Although the Net NP value does provide a good first indication of ARD potential, it is recommended that an interpretation based on the simple arithmetic difference between the NP and AP values should be used with caution. For example, A sample with a Net NP value of +10 derived from a sample having a high sulphide content and correspondingly high acid consuming ability, might have a greater potential to produce acid in the long term compared with a sample which also has a Net NP value of +10 but which has a very low sulphide content. Establishment of an absolute guideline in this regard is not possible. It has been suggested that the ratio between NP and AP values might provide a more reliable guideline for classification of samples, with suggestions that NP should exceed AP by at least 3 to 1 to ensure classification of a sample as non-acid producing. This might be over-conservative, and a classification based on an increasing NP/AP ratio for an increasing sulphide content might be more useful. In general, test results should be assessed within the context of each specific application and with consideration of other available predictive tools.

REFERENCES

1. Coastech Research, Modified Acid Base Accounting, *AMD Prediction Procedures*, Vancouver, B.C. July (1990).

Remark: This procedure is a modification of Coastech Research method (Modified Acid Base Accounting, July 1990)

3)

INTERNATIONAL METALLURGICAL AND ENVIRONMENTAL INC.

Carbonate Analysis

The following procedure is used for the determination of carbonate content.

Glassware Cleaning Procedure

All glassware must be cleaned with 10% HCl. DI water rinsed and acetone dried.

Preparation of CO2 Free Water

1) Boil DI Water for 15 Minutes
2) Transfer to a 2 Litre flask with the tube containing glass wool and CO_2 removing agent Ascarite II. Rapid cooling can be accomplished by running cold water over flask or putting into an ice bath.

Preparation of Reagents

0.1N HCl:(Pipette) 8.25 ml concentrated HCl into 1000 ml flask and bring to the mark with CO_2 Free water.

0.6N HCl: (Pipette) 50 ml concentrated HCl into 1000 ml flask and bring to the mark with CO_2 Free water.

0.1N NaOH: weigh 4gm of NaOH into 1000 ml flask and bring to the mark with CO_2 Free water.

40% Potassium Hydroxide: 40% in 100 ml flask , weigh 40.0 gms.
40% in 300 ml flask , weigh 120.0 gms.
40% in 200 ml flask , weigh 80.0 gms.

15% $BaCl_2$ Solution: weigh 150 grams $BaCl_2$ crystals into 1000 ml flask and bring to the mark with CO_2 Free water.

Indicator: dissolve 0.5 gms of Phenolphthalein in 50 ml Iso Propyl alcohol and add 50 ml CO_2 Free water.

Procedure:

1) Weigh out 1.0 to 5.0 grams of sample into a flat bottom flask.

2) Into a 1 Litre filtering flask Pipette exactly 50 ml of 0.1N NaOH and then add 4 to 5 drops of indicator. The indicator will turn the solution pink when added.

3) Connect a separatory funnel to the flat bottom flask and the filtering flask so a vacuum can be established between both flasks. Evacuate the system for about 5 minutes. Don't forget to close the stop cock to maintain a vacuum throughout the test.

4) Add 50 ml of 0.6N HCl (using a graduate cylinder) to the separatory funnel and slowly add to the flat bottom flask. (i.e., add three drops then shake, add 3 drops then shake etc.). Stop flow when a few drops remain in the bottom of the separatory funnel.

5) After contact for a few minutes, shake every 2 min. for 10 minutes.

6) Connect the top of the separatory funnel to the Gas Washing Tower containing 40% KOH and very slowly draw in CO_2 free air until the vacuum is destroyed. This should take about 10 minutes. Shake flasks for about 10 minutes.

7) Disconnect filter flask:
    - Rinse down sides with CO_2 free water.
    - Add 10 ml of $BaCl_2$ solution to the filter flask.
    - Titrate with 0.1N HCl until indicator becomes colorless.

NOTE: A reagent blank must be carried through the entire operation.

