THE IMPORTANCE OF SAMPLE SELECTION FOR THE PURPOSE OF DEVELOPING THE WASTE ROCK MANAGEMENT AND CONCEPTUAL CLOSURE PLANS AT KEMESS NORTH

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ABSTRACT

The paper focuses on the decisions involved in selecting appropriate samples when initiating the kinetic testing program to aid in designing the waste rock management plan and assisting in the conceptual closure plan for the Kemess North Project. The kinetic testing program was intended to: (1) estimate the time to onset of acid rock drainage (ARD) generation for the rock groups where ARD was likely and uncertain to occur; (2) assess the leaching rates for both the acidic and neutral materials; and (3) establish a site specific segregation criterion for the uncertain materials. A total of 11 laboratory waste rock cells and two field leach pads were initiated from a database of over 1200 ABA samples. In addition, one tailings humidity cell was run. A brief summary of the static testing characteristics of the samples selected to undergo testing, the resulting time to onset of ARD and leaching rates will be presented. These results will be discussed in light of the resulting waste rock management plan and the overall closure concept for the project. Had the kinetic testing program continued, only five of the laboratory cells and both leach test pads were recommended to continue. The justification behind selecting those cells to continue is the final focus of the paper along with the conclusions of the testing program to date.

INTRODUCTION

The Kemess North Copper-Gold Project is located approximately 450 km northwest of Prince George, BC (see Figure 1) and approximately 5.5 km north of the operational Kemess South Mine open pit. Kemess North was expected to operate at approximately 120,000 tonne per day mill throughput producing approximately 325 Mt of waste rock and 370 Mt of tailings over the 14 year mine life (KCBL, 2006). Owned by Northgate Minerals Corp., the project went through the joint Provincial-Federal Environmental Assessment process culminating in a Panel Review. The Panel, and ultimately the Federal and Provincial Ministers of the Environment concluded that "development of the Kemess North Copper-Gold project in its present form would not be in the public interest" (Joint Panel Review Report, 2007: xi). Despite the decision not to approve the project, a substantial amount of research and testing went into the waste characterization, waste management and closure plans.

Figure 1 **Project Location (KCCL, 2005)**

The static geochemical testing program consisted of seven composite tailings samples (originating from over 1700 drill core samples) and over 1200 waste rock ABA samples as well as 100 waste rock shake flask extraction tests. The static program established the tailings to be Potentially Acid Generating (PAG) and the ARD characteristics of the waste rock to range from naturally Already Acid Generating (AG), Potentially Acid Generating (PAG) and Non-Potentially Acid Generating (Non-PAG). Twelve laboratory kinetic testing cells (11 waste rock, one tailing) and two waste rock field leach test pads were initiated. The purposes of the kinetic testing program were to:

1. Estimate the time to onset of ARD for the tailings and PAG waste rock groups;
2. Assess the leaching rates for both the AG and Non-PAG materials and assess the leaching rates of the PAG material at the initial onset of ARD and at steady state; and
3. Establish a site specific NPR criterion to be used in the segregation of PAG and Non-PAG waste rock.

At the time of the Panel review, approximately 150 weeks of kinetic testing data were available. An additional 70 weeks of data were collected subsequent to Panel review and prior to the official decommissioning of the kinetic testing program. This paper focuses on the samples selected to undergo kinetic testing to develop the waste rock management and conceptual closure plans whereby waste rock and tailings would be stored in Duncan Lake, a 5 km long, 0.5 km wide lake approximately 3 km west of the proposed open pit (Figure 2). It provides a program update since the Panel review and presents the justification behind which cells were to be continued, had the program been needed.

SUMMARY OF PROJECT GEOLOGY

The Kemess North open pit area hosts a copper-gold ore zone associated with the intrusion of a quartz monzonite/quartz diorite unit into an andesitic Takla Volcanic rock unit. The main (higher grade) ore zone is situated towards the base of the approximately 400 m deep open pit (KCCL, 2005). Local bedrock geology of the Kemess North open pit area is shown on Figure 2. The main rock groups (from oldest to youngest) within the open pit are summarized as follows (taken from KCCL, 2005):

