Proceedings of the 15th Annual British Columbia Mine Reclamation Symposium in Kamloops, BC, 1991.
The Technical and Research Committee on Reclamation

A REVIEW OF ACID GENERATION RESEARCH AT THE SAMATOSUM MINE

April, 1991

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ABSTRACT

The Minnova Inc./Rea Gold Corporation Joint Venture operates the Samatosum 465 tpd open pit mine located near Kamloops, B.C. Ore production began in May, 1989.

Sulphide ore minerals are hosted primarily by quartz-carbonate vein. Waste rock in the immediate vicinity of the ore zone may contain up to 40% pyrite visually.

All waste rock types have been categorized either as acid consuming or potentially acid generating (PAG) based on the results of acid/base accounting. The waste dump design alternately layers acid consuming and PAG rock types. This has the effect of encapsulating PAG material in an envelope of acid consuming material.

A laboratory simulation (column leach test program) of the proposed waste dump geometry was initiated in February, 1989 in order to test the validity of the waste dump design hypothesis.

The end result of the column leach test program is expected to be a model of the layering technique which may be applied to other sites.

The laboratory simulation has, to date, confirmed the effectiveness of the layering technique in controlling leachate pH in a laboratory environment.

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Revue des recherches sur la génération d'acide à la mine Samatosum

par

T. Kress

La mine Samatosum est une exploitation minière à ciel ouvert, en co-exploitation par Minnova Inc. et Red Gold Corporation. Elle est située près de Kamloops, C.-B. La production de minerai y a débuté en mai 1989.

Les minerais sulfurés résident en général dans des veines de quartz. Les déchets rocheux, à proximité immédiate de la zone de minerais peuvent contenir jusqu'à 40% de pyrite.

Tous les types de déchets rocheux ont été classés soit dans une catégorie consommant de l'acide, soit dans une autre catégorie ayant le potentiel de produire de l'acide (PPA). Ce classement se base sur les caractéristiques acide/base, ainsi que sur des tests de confirmation. La conception des sites de dépôt à résidus alterne les couches de roches consommant de l'acide avec celles de roches PPA. Cette méthode a pour effet d'encapsuler les roches PPA dans une enveloppe de matériaux qui consomme l'acide.

Une simulation en laboratoire de la géométrie proposée au niveau des sites de dépôt fut entreprise, en février 1989, afin d'évaluer la validité des principes de conception du procédé en question.

Le résultat final du programme de lixiviation sur colonnes est prévu représenter un modèle de la technique d'entassement par couches pouvant être appliqué à d'autres sites. Des cordes de séries thermistances ainsi que des installations internes pour la collecte d'eau ont été incorporées à la construction du site de dépôt, pour permettre la corrélation des données de laboratoire et des résultats obtenus sur le terrain.

A date, la simulation en laboratoire (essai de lixiviation sur colonnes) a confirmé l'efficacité de la technique d'entassement par couches pour le contrôle des niveaux de pH du filtrat.

La corrélation des données de laboratoire et de terrain se poursuit.

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1. INTRODUCTION

1.1 Mine History

Ore production from the open pit began in May, 1989. The mill operates at 465 tpd ore feed and produces three mineral concentrates: Copper-silver, zinc and lead.

An underground exploration drift was completed in January, 1991 followed by diamond drilling of the underground portion of the orebody.

1.2 Geology

The Samatosum ore deposit is in the Adam's Plateau region of south central British Columbia near the contact of volcanic and sedimentary rocks.

Mafic volcanic rocks containing visible pyroclastic fragments as well as abundant dolomite with some quartz and carbonate veining are located in the hanging wall. Sericitization increases towards the ore zone becoming very intense in the immediate ore hanging wall. Pyrite content increases towards the ore zone becoming up to 40% visually.

The sedimentary rocks are generally in the footwall. They include argillite and chert which also become intensely sericitized in the immediate ore footwall. The sediments may also be silicified near the ore.

The sulphide ore minerals are hosted primarily by quartz-carbonate vein although there are some massive sulphide occurrences as well. The ore minerals are: tetrahedrite, chalcopyrite, sphalerite and galena.

2. WASTE ROCK ACID GENERATION POTENTIAL

2.1 Acid Base Accounting

During 1988 as part of Stage 1 of the B.C. Mine Development Review Process, acid-base accounting analyses were performed on diamond drill core and diamond drill core assay pulps.

The rock types, the number of acid-base analyses done for each rock type and the average NNP (net neutralization potential) for each rock type are shown in Table 1.

Table 1 Net Neutralization Potential (NNP)

Rock Type	Code	# Acid/Base Samples	NNP (equiv. t $CaCO_3$/t)
mafic pyroclastic	MAF	8	+305
sericitic tuff	SERT	55	- 33
argillite	ARG	10	- 51
muddy tuff	MUT	10	-222
quartz vein	QV	3	+ 76
quartzite	QITE	5	+ 28
chert	CHERT	6	-226

2.2 Waste Rock Classification

The rock types listed above were classified as either PAG (potentially acid generating) or acid consuming in order to allow detailed mine planning to proceed. All waste rock types except MAF were classified as PAG.