*****If titer is less than 5 ml re-run on a lower sample weight.**

*****Also re-run on a lower weight if solution turns milky when $BaCl_2$ solution is added.**

CALCULATIONS:

$$\frac{(\text{Blank titer, ml} - \text{Sample titer, ml}) \times \text{Normality of HCl} \times 5}{\text{Weight of sample(grams)}} = \text{Calcium carbonate equivalent, \%}$$

Standardize 0.1 N HCl against standard 1.00 Normality NaOH solution and check 0.1 N NaOH against standard 1.00 Normality HCl solution.

Reagent Standardization Method:

-Pipette 20 ml of 0.10 N HCl into a 50 ml beaker. Add 4 to 5 drops phenolphthalein indicator and place on a magnetic stirrer. Titrate with a certified 1.0 N NaOH standard solution from a conditioned 50 ml burette until the endpoint (from a clear to a pink color) is reached. Approximately 2 ml. (lets say 2.1 ml NaOH was used for the example equation).

-Pipette 20 ml of 0.1 N NaOH into a 50 ml beaker. Add 4 to 5 drops phenolphthalein indicator and place on a magnetic stirrer. Titrate with a certified 1.0 N HCl standard solution from a conditioned 50 ml burette until the endpoint (from a pink to a clear solution) is reached. Approximately 2 ml.

Normality (NaOH/HCl) : V(base) X N(base) = V(acid) X N(acid)

e.g.: 20 ml of ? N HCl ,2.1 ml of 1.0 N NaOH was used. Then;

(2.1 ml NaOH)(1.0 N NaOH) = (20 ml HCl)(? N HCl)

$$\text{Therefore: ? N HCl} = \frac{(2.1\ \text{ml})(1.0\ \text{N})}{20\ \text{ml}}$$

NOTE: Record Normality to 3 decimal places.

INTERNATIONAL METALLURGICAL AND ENVIRONMENTAL INC.

GRAVIMETRIC DETERMINATION OF SULPHUR

REAGENTS:

1) SATURATED NITRIC ACID-POTASSIUM CHLORATE SOLUTION.

Prepare a saturated solution by carefully adding, with constant stirring, potassium chlorate to reagent grade nitric acid.

2) BROMINE-ACETIC ACID SOLUTION.

Prepare a 1:1 (volume/volume) solution of bromine and acetic acid.

3) POTASSIUM CHLORATE.

Reagent grade potassium chlorate.

4) HYDROCHLORIC ACID.

Reagent grade concentrated hydrochloric acid.

5) BARIUM CHLORIDE SOLUTION.

Ten percent weight/volume solution of barium chloride and distilled water.

PROCEDURE:

1) Weigh a suitable weight of sample into a 400 ml short form beaker.

2) Add 20 ml saturated HNO3-KCLO3 solution. Cover and place on low hot plate for 5 minutes. Transfer to a medium hot place and boil until all nitrous fumes have been evolved. Use bromine when necessary.

3) Cool, add 10 ml concentrated HCl. Digest on a medium hot plate for 10 minutes.

4) Remove cover glasses and take to dryness on a low hot plate. Add 10 ml concentrated HCl and take to dryness a second time.

5) Add 5 ml HCl, 40-50 ml distilled water, and a small amount of filter pulp. Cover and boil until all soluble salts are in solution.

6) Filter through a 15 cm Whatman #42 filter paper, receiving the filtrate in 600 ml beakers. Wash two times with hot 1% HCl and 8 times with hot distilled water. Scrub the inside of the beakers with a rubber policeman.

7) Bulk the filtrate to 300 ml with distilled water, bring to a boil, add with constant stirring 25 ml of 10% BaCl2.

8) Allow the precipitate to stand in a warm place for at least 2 hours, preferably overnight.

9) Filter through a 15 cm Whatman #42 filter paper, scrub the inside of the beaker with a rubber policeman and wash 2 times with 1% hot HCl and 8 times with distilled water.

