Appendix 4

- **Ulu Project: Preliminary Assessment of Acid Rock Drainage Potential, Klohn-Crippen Consultants Ltd., October 1996.**

ECHO BAY MINES LTD. - LUPIN OPERATION

ULU PROJECT

Preliminary Assessment of Acid Rock Drainage Potential

October 1996

PM 7534 0102

KLOHN-CRIPPEN

KLOHN-CRIPPEN

October 30, 1996

Echo Bay Mines Ltd.
Lupin Operation
Post Bag #1
Nisku, Alberta T0C 2G0

Mr. David Hohnstein, AST
Manager, Environmental Affairs

Dear Mr. Hohnstein:

Ulu Project - Preliminary Assessment of Acid Rock Drainage Potential

We are pleased to present ten copies of the final report on the preliminary assessment of ARD potential at Ulu.

The report reviews previously available data and furnishes new field observations as well as interpretation of results of ABA testing on a comprehensive suite of samples collected by us and your staff geologist(s). Conclusions and recommendations for further work are made based on a synthesis of all data acquired to-date.

We have enjoyed working on this assignment and look forward to continuing with the kinetic test program.

Yours truly,

KLOHN-CRIPPEN CONSULTANTS LTD.

Y.T. John Kwong, Ph.D.
Senior Environmental Scientist

Peter J. Wheeler, P.Eng.
Manager, Mining Group, Calgary

YTJK/PJW/ll
Enclosures

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ECHO BAY MINES LTD. - LUPIN OPERATION

ULU PROJECT

Preliminary Assessment of Acid Rock Drainage Potential

October 1996

PM 7534 0102

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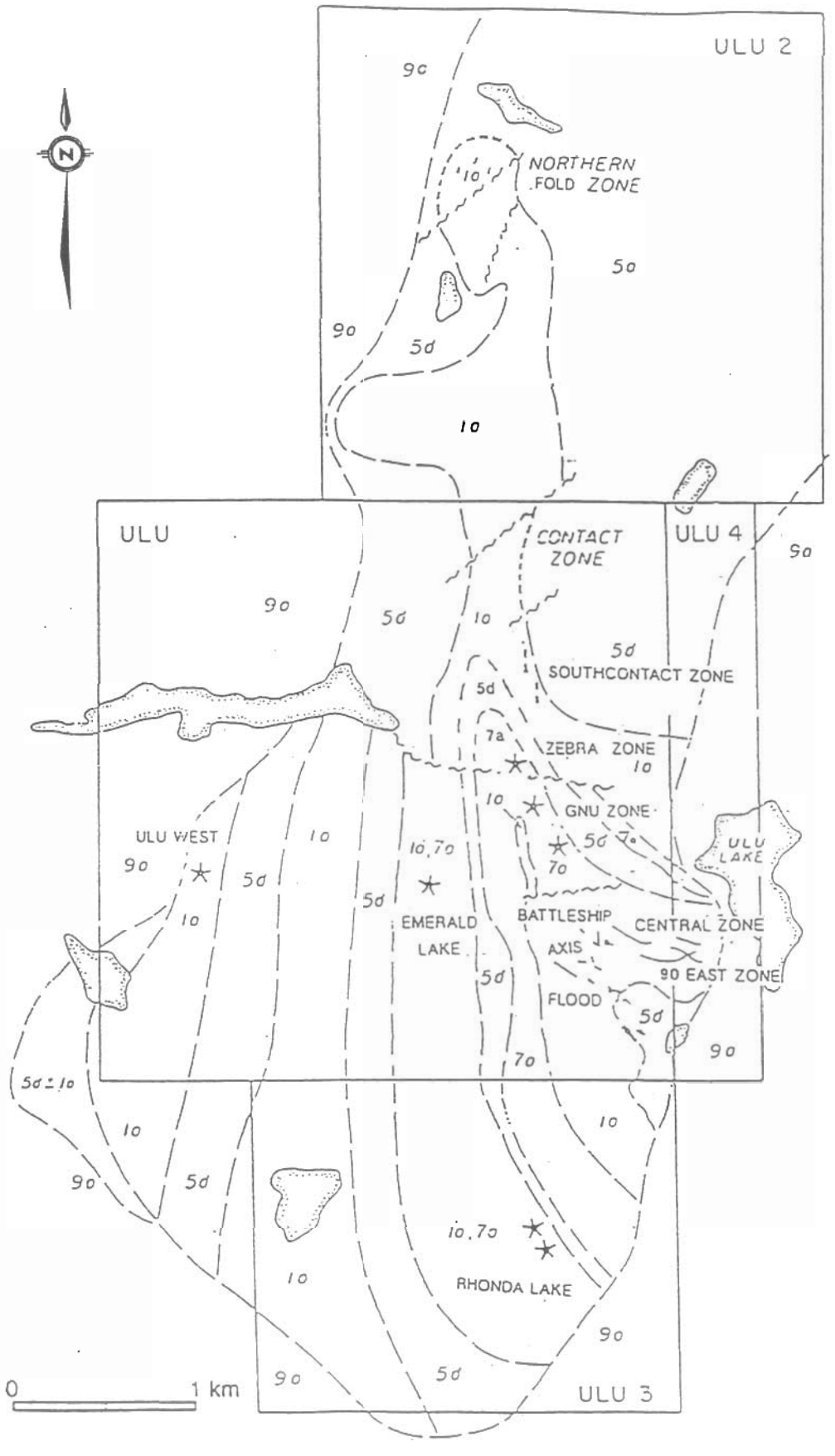
1. INTRODUCTION