Although QV and QITE have slightly acid consuming properties, they can not be practically isolated and employed as acid consuming material because of their relatively small volumes and occurrence within the PAG rock types.

Figures 1 and 2 following illustrate the relative volumes of the waste rock types to be mined in the open pit and the acid consuming/generating ability of the rock types based upon the projected open pit volumes.

FIGURE 1 SAMATOSUM WASTE ROCK VOLUMES

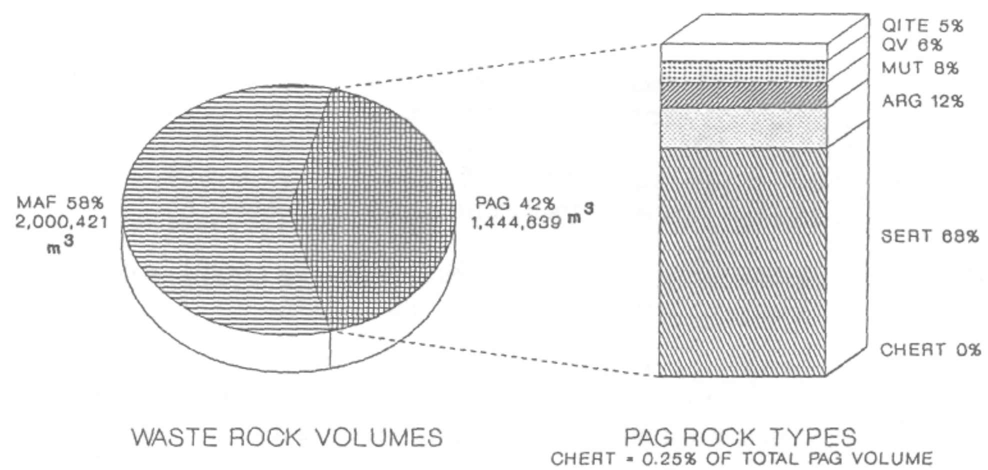
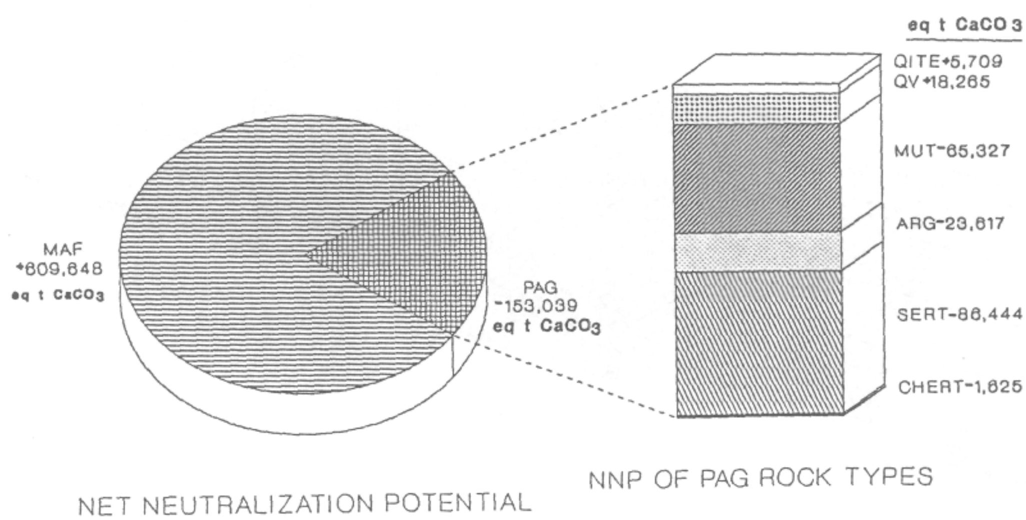