10) Transfer the filter paper containing the precipitate to a clay crucible. Char the filter paper without igniting it in the front of the muffle furnace. Move the crucibles to the rear of the muffle and heat to 900 Celcius for 30 minutes.

11) Cool in a dessicator and weigh as barium sulphate.

CALCULATION

$$\% \text{ SULPHUR} = \frac{(\text{WEIGHT } BaSO_4)\ (.1373)}{\text{SAMPLE WEIGHT}}\ 100\%$$

QUALITY CONTROL.

Include at least 1 certified reference standard with each run.

Run 1 duplicate sample for every 10 samples.

REFERENCES

1. Brenda Mines Limited, Peachland, B.C. Canada. (1994).

Remark: This procedure is a modification of Brenda Mines Limited method as modified by International Metallurgical and Environmental Inc. Kelowna, B.C. Canada. (1995).

INTERNATIONAL METALLURGICAL AND ENVIRONMENTAL INC.

Sulphate analysis by Turbidmetric Method

INTRODUCTION:

Sulphate, in the form of SO_4, is widely distributed in nature and may be present in natural water in concentrations ranging from a few to a thousand mg/L.
Mine drainage wastes can produce large amounts of sulphate due to oxidation of pyrites. Sodium and magnesium sulphate exert a cathartic action.

The sulphate ion is brought into solution by digestion and is then precipitated with barium chloride ($BaCl_2$) to form a barium sulphate ($BaSO_4$) crystal of uniform size.
Light absorbance of the barium sulphate suspension is measured and the sulphate concentration is determined by comparison of the reading to those of the standards.

INTERFERENCE'S:

Color or suspended solids in large amounts will interfere. Make determinations at room temperature.

REAGENTS:

1. Hydrochloric acid - concentrated reagent grade HCl.
2. Conditioning Reagent - Dissolve 150.0 g. Sodium Chloride (NaCl) in 600ml. deionized water. Add 100 ml. Glycerol ($C_3H_5(OH)_3$), 60 ml. Hydrochloric acid (HCl), 200 ml. isopropyl alcohol (CH_3CHOH), and bring to volume in a 1000 ml. volumetric flask.
3. Stock Sodium Sulphate Solution: 4000 mg/l- Dissolve 1.4786 g Sodium Sulphate (Na_2SO_4) in deionized water. Transfer to a 250 ml volumetric flask, and dilute to volume with deionized water.
4. Barium Chloride - Reagent grade ($BaCl_2$) crystal

STANDARD PREPARATION:

4000 mg/l Stock sodium sulphate solution:

1.) 400 mg/l standard : Pipette 20 ml of stock solution into a 200 volumetric flask and bulk to volume.

2.) 100 mg/l standard : Pipette 50 ml of the 400 mg/l standard into a 200 volumetric flask and bulk to volume.

Process a blank by measuring 100 ml deionized water into a 125 ml. erlenmeyer flask.

<u>100 mg/l standard</u>
(125 ml. erlenmeyer flasks)

2.0 mg/l SO_4- 50:1 dilution = 2 ml to 100
5.0 mg/l SO_4 - 20:1 dilution = 5 ml to 100
10.0 mg/l SO_4 - 10:1 dilution = 10 ml to 100
20.0 mg/l SO_4 - 5:1 dilution = 20 ml to 100

<u>400 mg/l standard</u>
(125 ml. erlenmeyer flasks)

40.0 mg/l SO_4 - 10:1 dilution = 10 ml to 100

<u>PROCEDURE</u>:

a) Weigh 1.0 gram of sample into a (acid washed) 100/150 ml beaker. Samples <u>known</u> to contain a high concentration SO_4 use a 0.250 gram sample.

b) Add 47.5 ml deionized water and 2.5 ml HCl to each beaker. Also process a reagent blank with each run.

c) Cover with (acid washed) watch glass. Place on hot plate and <u>simmer</u> for about 1 hour. Stir periodically.

d) If color forms during step c, add filter pulp and the color should lessen.

e) Remove from hot plate and wash off watch glasses.