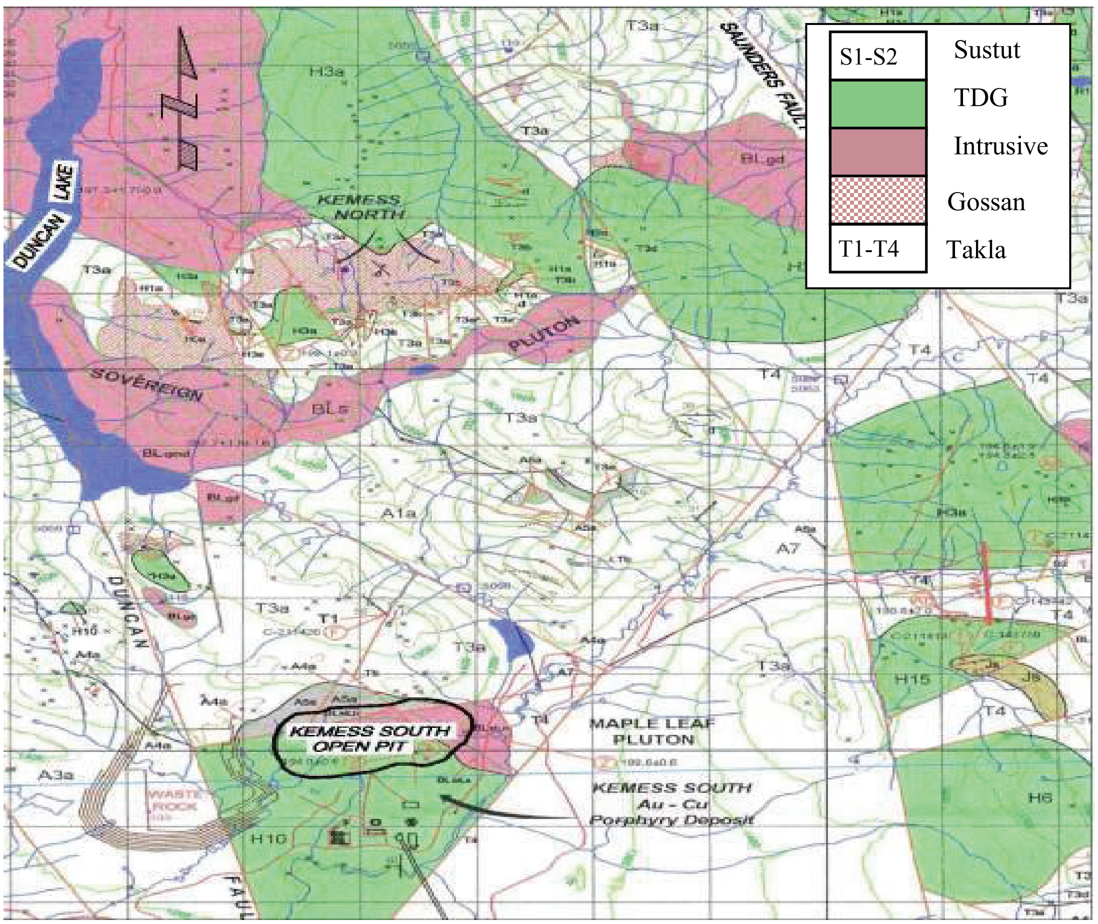

Figure 2 Key Features of the Kemess North Property (KCCL, 2005)

The **Andesite Volcanics Takla Group** (Upper Triassic) consists of andesitic/basaltic flows. The Takla group hosts some of the main ore zone along the contact with the quartz monzonite intrusion. A geologically important Takla subgroup, is the **Bladed Feldspar Porphyry (BFP)**.

The **Quartz Monzonite/Quartz Diorite – Hypogene (Late Triassic)** are intermediate intrusive units and host the main orebody.

Mantling the northern and eastern limits of the open pit, the **Dacitic - Toodoggone (TDG) Formation (Lower to Middle Jurassic)** is a matrix supported polylithic fragmental volcanic unit. The TDG is a younger intrusion/flow within the Takla. Typically the unit has lower sulphide concentrations and low mineralization.