1.1 Project Background

The Ulu gold property is located 45 km north of the Arctic Circle and 135 km north of the Lupin Mine in the Mackenzie Mining District, Northwest Territories (Figure 1, inset). Echo Bay Mines - Lupin Operation (EBM-Lupin) purchased the property from BHP Minerals Canada Ltd. in 1995, intending to develop it to supply ore for milling at the Lupin Mine. The tentative mining plan involves stockpiling ore materials at the Ulu site year-round and transporting them to the Lupin Mine when winter roads are operational. EBM has commissioned Klohn-Crippen Consultants Ltd. to conduct a preliminary assessment of the acid rock drainage (ARD) potential of the various types of geologic material that will be disturbed during mining operations. Of particular importance is the assessment of the acid generating potential of rocks targeted to be utilized for construction and predicting the quality of water draining from prospective ore stockpiles.

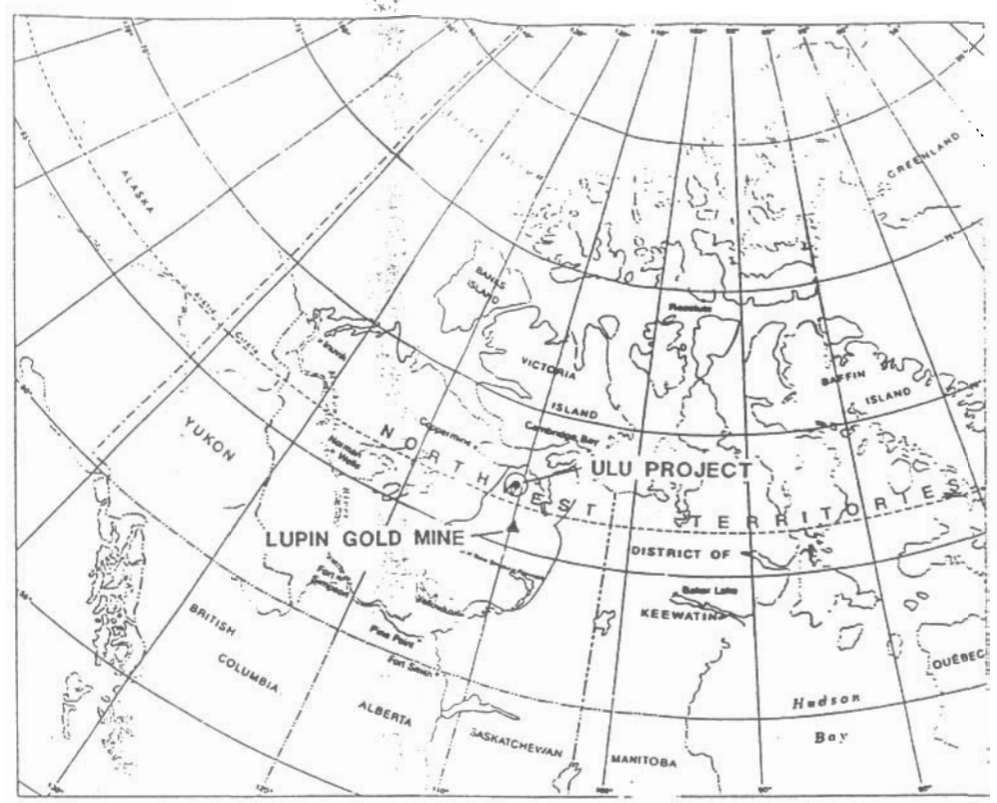
1.2 Scope of Work

The scope of work for this project included: (1) reviewing available information on the geology and mineralogy of the Ulu deposit with respect to its susceptibility to generate ARD; (2) conducting a brief field examination and collecting/selecting a representative suite of samples for acid-base accounting (ABA) analysis; (3) interpreting the results of the ABA testwork in terms of their implications for strategies for ore stockpiling and mine waste management; and, (4) preparing a report outlining the findings and recommending further testwork as required.



LEGEND

1a	MAFIC VOLCANICS
5d	BIOTITE SCHIST
7a	GABBRO
9a	GRANITE
——	Au ZONES ★
— —	CONTACT
~~	FAULT



LOCATION PLAN

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KLOHN-CRIPPEN

PROJECT: ULU PROJECT			
TITLE: GENERALIZED GEOLOGY			
CLIENT: ECHO BAY MINES LTD.	DATE OF ISSUE: OCT 96	PROJECT No.: PM 7534.01	DWG. No.: FIGURE 1
	APPROVED:		REV.

2. REVIEW OF EXISTING INFORMATION PERTINENT TO ARD ASSESSMENT

To aid sampling the Ulu deposit for ARD potential assessment, the deposit geology and mineralogy as well as previous ABA testwork were reviewed. Primary sources of information include a report entitled "Environmental Overview and Baseline Studies" completed in 1990 by Rescan Environmental Consultants on behalf of BHP Minerals, a 1992 Geology Report by BHP Minerals and miscellaneous petrographic reports including sections of a M.Sc. (Smith, 1990) and a B.Sc. (Carpenter, 1994) thesis. Salient data and their implications are summarized below.