f) Add 1 drop of floc, and allow to cool for about 5 minutes.

g) Filter the solutions through 12.5 cm # 5 Whatman filter papers into 125 ml. erlenmeyer flasks. (for solutions that will be diluted, filter into 100 ml flasks.).Wash the filter paper 3 to 4 times with hot deionized water.

h) Let samples cool, then bulk to 100 ml. For dilution samples: pipette desired amount into 125 ml. erlenmeyer flask and bulk to 100 using a graduated cylinder.

i) Add 5 ml. of the conditioning reagent. While sample is being stirred, add 0.5g. of Barium Chloride ($BaCl_2$), and continue to stir for 2 minutes. Allow to stand for a further 8 minutes. Swirl and read turbidity on the turbidimeter. It is important for the accuracy of the results, that the speed of the magnetic stirrer, and the measurement of time remain constant throughout the entire run.

CALCULATIONS:

a) Calculate the linear regression equation of the standards.
b) Calculate the concentration (mg/l) of the sample.
c) Calculate the % Sulphate in the sample.
d) Calculate the % Sulphur in the sulphate.

A) *LINEAR REGRESSION EQUATION:*

-call up Microsoft excel program.
-file
-open
-C:\data\ssdata\ SO4.XLS
-enter standards in column A.
-enter corresponding NTU readings in column B.
Note: the chart at the right should re-adjust to the numbers you enter.
-tools
-data analysis
-regression, ok
-input / input y -highlight column A.
input x -highlight column B.
-output / output range - put cursor in selection box then click on Summary Output on the spread sheet, A12 should appear in selection box.
-residuals / residuals - make sure this activated.
- keypunch **ok**, this will update the calculations according to the new data..

Slope = x Variable on spread sheet
Intercept = intercept on spread sheet
Standard Error = Standard Error on spread sheet
r = Multiple R on spread sheet

After your equation has been determined, enter the date of your test onto the chart and then print a copy. At this time you can computer calculate the concentrations and % SO_4 of your samples by going to sheet 2.

B) *CALCULATE THE CONCENTRATION OF THE SAMPLE:*

mg/l SO_4 = NTU (X) SLOPE (+) INTERCEPT

C) *CALCULATE THE PERCENT SULPHATE IN THE SAMPLE:*

% SO_4 = mg/l SO_4(bulked Volume / Sample weight / 10,000)

D) *CALCULATE THE PERCENT SULPHUR IN THE SULPHATE:*

% S = % SO_4 (X) 0.3338

In excel, your linear regression spread sheet and chart are found on sheet 1. Now go to sheet 2.

-Enter your sample #s in column A (heading Sample) and the corresponding NTU numbers in column B (heading abs). If no dilution was done enter 1 in column C.

Column D gives you your results in mg/l. Column E gives you your results in % SO_4 as indicated and Column F gives you your results in %S as indicated.

NOTE: If there is a change in the weight or bulked volume from 1.0g/100ml. then the results showing in columns E and F are wrong. The formula would have to be updated.

QUALITY CONTROL:

With each run:
- 1 calibration blank to indicate zero.
- 1 reagent blank to monitor glassware contamination.
- duplicate samples (every 10 samples) to monitor precision
- 1 or 2 standard checks with each run.

REFERENCES

1. Clesceri, Lenore S, Arnold E. Greenberg, & R. Rhodes Trusssell ed. 1989 *Standard Methods,* 17th Edition. pp.4:207-4:208.

2. Brenda Mines Limited, Peachland, B.C. Canada. (1994)

Remark: This procedure is a modification of Brenda Mines limited method (adapted from Standard Methods, 17th Edition) as modified by International Metallurgical and Environmental Inc. Kelowna, B.C. Canada. (1995).

QUALITY ASSURANCE AND QUALITY CONTROL

International Metallurgical and Environmental Inc. subscribes to the rigourous use of certified standards and dupicate analysis to assure the quality of reported results.