A highly weathered flat-lying Gossan Zone extends approximately 75 m from surface and overlies the Takla, BFP and TDG Formation. The Gossan accounts for the naturally occurring ARD which results in low pH and elevated elemental contents in the two streams draining the Kemess North open pit area. Several drill core samples that have been found to contain low paste pH values at depths greater than 75 m and are exclusively located along the weathered faces of structural controls bounding the open pit. These include the Kemess North Fault and the faults that define the contacts between the TDG and Takla rock groups on the east and west margins of the open pit area.

WASTE ROCK ML/ARD PREDICTION

Over 1200 waste rock samples underwent ABA and elemental analysis with a subset of 100 undergoing shake flask extraction testing. The results of the ABA and shake flask testing were interpreted according to rock group and alteration type and resulted in the ARD classification summarized in Table 1. The details of the interpretation that resulted in the classification scheme are beyond the scope of this paper.

Table 1 Waste Rock ARD Classification Summary[1]

Already Acid Generating (AG)	Already Acid Generating (AG)	Potentially Acid Generating (PAG)	Potentially Acid Generating – Uncertain (PAG)[2]	Non-Potentially Acid Generating (Non-PAG) *
Paste pH ≤ 6	6< Paste pH ≤ 7.5	Paste pH > 7.5, NPR ≤ 1.0	Paste pH > 7.5, 1.0 < NPR ≤ 3.0	Paste pH > 7.5, NPR > 3.0

[1] KCCL, 2005
[2]The NPR cutoff between PAG and Non-PAG waste rock was to be confirmed by the kinetic testing program

From the waste rock ABA database seven flood leach humidity cells (FL), four trickle leach columns (TLC) and two field leach test pads (LTP) samples were selected. The FL humidity cells operated according to standard procedures (Price, 1997) while the TLCs were set up to receive 3 times annual precipitation each month to flush out as much mass as possible during the testing period. The LTP were constructed wooden cribs containing ~210 kg of rock exposed to ambient air temperature and precipitation and outfitted with a drain and bucket collection system. The pre-test characteristics of all 13 kinetic tests are summarized in Table 2.

Table 2 **Kinetic Testing Program Summary of Pre-Test ABA & ICP Characteristics[1]**

	Paste pH	Total S (%)	Sulphide S (%)	NP (kg $CaCO_3$/t)	NPR	Cu (ppm)
FL1 – TDG	9.40	0.34	0.33	14.9	1.45	125
FL2 – TAKLA	8.50	8.59	8.57	62.4	0.23	286
FL3 – BFP	8.50	6.39	6.38	15.3	0.08	224
FL4 – TDG	8.38	1.73	1.73	3.40	0.06	214
FL5 – TDG	8.41	0.25	0.25	12.4	1.62	93
FL6 – TAKLA	7.71	6.64	6.64	12.6	0.06	415
FL7 - TAKLA	7.92	5.51	3.10	13.6	0.14	559
TLC1 – TAKLA	7.0	6.47	6.46	23.8	0.12	363
TLC2 - BFP	8.1	5.13	5.12	10.5	0.07	153
TLC3 – TAKLA	4.7	1.34	1.16	0.85	0.06	107
TLC4 - TDG	8.2	0.01	0.01	0	0	1
LTP1 – TAKLA	5.6[2]	1.69	N/A	7.20	0.07	141
LTP2 - TDG	7.4[2]	<0.01	N/A	1.43	>3[3]	7

FL = Flood Leach, TLC = Trickle Leach Column and FB = Field Bin
[1]KCCL, 2005
[2]Values shown are Rinse pH. Paste pH not available
[3]Value not calculated exactly due to undetectable total sulphur

FL1, FL4 and FL5 were charged with samples selected to represent the TDG material. All three of the samples have a paste pH > 7.5; however, the NPR values place FL1 and FL5 in the uncertain (NPR 1.0 – 3.0) and FL4 in the PAG (NPR ≤ 1.0) categories. Sample FL1 has a low total sulphur content (comprised almost entirely of sulphide) and was expected to be reasonably representative of the TDG waste rock located in the northern portion of the open pit. Due to its NPR, it was expected to aid in refining a site specific NPR criterion, segregating the PAG and Non-PAG TDG rock. The sample selected for FL5 had unexpectedly low total sulphur and significantly higher NP than initially targeted. Rather than monitoring the onset to acid generation of the PAG TDG material, this sample (in addition to FL1) would instead aid in establishing the site specific NPR segregation criterion. Sample FL4 has a low NPR and is not representative of the TDG rock group as a whole. Rather, it was chosen to monitor the onset of ARD and metal leaching rates of the TDG on the contact with the Takla.