FIGURE 2 SAMATOSUM WASTE ROCK ACID GENERATION POTENTIAL



3. MAIN WASTE DUMP

3.1 Main Waste Dump Design Concept

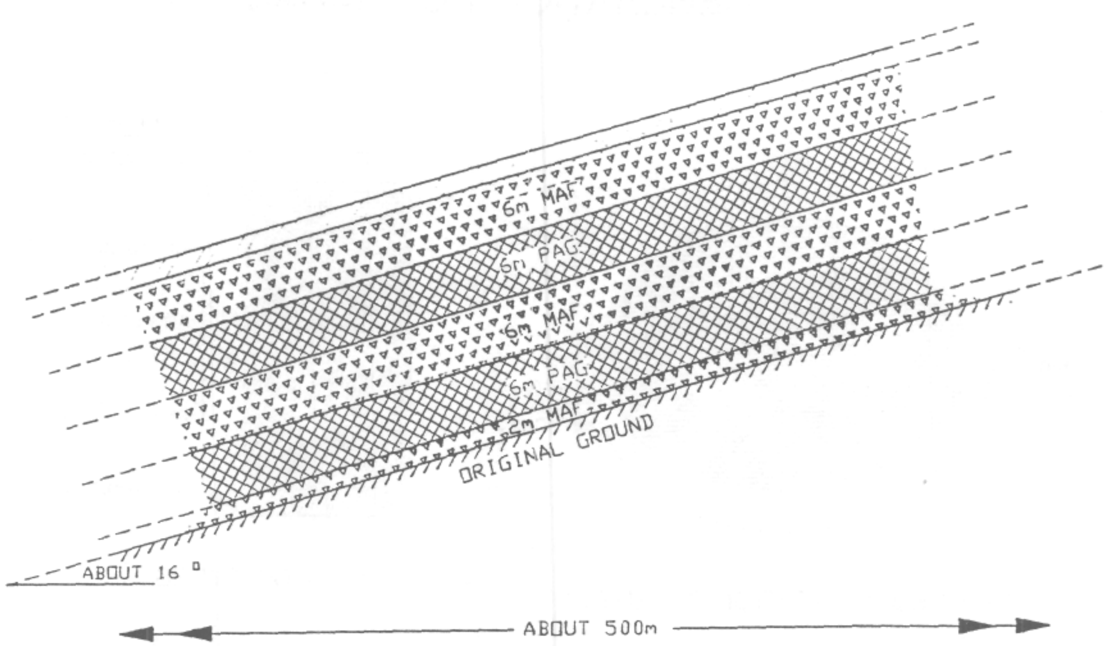
Figure 3 below illustrates the concept of the main waste dump design. The PAG rock types will be completely enveloped within the acid consuming mafic pyroclastic rock type. There is no mixing or blending of rock types.

Specifically, smoothed 6m thick PAG layers are covered by smoothed 6m thick MAF layers. The first PAG layer is underlain by a smoothed 2m thick MAF base. Combined overburden and till originally stripped from the area of the open pit will provide a final low permeability cover over the waste dump.

The dump is underlain by unworked organic soil and till with permeabilities in the order of 10^{-5} to 10^{-7} m/s.

The design concept is based on the hypothesis that percolating water will gain alkalinity from the MAF layers which will neutralize acidity generated within the PAG layers. In this way, acidity will be slowly leached from the PAG layers but leachate from the dump will remain alkaline. Therefore, the acid generation reactions should not enter the exponentially increasing stage.

FIGURE 3 SAMATOSUM MAIN WASTE DUMP SCHEMATION PORTION OF LONG SECTION



4. COLUMN LEACH TEST PROGRAM

4.1 Column Leach Test Design and Implementation

The Samatosum column leach test program was initiated during Stage 1 of the B.C. Mine Development Review Process. The prime objective of the research program was to test the validity of the main waste dump design concept. A broader result of the column leach test and Samatosum correlation may be a model which utilizes rock characteristic data to predict layering technique results at other sites.

The columns were set up as illustrated in Figure 4 below. Note that the amount of material in columns 1 and 4 relate to the amount of material in the upper mafic pyroclastic and PAG layers in column 2. This was done in order to allow an analysis of the interaction of the component pieces of column 2.

The construction of column 3 represents the worst case open pit bench (ie. most MUT and least SERT of any single pit bench).

Column 4 was suspended after 20 weeks of analysis. The acid consuming properties of MAF had been confirmed at this point.

Column 5 was initiated in week 23 of the program. Alkalinity was leached out of the PAG material by flushing with acid and the column was innoculated with thiobaccilus ferrooxidans. The intention was to evaluate the rates and quantities of acid which can be generated by the PAG material.