The result of analysis of certified standard materials are reported with the sample analysis.

Duplicate analysis of approximately 5 to 8 percent of the recieved samples has been conducted to provide a confirmation of the quality of sample preparation and sample handling at International Metallurgical and Environmental Inc. This analysis is reported as "check samples" and are reported with the appended data.

The measured value of the neutralization potential of a sample is known to be a function of the acid digestion used in the 24 hour test, and its determination variable to the point that overall rock characterization is affected. Neutralization potentials are conducted in duplicated and results are averaged to provide a measure of the neutralization potential. Discrepancies of 10 percent between the measured neutralization potentials of a sample will result in the test work being repeated.

International Metallurgical and Environmental Inc. is a registered member of the Environmental Data Quality Assurance Program - Ministry of Environment, Province of British Columbia.

Humidity Cell Procedure

OBJECTIVES

To provide a stable environment to observe the oxidation and leaching of various chemical species from an ore, waste rock, tailings or sludge sample.

PRINCIPLES OF TEST

The humidity cell test provides an opportunity to determine the rate of release of metals and oxidation products as a function of time from a specific sample. The basic test is supported by a wide variety of analysis and chemical measurement of the leachates from the test, most of which is specific to a particular project. However common elements of the test include measurement of pH, sulphate, alkalinity and acidity and some level of detailed metal analysis.

The term humidity cell is derived from the elevation and control of humidity in the tested rock samples to mimic sub-terrainian humidity levels. The sample is regularly washed with a distilled water wash to remove and recover soluble species from solids. Solids which are washed from the cell by the flush water are recovered in the decanting of the leachate and returned to the upper surface of the cell during the following flushing cycle one week later.

The scale of humidity test work can be varied and very large scale tests can be completed using custom apparatus and specific methodologies.

HUMIDITY CELL SET-UP

The standard bench scale humidity cell uses a 125 mm diameter glass humidity cell, a support deck and filter media. New filter media and support deck are used with each new humidity cell test. All apparatus should be acid washed, rinsed with distilled water and air dried. The cell is then placed in the support rack and support deck and filter media placed in the cell.

Sample material is weighed and added to the cell in a manner as to not segregate the material in terms of particle size distribution. The cell can be filled to within 3 cm of the top of the cell. Sample weight is recorded to 0.1 grams. In the event that the sample is wet, a separate sample is taken for moisture determination and the humidity cell solid weight is determined by calculation.

The humidity cell is connected to the humidifier and covered with an acid washed glass lid.

HUMIDITY CELL OPERATION

The cell is typically flushed with a volume of distilled water each week during the first 20 weeks of operation and leachates analyzed for a number of metals and chemical parameters. The volume and schedule of water flushing are determined by the requirements of the project. Other project specific operation items may include temperature control, sample pre-treatment via acid leaching, or inoculation of samples using active biological cultures.

The most common flush volume for a 2 kg humidity cell sample is 500 mls of distilled water. The exact volume is measured using a volumetric flask. A portion of the flush water is added to the collection flask and the residual solids are re-suspended and washed back into the humidity cell. The collection flask is then placed to recover the leachate from the cell and the balance of the flush water is slowly added to the entire surface of the humidity cell sample. The draining of the sample is continued for approximately 1 hour and the leachate sample removed. The humidity cell is then covered and left till the next flush cycle.

The leachates are analyzed for the following parameters:

pH
mV
conductivity
sulphate
alkalinity
acidity
ICP metal scan

INTERNATIONAL METALLURGICAL AND ENVIRONMENT INC.

Acidity- Titrimetric Method pH 8.3

Introduction:

Acidity of a water sample is its quantitative capacity to react with a strong base to a designated pH. The measured value may vary significantly with the endpoint pH used in the determination. Acidity is a measure of the aggregate property of water and can be interpreted in terms of specific substances only when the chemical composition of the sample is known. The measurement provides an indication of corrosiveness which in turn can provide insight into water quality.