The Takla Volcanic sample in Cell FL2 represents the PAG rock group with total sulphur content of 8.59% comprised almost entirely of sulphide. The total sulphur value is approximately the P_{90} according to the ABA database of all 472 Takla samples. The sample was selected to assess the time to onset of ARD and the metal leaching rates from the Takla waste rock. The Takla material contained within FL6 and FL7 were chosen to provide further confidence in the time to onset of ARD for the low NPR Takla. Both samples show similar paste pH, total sulphur and copper contents. However, Cell FL6 shows that almost all of the total sulphur is sulphide while the sulphide content in Cell FL7 is approximately half of the total sulphur. Both samples have similar Cu contents (which due to material variability were below the median values for the Takla rock group). The BFP sample chosen for Cell FL3 has an above average total sulphur (6.39% versus 5.46% average, for the total database of 214 BFP samples) of which 6.38% is sulphide. It has an extremely low NPR (NPR = 0.08) and was selected to characterize the onset to ARD and metal leaching of the BFP waste rock.

Two samples were chosen from the Takla and one each from the TDG and BFP units for the TLCs. The Takla and BFP samples used in the trickle leach column tests (TL1 and TL2) were recommended to be split samples of those in the flood leach humidity cells (FL2 and FL3). The objective was to directly correlate the oxidation process observed in the FL humidity cells with the metal loading rates measured in the TLC leachate. However, the material used in the TLCs originated from the interval directly above that used in the FL cells due to an insufficient amount of drillcore available to charge both the FL and TLC tests. The material in Cell TL3 and TL4 are splits of the Takla and TDG Talus material in the LTPs located at site. However, the grain size of the material in the TLCs is smaller than that of the field bin material (100% <2" mm in the TLC vs. 100% <3" in the LTP). Undertaking TLC testing on the LTP material may accelerate the weathering and metal leaching compared to the LTP. The TLCs were not acidified further prior to testing because it was expected that the time to net acid generation would be relatively short.

As mentioned, the samples for the LTPs were selected from the TDG and Takla Talus material located at the surface of the Kemess North open pit area in order to characterize that material which has undergone oxidation since its emplacement.

TAILINGS ML/ARD PREDICTION

Kemess Mine geologists selected over 1700 drill core samples and combined these into 30 ore composites according to mine domain and location within the pit limits. Composites were subsequently combined into seven super composite (SC) ore samples for locked-cycle testing to ensure a broad representation of the ore reserves (KCCL, 2005). ABA, ICP and mineralogical analyses were conducted on all seven super composites and NPR values were consistently below 1.0 indicating the likely potential for ARD. These SC samples were then further combined to prepare additional metallurgical samples for locked-cycle testing. A total of four additional combinations of tailings samples were generated; two representing the overall ore deposit (SCO and SCO2), two for the upper (early operations) portion of the deposit (SCU) and one for the lower (final years of operations) portion (SCL). It was determined that the locked cycle test from the SCO2 tailings blend yielded metallurgical results that were very typical of previous tests completed in the program and could therefore be counted on as a "typical" tailings sample. Sample SCO2 therefore underwent the full suite of static and kinetic testing with independent ABA testwork conducted at three different laboratories yielding consistent results. Table 3 summarizes the pre-test ABA characteristics of the Kemess North tailings humidity cell.

Table 3 Pre-Test Characterization of Tailings Humidity Cell (Sample SCO2)[1]

Paste pH	Total S (%)	SO_4-S (%)	S^{2-}-S (%)	Carb-NP (kg $CaCO_3$/t)	Sobek-NP (kg $CaCO_3$/t)	Carb-NPR	Sobek-NPR	Cu (ppm)
7.2	3.79	1.33	2.46	10.8	23.5	0.14	0.30	259

[1] From KCCL, 2005

The ABA test results show that the Kemess North tailings have a likely potential for ARD. The mineralogical assessment of the tailings solids confirmed that the sulphide present was pyrite and the sulphate was gypsum and anhydrite. Trace calcite was noted in the mineralogical assessment with the primary NP contributors being the aluminosilicates.