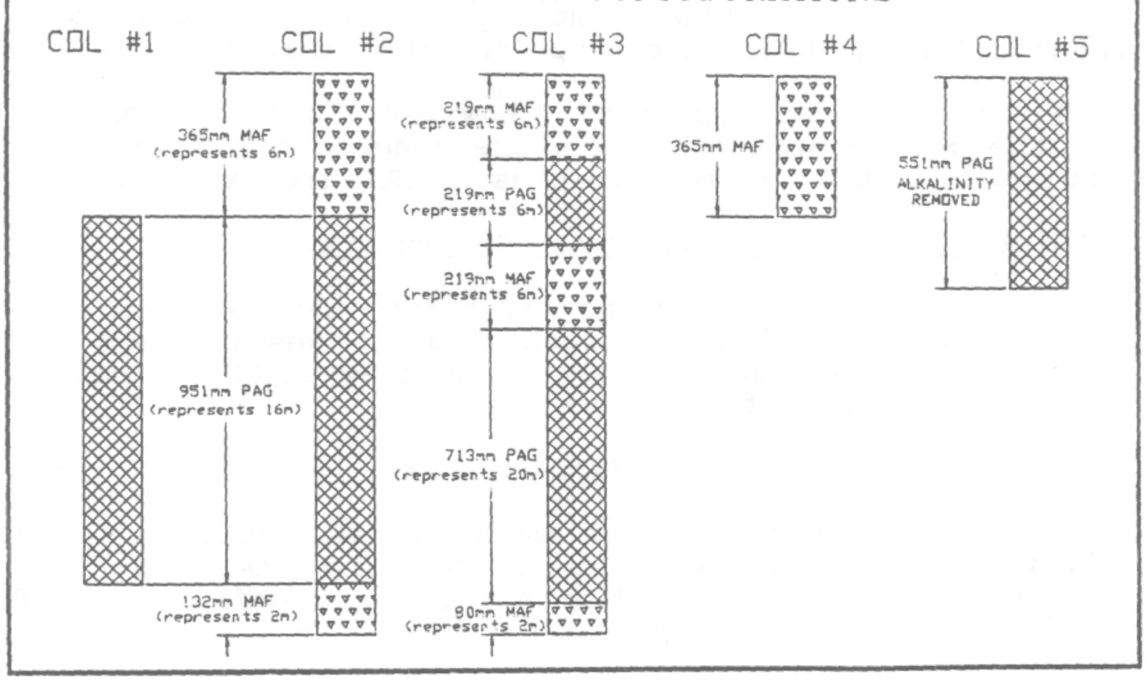


FIGURE 4 SAMATOSUM COLUMN LEACH TEST COLUMN CONFIGURATIONS

4.2 Column Leach Test Notes and Concerns

4.2.1 Water Feed Rate and Wet/Dry Cycles

The columns are exposed to humidified air and distilled water at a constant feed rate of 7.5 $L*m^{-2}*d^{-1}$. The feed rate is not based upon site precipitation or estimated percolation rates. It is a convenient flow rate commonly used for column leaching. The average annual net precipitation at the minesite is 940mm.

4.2.2 Grain Size

The grain sizes used in the columns are not based upon fragmentation analyses of waste rock. The mafic pyroclastic has a larger fragmentation size than do the PAG rock types and correspondingly less fines.

For this reason, the mafic pyroclastic sample was not crushed as fine as was the PAG sample.

4.2.3 Water Flow Paths

Water flow paths through the main waste dump are unknown. The design concept assumes that water flow will be near vertical through the layers as it is in the test columns.

Because a large portion of the waste rock is intensely sericitized, it is possible that water will not flow through the PAG layers vertically but will flow downhill within the layer or at a MAF/SERT contact.

4.2.4 Muddy Tuff "Hotspots"

There is no individual handling of MUT in order to prevent a concentration of MUT in one dump location creating a "hotspot".

The creation of "hotspots", however, is considered unlikely given the mining sequence. The ore zone is mined in 2.5m lifts which means that only small volumes of MUT are excavated at once.

4.3 Column Leach Test Results and Interpretation

Figures 5 to 19 following illustrate the leachate chemistry and metal concentrations for each column. Results were avaiable to week 110 for columns 1, 2 and 3 and to week 88 for column 5 at the time of writing of this paper.

4.3.1 Week 6 Evaluation and Extrapolation

Results from the first six weeks of test results were analyzed in April 1989 for purposes of determining the period of time required to exhaust available alkalininty defined as 20% of available neutralization potential from each of the first four columns.

FIGURE 5 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VS LEACHATE CONDUCTIVITY

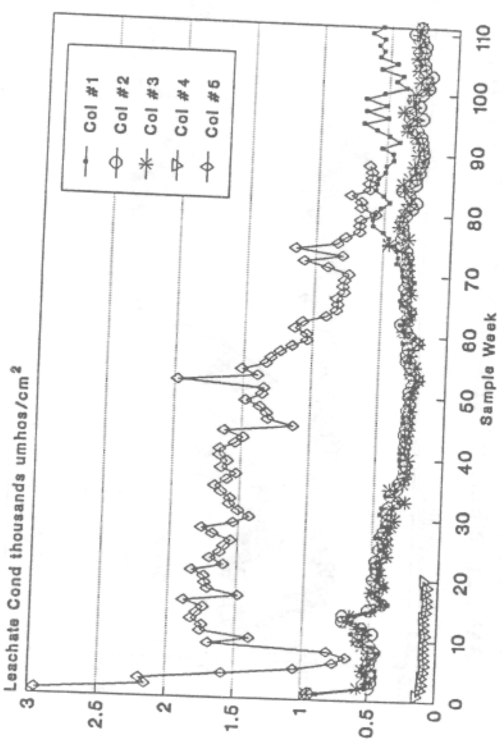


FIGURE 6 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VS LEACHATE pH

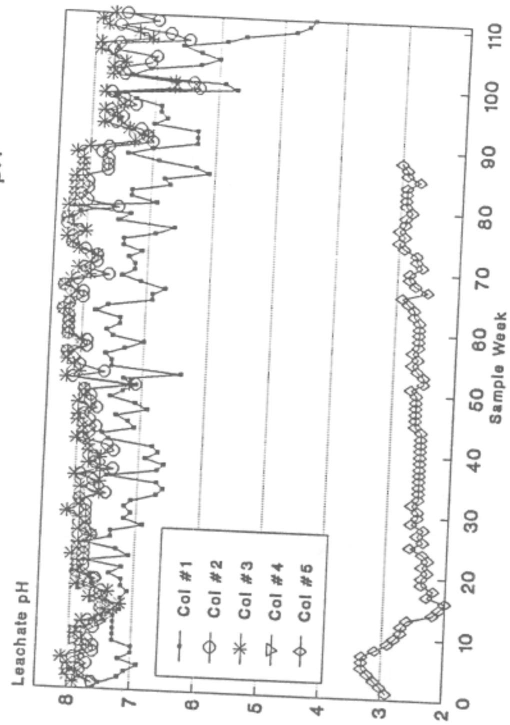


FIGURE 7 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS SULPHATE PRODUCTION