2.1 Deposit Geology and Mineralogy

The Ulu deposit is an Archean epigenetic lode-gold occurrence located within the High Lake greenstone belt of the north-central Slave Province. Pillowed to massive mafic volcanic rocks and co-magmatic gabbro sills are interlayered with graywacke-mudstone turbidite sequences that form a tight north-trending anticline bound on all sides by late Archean granite (Figure 1). Mineralization is hosted in discordant quartz veins concentrated along the axial trace of the anticline. Regional metamorphism to the lower amphibolite facies has converted the sedimentary package largely to biotite schist. Mafic metavolcanic and metagabbro rocks proximal to mineralization are similar in mineralogy and bulk chemistry and are classified as sub-alkaline, high-iron tholeiites (Carpenter, 1994). Gold mineralization is commonly hosted in mafic metavolcanics (e.g., the Flood Zone), less commonly in metagabbro (e.g., the Gnu Zone) and rarely within metasediments (e.g. the Sediment Core Zone).

In the Flood Zone, where most recent work has been focused and where initial mining development will probably commence, the ore mineralization is associated with pervasive silicification and feldspar alteration. Gold occurs adjacent to acicular arsenopyrite in the silica-feldspar altered mafic metavolcanic wallrock and breccia. Pyrrhotite occurs as late

anhedral grains that may be found vein-forming and cross-cutting the arsenopyrite-gold mineralization. Pyrite with or without trace amounts of chalcopyrite occurs in late quartz stockwork selvage and fractures. Marcasite, goethite and limonite are present as late weathering products. The hanging wall metavolcanics show retrograde metamorphism and propylitic alteration characterized by actinolite, epidote with minor chlorite, quartz and sericite. Late quartz-actinolite-carbonate veins are occasionally found overprinting the metamorphic assemblages. The footwall rocks exhibit pervasive biotite and albite alteration with quartz, epidote and chlorite as minor constituents.