Sample Preparation:

Collect samples in polyethylene or borosilicate glass bottles and store at a low temperature. Fill bottles completely and cap tightly. Because waste samples may be subject to microbial action and to loss or gain of $C0_2$ or other gases when exposed to air, analyse samples without delay, preferably within 1 d. If biological activity is suspected analyse within 6 h. Avoid sample agitation and prolonged exposure to air. Do not filter, dilute, concentrate, or alter sample. Carry out acidity on the as-is, received sample.

Interferences:

Suspended matter present in the sample, or precipitates formed during the titration may cause sluggish electrode response. This is overcome by allowing 15-20 second pauses between titrant additions and by drop by drop titrant additions near the end point. Chlorine should be neutralised with $Na_2S_20_3$

Apparatus:

1. 50 ml beakers
2. 10 ml burette
3. 50 ml graduated cylinder
4. Magnetic stirrer and Teflon stir bars
5. Any commercial pH meter and glass electrode

Reagents:

1. 0.1N Sodium Hydroxide: Dissolve 4.0 g. of NAOH in 1.0 L of distilled water. Standardise by titrating against 1N certified Hydrochloric acid.

2. 1 N Hydrochloric acid: (certified 1 N solution)

   Note: With regards to the HCl and NaOH, one of these reagents must be a certified grade and is used to calibrate the other reagent.

Reagent Calibration:

Titrate 20 mls of 0.1N HCl made from the certified 1N HCl, against the 0.1N NaOH, using a 10 ml burette and a magnetic stirrer. Titrate from a pink to clear color using phenolphthalein indicator.

Normality NaOH: V(base) X N(base) = V(acid) X N(acid)

Method:

1. Measure 40 mls of sample into a clean 50ml beaker.
2. While stirring sample, titrate to pH 8.3 and record volume of NaOH titrant used to attain that pH. As the end point is approached make smaller additions of alkali and be sure that pH equilibrium is reached before making the next addition.

Calculations:

$$\text{Acidity (mg CaCO}_3\text{/L)} = \frac{\text{(ml NaOH titrant used) X (normality of NaOH) X 50000}}{\text{ml of sample}}$$

Report as: "The acidity to pH ______= ______ mg $CaCO_3$/L." If a negative value is obtained, determine the alkalinity of the sample.

INTERNATIONAL METALLURGICAL AND ENVIRONMENT INC.

Alkalinity-Titration Method pH 4.5

Introduction:

Alkalinity of a water is its acid-neutralising capacity- the sum of all titrable bases. The measured value will vary significantly with the end-point pH used. Alkalinity is primarily a function of carbonate, bicarbonate, and hydroxide concentrations, but may also include contributions from borates, phosphates, and silicates.

We use a titration method for determining Alkalinity. The hydroxyl ions present from the hydrolysis or dissociation of solutes react with additions of a standard acid to an end-point pH.

Sample Preparation:

Do not filter, dilute, concentrate, or alter sample. Carry out alkalinity on the as-is, received sample.

Interferences:

Do not let samples sit exposed to air for long periods, as this may increase the alkalinity.

Apparatus:

1. 50 ml beakers
2. 10 ml burette
3. 50 ml graduated cylinder
4. Magnetic stirrer and stir bar

Reagents:

1. 0.02N Hydrochloric acid: Made from a certified 1 N solution. Place 20 ml of 1 N HCl in clean 1 L volumetric flask and bulk to 1 L with de ionized water.

2. 0.02 N Sodium Hydroxide: Dissolve 0.8g of certified grade sodium hydroxide in a 1L flask and bulk with distilled water.

3. Bromocresol Green Indicator: Dissolve 0.10g Bromocresol Green in distilled water and transfer to a clean 100 ml flask and bulk with distilled water.

   Note: With regards to the HCl and NAOH, one of these reagents must be certified grade and is used to calibrate the other reagent.

