitka Chert Talus with 10% Graphite	2003

Plate 2: Field Test Pads (2002)

The objective of the Field Test Pads is to:

- Determine in-situ flushing of weathering products under field conditions (i.e. freezing, snow melt etc.);
- Monitor the trend in pH to determine whether acidic leachate is being produced and to evaluate the effect of buffering minerals;
- Determine the in-situ sulphide and carbonate consumption rates and metal release rates;
- Determine the relative rates of oxidation and buffering and determine mole ratios to evaluate changes in buffering reactions;
- Develop site-specific relationships between metal concentrations and pH; and;
- Compare sulphide oxidation rates, carbonate depletion rates, acid generation lag times and metal leaching rates with results from the laboratory testing.

OPERATIONAL HANDLING PROCEDURES

The Environmental, Engineering and Geology Departments at Kemess Mine work closely with the employees to ensure everyone is knowledgeable of the materials handling procedures. In this way, Kemess Mine has a number of formal and informal checks within the operation to reduce the potential of error. As an example, truck drivers and shovel operators are instructed on the location for disposal of the waste types, based on the analyses of samples collected. However, if a shovel operator or truck driver notices something that indicates the material might have been misidentified, they immediately contact the Environmental or Geology departments to confirm disposition. It has been found that involving the operators in the decision making process has reduced the transport of materials to improper destinations.

A comprehensive production database is maintained to track material movement, including over 10,000 ABA analyses. A detailed computer model has been constructed of the Ex-pit PAG Dump where periodic surveys have been used to construct a 3-D model of the dump. The volume and origin of material, the geological and ML/ARD characterization data, final location and dumping times at each part of the dump are accurately recorded and traced for future interpretation. This information will facilitate the quick removal of any rock that demonstrates early stages of the ARD process, which will be permanently placed in a flooded location of the pit or in the tailings impoundment. This information will also be used to allow a decision to be made on whether or not to process currently classified marginal low-grade material such as the Hypogene PAG material.