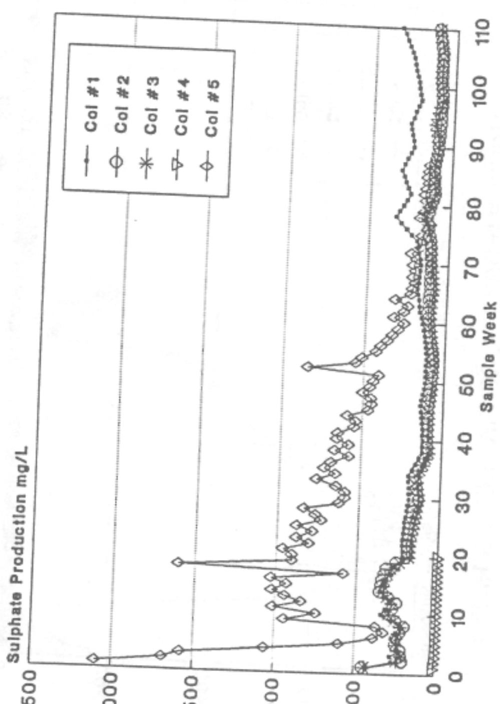


FIGURE 8 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS CUMMULATIVE SO4 PROD.

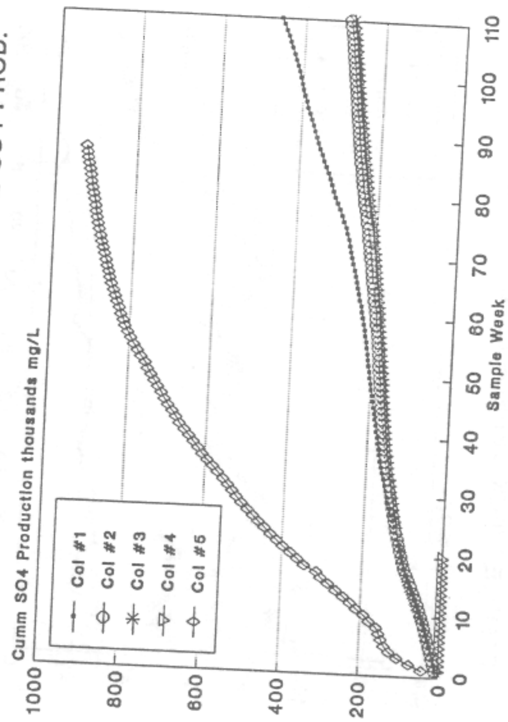


FIGURE 9 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS LEACHATE ACIDITY

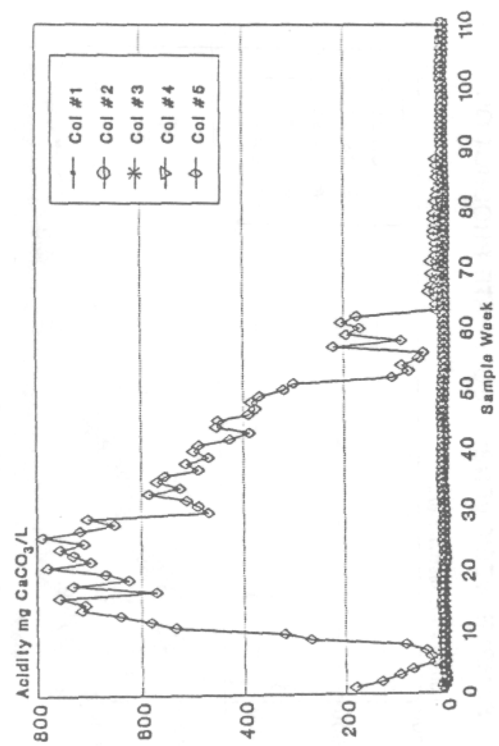


FIGURE 10 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS LEACHATE ALKALINITY

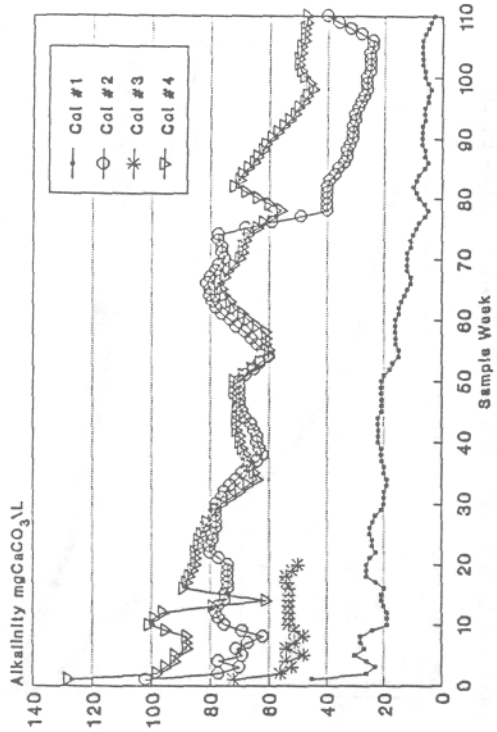


FIGURE 11 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VS LEACHATE Eh (REDOX POT.)