Mesothermal lode gold deposits are ranked low in overall susceptibility to give rise to ARD problems among the seven common deposit types investigated by Kwong (1993). In the Ulu deposit, with the possible exception of metasediment-hosted mineralization, the basic to ultra-basic character of the barren host rocks is likely to render prospective waste rock not susceptible to acid generation in spite of the scarcity of carbonate minerals. Due to pervasive silica and feldspar alteration and the presence of pyrrhotite in the mineralized zones, however, the ore material is likely to be net acid-generating. Whether or not an ore stockpile would generate acid in the temporary storage pad will depend on the pyrrhotite oxidation rate under the climatic conditions at the site. To avoid contaminating benign waste rock that can be used for construction purpose, care should be taken to characterize and isolate sulfide-bearing sub-ore material that may be net acid-generating.

2.2 Previous ABA Testwork

Two sets of results of previous ABA testwork have been identified and are summarized in Table 1. The 1990 testing was performed as part of the environmental overview (Rescan, 1991) and attempted to characterize the ARD potential of the various lithologies occurring in the Ulu property through the analysis of 15 samples. The 14 samples analyzed in 1992 specifically addressed the ARD characteristics of the ore material and rocks in the hanging wall exposed in a trench in the NW Flood Zone.

Table 1 Results of Previous ABA Testwork

Sample #	%S	AP	NP	NNP	NP/AP	Rock type	Description
		(kg H2SO4/tonne)					
A) 1990 all lithologies							
ARD-1	0.24	7.35	21.53	14.18	2.93	gabbro	adj zone
ARD-2	0.74	22.79	34.95	12.16	1.53	mafic volc.	lo grade
ARD-3	0.29	8.88	50.91	42.03	5.73	diabase	fresh
ARD-4	0.04	13.29	23.02	9.73	1.73	band tuff	below ore
ARD-5	0.02	5.57	27.19	21.62	4.88	q-f porphy	footwall
ARD-6	0.01	4.38	41.85	37.47	9.55	basalt	hang wall
ARD-7	0.25	7.78	29.47	21.69	3.79	basalt	footwall
ARD-8	0.17	5.27	20.04	14.77	3.80	greywacke	footwall
ARD-9	0.02	7.35	52.32	44.97	7.12	diabase	hang wall
ARD-10	0.13	3.98	10.15	6.17	2.55	gabbro	fresh
ARD-11	0.12	3.74	19.25	15.51	5.15	basalt	fresh
ARD-12	0.01	0.36	38.45	38.09	107	f-porphy	fresh
ARD-13	0.25	7.72	15.48	7.76	2.01	graywacke	fresh
ARD-14	0.22	6.83	83.09	76.26	12.2	basalt	country rx
ARD-15	0.57	17.49	39.92	22.43	2.28	basalt	country rx
B) 1992 Trench in NW Flood Zone: hanging wall and mineralization							
						oz/t Au	Interval
92VTT(-1)	0.39	12	15	3	1.25	0.001	10.00-10.10
92VTT(-2)	0.11	3	17	14	5.67	0.001	10.10-10.20
92VTT(-3)	0.07	2	18	16	9.00	0.001	10.20-10.30
92VTT(-4)	0.5	15	30	15	2.00	0.001	10.30-10.40
92VTT(-5)	0.12	4	21	17	5.25	0.001	10.40-10.50
92VTT(-6)	0.21	6	15	9	2.50	0.144	10.50-10.60
92VTT(-7)	0.61	19	21	2	1.11	0.184	10.60-10.70
92VTT(-8)	2.1	64	19	-45	0.30	0.608	10.70-10.81
92VTT(-9)	1.6	49	18	-31	0.37	0.406	10.81-10.90
92VTT(-10)	2.3	70	17	-53	0.24	0.501	10.90-10.10
92VTT(-11)	1.9	58	13	-45	0.22	0.556	10.10-10.11
92VTT(-12)	0.78	24	21	-3	0.88	0.008	10.12-10.13
92VTT(-13)	1.4	43	18	-25	0.42	0.287	10.13-10.14
92VTT(-14)	1.2	38	18	-20	0.47	0.813	10.14-10.15