4. Phenolphthalein Indicator: Dissolve 0.5g Phenolphthalein in 50 ml ethyl or isopropyl alcohol and bulk to 100 ml with distilled water.

structions for Field Column Maintenance and Leachate Collection

A. *Column Maintencance*

Each field column is consisted of two staggered 18-litre plastic pails. The upper pail with a perforated bottom ontains 15 kg waste rock and the lower pail serves as a leachate collector. The system is held upright in a slot n the broad-base wood frame made up of two palettes.

nspect monthly during the dry season and during each sampling event in the wet season the physical integrity of the columns. Either pail can be replaced if serious disintegration is observed. Just ensure that the eplacement pail(s) is(are) thoroughly cleaned prior to be used.

Ensure also during each inspection that the field columns are well supported in the wood-frame base such that hey will not topple over in strong wind.

B. *Leachate Collection*

As soon as spring freshet starts, collect the leachate in each column weekly* following the steps given below:

1.) Pull out the waste rock (upper) container in the column assembly and sit it on a clean plastic sheet.
2.) Decant the leachate in the collector (lower) pail into a clean, plastic sampling container; measure** its volume, pH, conductivity and temperature; filter it through a 0.45 µm cellulose acetate filter, ship a subsample (minimum 200ml, preferably 500 ml) together with a data record sheet (sample attached) to John Kwong at Klohn-Crippen Consultants, Calgary.
3.) With a rubber policemen or spatula and using a minimum amount of water (<20 ml), return all the fin solids collected in the lower pail and the filter paper to the upper pail.
4.) Re-assemble the column system and put it back in the wood-frame support.

Note:

* Sampling frequency is, to a large extent, dependent on precipitation. After a heavy rainfall, a samplin campaign may have to be initiated immediately. During dry spells, leachate sampling may be stretched to nonthly basis. A minimum of 200 ml filtrate is required for chemical analysis.

** If measurements are to be made in the laboratory, ensure that they are done within a couple of hours afte collection. Extra care should be taken in decanting the leachate in the collector pail into the sampling containe o avoid excessive loss of fine particles that came through with the leachate to the collector pail.

Field Column Leachate Collection Record

Date of collection: ______________________________

Volume of leachate: ________________________ ml.

Leachate pH _______________

Eh _______________ mV

Temperature _______________ deg. C

Conductivity _______________ μS/cm

Measurements made in _____ field or ____ laboratory (Check 1)

ıme elapsed since collection if measurements were made in the laboratory _________ hrs.

Date of shipment* to Klohn Crippen: ______________________________

*Shipment can be made on a monthly basis. Just keep the sample(s) in a refrigerator (≈ 4 deg. C) prior to shipment.

APPENDIX III

Original Laboratory Reports

Harris

EXPLORATION
SERVICES

MINERALOGY AND GEOCHEMISTRY

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Report for:
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Report 97-28

April 3, 1997

MINERALOGICAL EXAMINATION OF SAMPLES FROM THE LUPIN PROJECT

Introduction:

3 samples, labelled as below, were submitted by Chris Werbicki. Small portions of each were prepared as polished thin sections.

Sample	Slide No.
Lupin B1 Ulu Ore	97-2223
Lupin B2 Ulu Waste	97-2224
Lupin B3 Tailings	97-2225

Summary:

All three samples are made up of fine-grained crystalline metamorphic rocks of amphibolitic and/or metasedimentary/metatuffaceous aspect. These are composed of quartz, plagioclase, hornblende and biotite, in various proportions, with accessory sphene, ilmenite and sulfides. Total sulfide contents are estimated as about 5% in B1 and B3, and about 3% in B2.

The sulfides consist of pyrrhotite, arsenopyrite and pyrite in various proportions. They typically occur as individual disseminated grains, 10 - 200 microns in size, in the fine-grained host rock. Sulfides and host rock are homogenous, unfractured, and strikingly fresh in all cases.

Carbonate contents in these samples are low (maximum 0.5%) so they will have negligible self-buffering capacity.

Individual petrographic descriptions are attached.

J.F. Harris

J.F. Harris Ph.D.