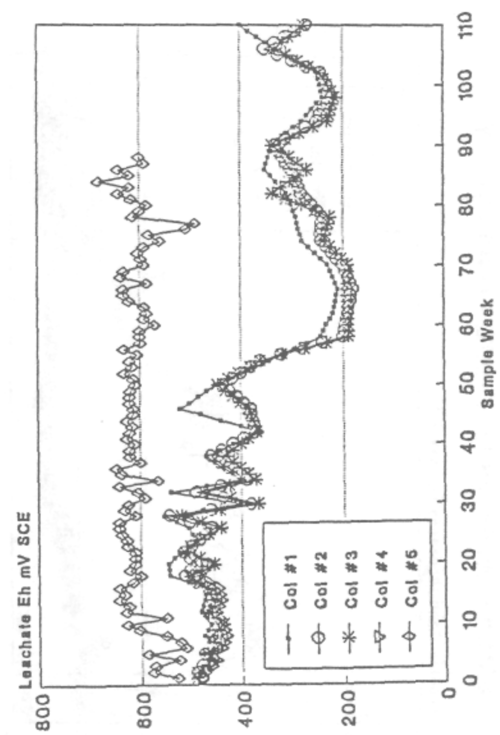


FIGURE 12 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS ZINC CONCENTRATION

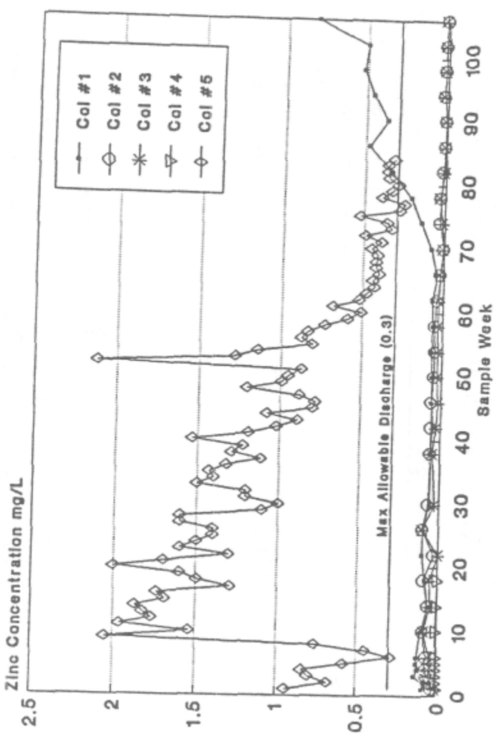


FIGURE 13 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS MANGANESE CONC.

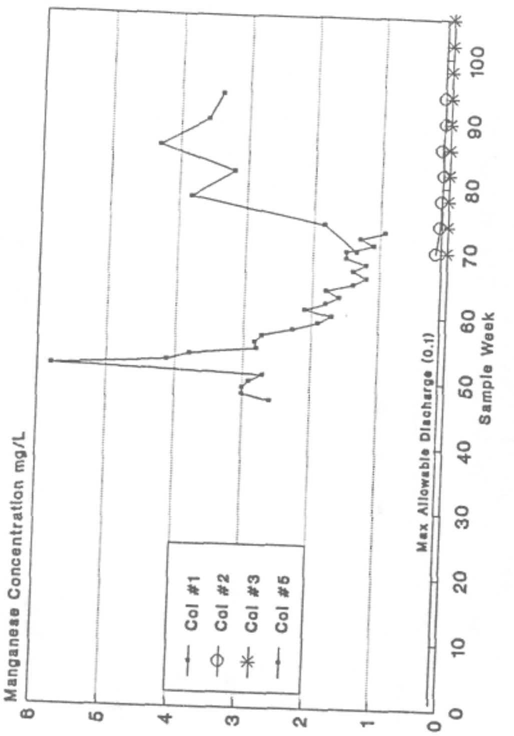


FIGURE 14 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS IRON CONCENTRATION