Additional testing on the separate tailings streams (Rougher tailings and Cleaner Scavenger tailings) was also performed on the tailings blends. These tests indicated that there is a preferential separation of the sulphides into the Cleaner Scavenger tailings, resulting in lower sulphide content in the Rougher tailings and bringing the NPR typically to about 0.6 but as high as 1.6 on one sample. However, the Rougher tails remain classified as a Potentially Acid Generating. Further "cleaning" of these tailings in a de- pyritization circuit would generate a consistently low sulphide tailing for the final reclamation of the tailings beaches. The rougher tailing is also lower in sulphate than the Cleaner Scavenger tailings, further enhancing the objective of having low sulphate tailings on the final beaches to reduce the long-term flushing of gypsum from the tailings into the impoundment.

KINETIC TESTING PROGRAM RESULTS AND PLANNING FOR CLOSURE

Table 4 summarizes the kinetic testing program results. Four of the waste rock cells as well as the tailings cell achieved acidic conditions over the testing period providing valuable information on the time to onset of ARD and the related metal leaching rates. It should be noted that at the time of Panel review, only 130 weeks of data were available for presentation and only one cell (waste rock cell FL7) had achieved acidic conditions.

Table 4 Kinetic Testing Program Results

	Test Duration (wks)	Time to Onset of ARD (wks / yrs)[1]	At the time of Decommissioning		
			pH	SO_4 (mg/L)	Cu (mg/L)
FL1 – TDG	199	N/A / N/A	6.82	2	0.0017
FL2 – TAKLA	199	N/A / N/A	7.09	24	0.0023
FL3 – BFP	199	198 / 3.8	6.27	27	0.016
FL4 – TDG	177	N/A / N/A	7.03	19	0.0020
FL5 – TDG	177	N/A / N/A	7.62	< 1	0.00087
FL6 – TAKLA	177	140 / 2.7	3.77	73	3.3
FL7 - TAKLA	177	100 / 1.9	4.52	413	0.91
TL1 – TAKLA	189	N/A / N/A	7.52	51	0.0013
TL2 - BFP	189	161 / 3.1	6.07	59	0.045
TL3 – TAKLA	189	0[3] / 0[3]	3.46	24	0.025
TL4 - TDG	189	N/A / N/A	5.78	<1	0.0012
Field Bin – TAKLA	Ongoing	0[3] / 0[3]	-	-	-
Field Bin - TDG	Ongoing	N/A / N/A	-	-	-
SCO2 Tailings	184	155 / 3.0	3.22	460	6.8

[1]ARD achieved when pH consistently reported below pH 6.5
[2]N/A = Not Applicable, ARD not achieved

[3]TLC3 began the testing period with an acidic pH (pH 3.87)

Since project inception, scientists agreed that the AG waste rock at this site would require immediate sub-aqueous disposal. The operational waste management plan and thus the closure concept were developed such that this rock was to be stored within the deepest basin of Duncan Lake (Duncan Impoundment) over low permeability lakebed sediments. Kinetic testing was not required to determine the appropriate management strategy for this rock. Due to its naturally existing AG condition, the creeks draining the open pit area provided the most appropriate long-term pH and metal loading rates should this waste rock remain on surface. Laboratory shake flask extraction tests were used to identify the potential magnitude of the short-term loading rates. However, the Takla Talus splits used in TLC3 and LTP1 served to confirm the long term metal loads. The leachate pH of TLC3 remained between pH 3.4 and 4.1, lower than the maximum recorded on site (pH 4.6) during the baseline sampling period and the Cu concentration of TLC3 peaked at 0.11 mg/L similar to the maximum Cu concentration of 0.26 mg/L recorded during baseline sampling. However, since waste rock on site had been acidic for potentially thousands of years, the initial ARD strength and resulting metal loads also required characterization.

The operational waste management plan was based on the use of PAG waste rock as equipment work platforms within the impoundment footprint. The commitment was made that these work areas would be submerged by the rising impoundment water level prior to the onset of ARD. The kinetic testing program was intended to assist in determining firstly, the loading rates from this temporarily un-submerged and neutral PAG waste rock and secondly, the time to onset of ARD and therefore the time before this PAG waste rock would require submergence. Thirdly, upon the onset of ARD, these samples would provide the magnitude of metal leaching. As indicate above, the steady-state, long-term ARD leaching rates were being provided by the Gossanous waste rock on site. Samples selected to charge FL2, 3, 6 and 7 (PAG, Takla or BFP material) were chosen for both of these purposes.