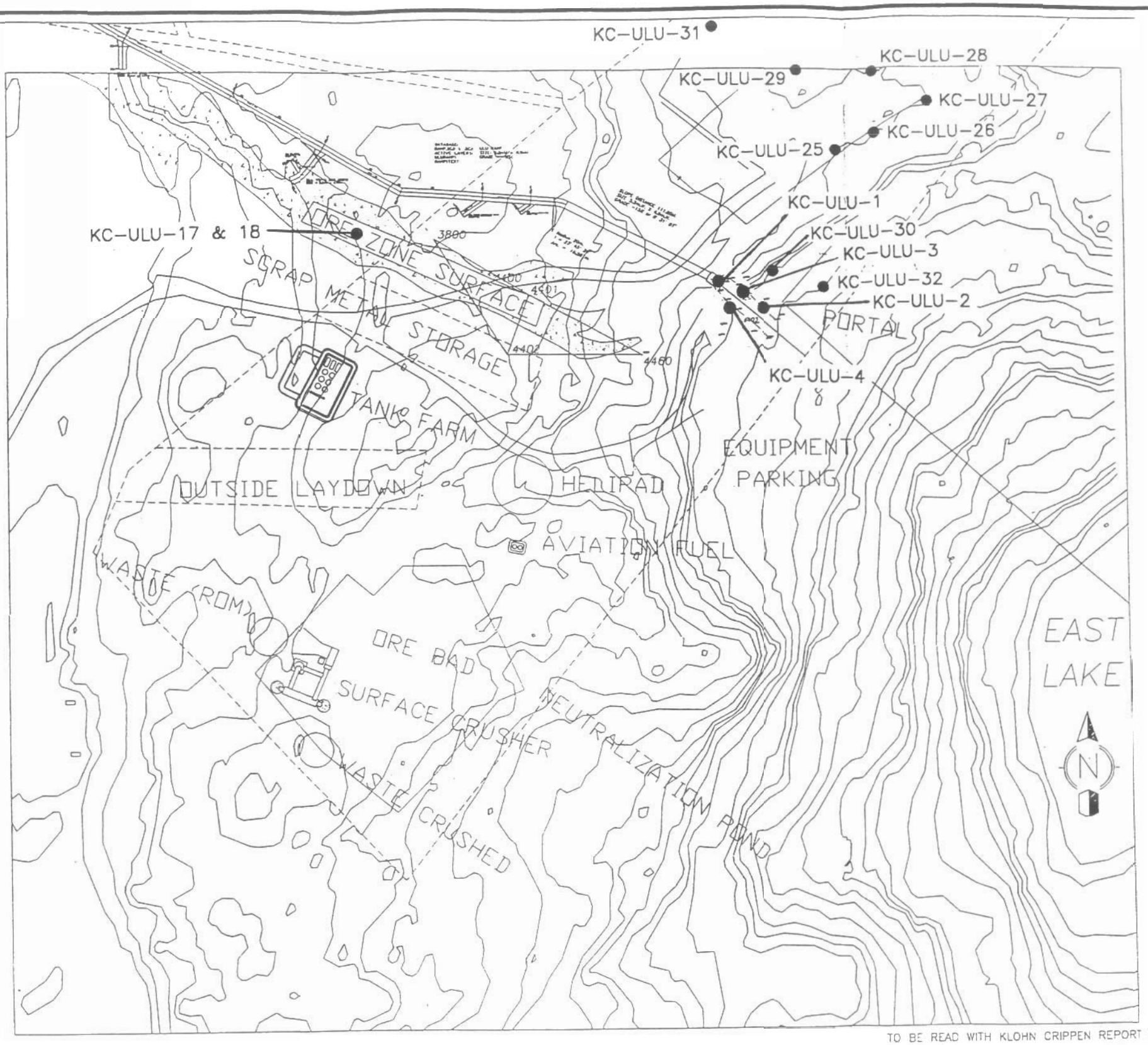
Data summarized in Table 1 support the contentions of the preliminary ARD assessment based on the deposit geology and prevalent mineralogy. The ore material is potentially acid-generating while most barren rocks are not. Rocks in the contact zones with ore mineralization generally have a lower NP/AP ratio. The sulfide content appears to be the primary factor determining whether or not the ratio is to fall below the safety threshold values recommended by the regulatory agencies (NP/AP = 3/1 according to the U.S. Environmental Protection Agency; and NP/AP = 4/1 according to the B.C. ARD Guidelines).