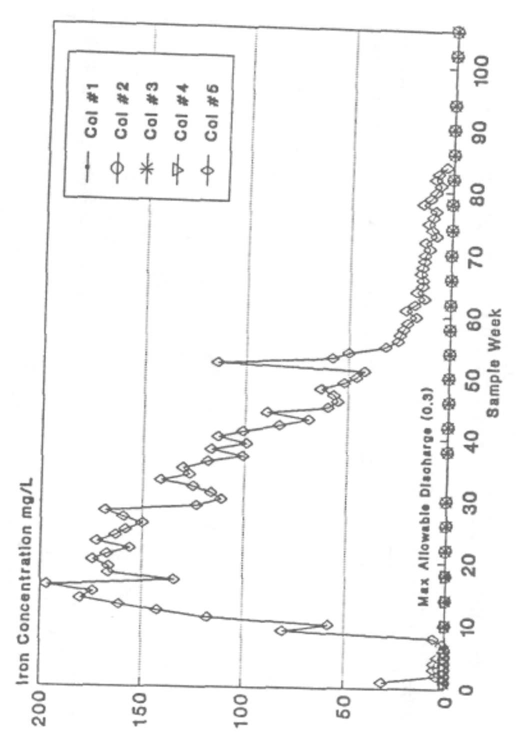


FIGURE 15 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS COPPER CONCENTRATION

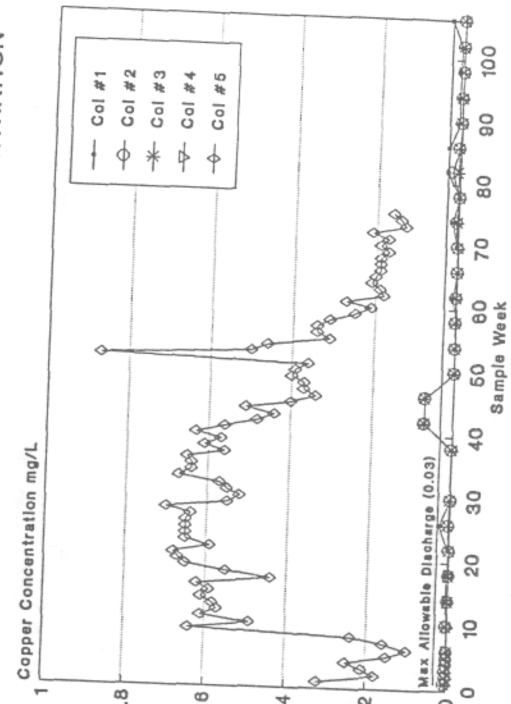


FIGURE 16 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS SILVER CONCENTRATION

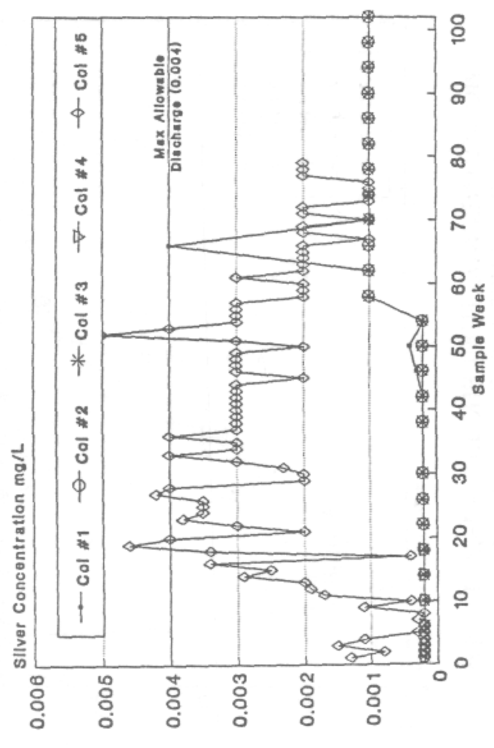


FIGURE 17 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS LEAD CONCENTRATION

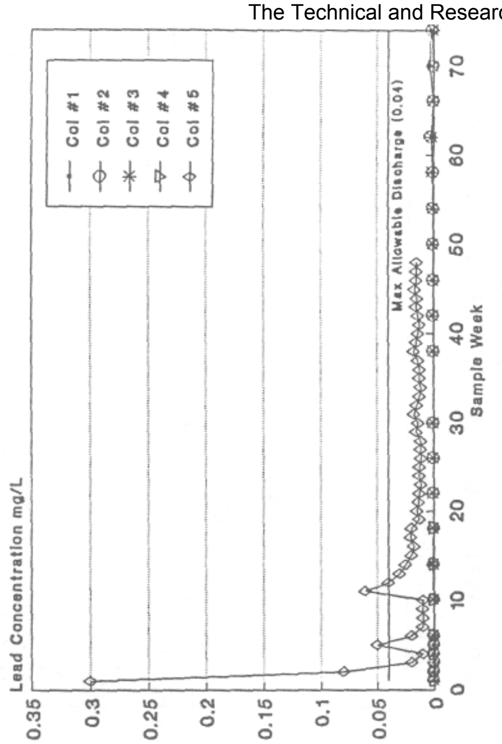


FIGURE 18 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS ARSENIC CONCENTRATION