Humidity cells FL2 and FL3 had longer periods of record than Cells FL6 and FL7 and therefore either FL2 or FL3 were thought to be appropriate for developing un-submerged waste rock loading rates. Both cells showed similar sulphate and copper concentrations in the leachate over the test duration prior to Panel review. At the time of impoundment water quality modeling, the loading rates from FL2 were selected instead of FL3. ARD conditions were never achieved prior to decommissioning FL2 whereas they were achieved at week 198 (after Panel review) for FL3. Approximately 30 weeks prior to the change from neutral to acidic conditions, copper concentrations began to increase in FL3. It is therefore concluded that the use of FL2 to develop steady-state neutral loading rates of the un-submerged waste rock prior to ARD was appropriate.

At the time of Panel review, only FL7 had developed acidic conditions. The operational waste rock management plan developed at that time conservatively committed to ensuring submergence of PAG waste rock within two years of placement within the Duncan Impoundment. This is equal to the time to onset of ARD within the laboratory and did not consider any difference in lag time between the laboratory and field. Prior to decommissioning, FL3, FL6 and TL2, acidic conditions had developed between 2.7 and 3.8 years in the laboratory. Therefore, there may have been some justification in increasing the allowable time to submergence from two years to four years without compromising the impoundment water quality.

The material in cells FL1 and FL5 with the uncertain potential to generate ARD (having an NPR of 1.0 - 3.0) was also to be submerged within 2 years. This was considered to be a conservative commitment since should the onset to ARD occur, the lag time would be greater than for lower NPR (NPR $\leq$ 1.0) material. The kinetic testing program was intended to aid in refining the NPR criterion such that only PAG rock would be submerged within two years whereas Non-PAG rock could be stored in an on-land dump. However, since the waste rock humidity cell program was terminated, refinement of the NPR segregation criterion was never completed.

Waste rock with no potential for ARD was proposed to be stored within an on-land waste dump. Estimated loading rates from the Non-PAG waste rock were characterized using the LTP2.

Like the majority of the waste rock cells, the tailings humidity cell achieved acidic conditions after Panel review (at 154 weeks of testing). Closure commitments stated that any tailings remaining unsaturated at the time of mine closure would be de-sulphurized prior to placement within the impoundment. This commitment was made to prevent high sulphate leaching rates into the impoundment over the long term, as sulphate was identified through both mineralogy and kinetic testing as the major contaminant of concern. Though it was known that the tailings were PAG based on the static testing results, ARD had not yet been realized at the time of Panel review. The kinetic testing program confirmed both the time to onset of ARD (154 weeks in the lab) and that the closure measure of tailings de-sulphurization for the material used to cover the beaches would also reduce the severity of ARD and any associated metal leaching.

KINETIC TESTING DECOMMISSIONING

As indicated previously, the kinetic testing program has been discontinued due to the termination of the Kemess North Project as a whole. However, had funding been available to maintain the program on a research basis, the kinetic testing program would have been downsized based on the reasons presented in Table 5.

Table 5 Reasons for Decommissioning or Continuing[1]