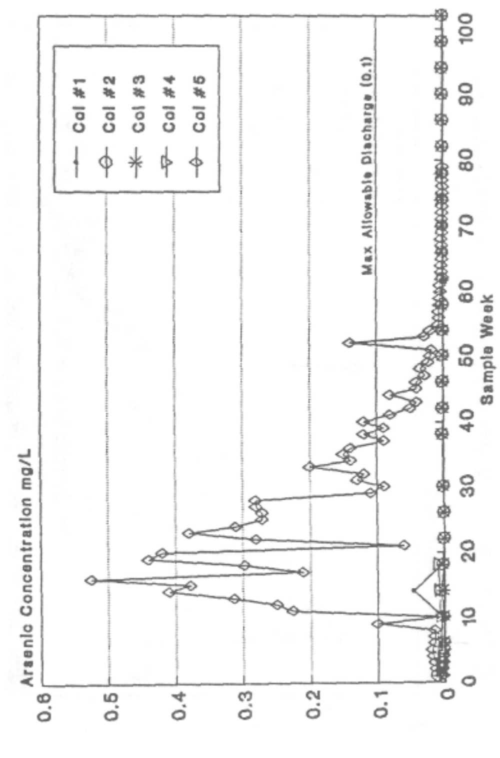
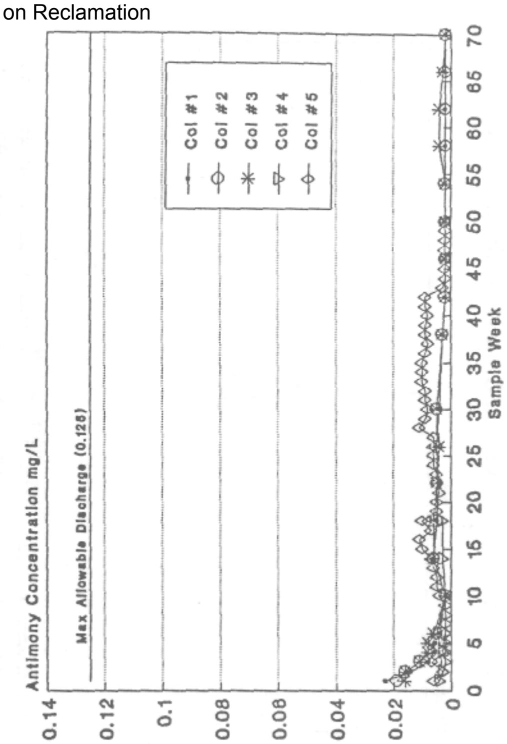


FIGURE 19 SAMATOSUM COLUMN LEACH TEST
SAMPLE WEEK VERSUS ANTIMONY CONC.



Sulphate production rates were calculated to be 0.644, 0.361, 0.379, and 0.0152 gm SO_4/kg-month for Columns 1, 2, 3, and 4, respectively.

Calculations, which were based on extrapolating the first 6 weeks of sulphate generation, indicated that Column 1 would start to go acid in about 18.7 months while Columns 2 and 3 would take approximately 3.5 years. By this method, Column 4 or the mafic pyroclastics, would exhaust 20% of alkalinity in about 119 years.

4.3.2 Columns 1, 2 and 3

Column 1 showed signs of acid generation between weeks 70 and 80 (17.5 to 20 months) of testing, with increases in conductivity, sulphate production, zinc and manganese concentrations and almost devoid (<4.0 mg/L $CaCO_3$) of alkalinity at week 77. These observations confirm the projections based on sulphate production rates at week 6.

Using the data generated to week 110, two methods were used to determine the time for Columns 2 and 3 to exhaust available alkalinity and to show similar signs of acid generation; extrapolation of the alkalinity curve to 4.0 mg/L $CaCO_3$ and recalculation using updated sulphate production rates. The results of these calculations are shown in Table 2.

Table 2
Projected Time to Depletion of Available Alkalinity
From 6-week, Extrapolated and 110-week Study Results

	Projected by calculation at week 6 (months)	Observed/ extrapolated at week 110 (months)	Projected by calculation at week 110 (months)
Column 1	18.7	17.5 to 20.0	20.9
Column 2	42.5	47.5	67.6
Column 3	40.9	54.0	70.2
Column 4	1425.0 (119 years)	suspended	suspended

4.3.3 Column 5

Column 5 is approaching completion of acid generation and elevated metal levels. Sulphate production (138 mg/L) is less than column 1 (341 mg/L) and nearly as low as columns 2 and 3 (110 and 105 mg/L, respectively). Leachate pH, however remains low (3.0).

Metal concentrations are at or approaching total depletion.

The causes of the apparent fast rate of metal and acid depletion from column 5 will be the subject of future research projects.

4.4 Column Leach Test Conclusions

The effectiveness of the waste dump design in controlling acid generation continues to be confirmed at *a* laboratory scale. Leachate pH and chemical activity in PAG material are positively affected by mafic pyroclastic layers.

The data indicate that bacterial enhanced activity play a significant role in the acid generation process on acidified waste under laboratory conditions. However, other mechanisms still to be investigated appear to inhibit this process in the short term.

5. ACKNOWLEDGEMENTS

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5) BC AMD Task Force
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