TEST	D/C[2]	REASON FOR DECOMMISSIONING OR CONTINUING
FL1 – TDG	D	Low initial total sulphur content and steady near-neutral pH over testing period. Low overall sulphate flushing throughout the testing period means this cell will continue to leach slowly and not provide additional useful information on the TDG rock group over the time-scale required.
FL2 – Takla	D	Near-neutral pH over the duration of the testing period and no substantial elemental leaching.
FL3 – BFP	C	Gradual decline in pH means that this cell could produce acidic conditions and elemental loading rates similar to FL6 and FL7 over the longer term. It is selected to remain on-going to represent the BFP rock group elemental loading rates. This cell was chosen over TL2 since humidity cells have a standard test method (whereas the trickle leach columns set up for this project were non-standard) making data more directly comparable to other sites.
FL4 – TDG	D	Near-neutral pH over the duration of the testing period. Initial ABA results show that the sample in this cell has a low NPR as compared with the TDG rock group as a whole and is not representative of the bulk of the TDG rock within the open pit.
FL5 – TDG	C	Low initial total sulphur content and steady near-neutral pH over testing period. Selected to remain on-going as an example of the TDG having an NPR between 1 and 3 and potentially to support developing a site-specific, NPR criteria for geochemical classification.
FL6 – Takla	C	Similar results to FL7, but in most cases, lower overall elemental loading rates, but the highest and steepest initial copper loading rates. Selected to remain on-going since the copper values are similar to those of the Huckleberry Column 4 used in the upper bound water quality modeling and this cell may confirm whether the Huckleberry Column 4 data was a good surrogate for the Kemess North Takla rock group, the bulk of the deposit.
FL7 – Takla	C	Similar results to FL6, but higher elemental concentrations for many of the parameters. This cell is recommended to continue since it was used in much of the water quality modeling because of its high initial sulphate concentration. This cell could be decommissioned once enough sulphate has been released to represent the initial sulphate content as determined by ABA testing.
TL1 – Takla	D	Near-neutral pH over the duration of the testing period.
TL2 – BFP	D	Similar results to FL3, chose to maintain FL3 (see explanation above)
TL3 – Takla	D	Acidic pH over the duration of the testing period. All information has been gained from this test. Field bin KN-01 is the same material.
TL4 - TDG	D	Consistent pH throughout the testing period, no additional information to be gained from this test. Field bin KN-02 is the same material.
SCO2 Tailings	C	Assess maximum decline in pH and long term elemental loading rates.

[1]MEA, 2007
[2]D = decommission, C = continue

CONCLUSIONS

Selecting samples to meet specific project goals is probably the most agonizing decision for any geochemist without the help of hindsight. For the Kemess North Project, 13 waste rock and one tailings test defined the kinetic testing program. The program was developed to provide information on the loading rates for the Non-PAG waste rock, estimate the time to onset of ARD, and assess the loading rates associated with the PAG waste rock prior to, immediately following and at steady state ARD conditions. It was anticipated that the program would also be able to refine the division between the PAG with uncertain ARD potential and Non-PAG rock such that a greater volume of rock could be stored on land rather than within the Duncan Impoundment.

Waste rock pre-test ABA characterization targets were not always met due to either, the unavailability of sufficient sample to run duplicates (as in the cases of TL1 and FL2 and TL2 and FL3) or the variability in the rock itself resulting in unexpected ABA values (in the case of FL5). Interestingly of the two TDG FL cells (FL1 and FL5), FL5 was selected to continue had the program continued. Though FL5 did not initially meet the targeted ABA characteristics, it was selected to remain on-going as an example of the TDG having an uncertain NPR and potentially to support developing a site-specific NPR segregation criterion. Regardless of these issues, most of the basic objectives of the program were met. Since several cells have shown that the original sulphate content has flushed out, a site-specific NPR criterion could potentially be established.

As difficult as the decisions are as to which samples should be selected to ensure the appropriate data is collected to develop any waste rock management and closure plan, the decisions to decommission humidity cells can be equally difficult. The duration of humidity cell tests in general is until the rates of sulphate production and metal leaching have stabilized at constant rates for five weeks. Experience in BC shows that stabilization often takes 40 and sometimes over 60 weeks. Therefore the criteria on which to close down a cell depend on site-specific objectives and the degree of uncertainty in the predictions (Price, 1997). In the case of Kemess North, the discontinuation of the project established that all cells would be shut down and no concluding interpretation or post-test data analysis would be completed. The trends in several cells including FL3, FL6, FL7 and the tailing SCO2 test would be integral in establishing the minimum acidic pH and the maximum metal loading rates. However, even after nearly four years of data collection, a comparison of the PAG rock metal leaching rates prior to, immediately following and with steady state ARD rates could not be completed since the copper concentrations continued to show exponential increases.

In the end, nine of the 13 waste rock cells provided information used in waste management and closure planning. The results of the tailings humidity cell test work subsequent to Panel review confirmed the need for the commitment to ensure de-sulphurized tailings were used over the tailings beach ensuring not only long-term low sulphate concentrations in the tailings pond itself, but also ensuring ARD generation from the tailings did not become an issue post-closure.

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