3. SAMPLE DESCRIPTIONS AND ANALYTICAL RESULTS

To supplement the previous ABA testwork and to address the specific needs for the current development at the Flood Zone (Figure 2), 32 samples were collected or selected for detailed analysis in the current investigation. These include the following:

- 16 composite chips samples of the portal under construction, including 4 collected by the Klohn-Crippen personnel while working on site (Ulu-KC-1 to 4), 4 previously collected by an EBM-Lupin geologist (Ulu KC-5 to 8), and 8 subsequently collected by an EBM-Lupin geologist from the camp pads (Ulu KC-25 to 32)..
- 8 composite pulp samples covering two mineralized zones encountered in diamond drill hole 96UL-20; both the ore material and its immediate wallrock alteration were included (Ulu-KC-9 to 16).
- The fresh interior (KC-Ulu-17) and the alteration rind (KC-Ulu-18) of a grab sample collected by an EBM-Lupin geologist from the Ore Zone Surface (Figure 3).
- 6 barren country rocks (3 gabbro, 2 biotite schist and 1 mafic volcanic rock) sampled from drill cores 96-UL-1 to 4 by a mine geologist (Ulu-KC-19 to 24).

To shed light on the extent of sulfide oxidation and to determine the availability of carbonate neutralization capacity in the sample suite, both acid-soluble sulfate and carbonate-carbon were included in the ABA testwork. The analytical results together with a brief sample description are given in Table 2. The raw data and the analytical methods used are furnished in Appendix I. In Table 2, the acid generation potential (AP) of a given sample was calculated based on the sulfide-sulfur content (i.e., total S minus sulfate-S); in other words, the acid generation potential attributable to sulfides (SAP) was calculated. The net neutralization potential (NNP) was calculated by subtracting the acid generation potential (SAP) from the measured neutralization potential (NP). The NP to AP ratio (or NPR) was also calculated using the SAP. The neutralization potential due to carbonates occurring in the samples (Carbonate-NP) was calculated based on the carbonate-carbon analyses and expressed in kg $CaCO_3$ equivalent /tonne, the same unit as SAP, NP and NNP for easy reference.



● SAMPLE LOCATION

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KLOHN-CRIPPEN

CLIENT: ECHO BAY MINES LTD

PROJECT: ULU PROJECT

TITLE: TENTATIVE SITE PLAN

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT 96	PM 7534.01	FIGURE 2	
APPROVED			

October 30, 1996

Table 2 Ulu Project Acid Base Accounting, 1996

Sample #	Description	Paste pH	Total S %	Sulfate-S %	Sulfide-S %	SAP kg/tonne CaCO3	NP kg/tonne CaCO3	NNP kg/tonne CaCO3	NP:SAP Ratio	Carbonate NP
Ulu KC-1	Portal, working face; basalt	8.63	0.26	0.005	0.255	8	45	37	5.6	24.1
Ulu KC-2	Portal, N ramp; basalt and gabbro	8.62	0.09	0.01	0.08	3	27	24	10.6	0.2
Ulu KC-3	Portal, N ramp, sulfide (po+py)-rich	8.11	3.91	0.02	3.89	122	13	-109	0.1	0.4
Ulu KC-4	Portal, S ramp; basalt and gabbro	9.26	0.49	0.01	0.48	15	22	7	1.5	1.7
Ulu KC-5	EBM-Ulu pulp 18701; portal material	8.56	2.65	0.01	2.64	83	21	-61	0.3	6.5
Ulu KC-6	EBM-Ulu pulp 18702; portal material	8.34	2.80	0.01	2.79	87	14	-73	0.2	2.2
Ulu KC-7	EBM-Ulu pulp 18703; portal material	8.38	3.15	0.01	3.14	98	21	-77	0.2	3.8
Ulu KC-8	EBM-Ulu pulp 18704; portal material	8.69	2.29	0.02	2.27	71	24	-47	0.3	6.7
Ulu KC-9	Altered basalt, BH96-20, 117.9-118.9 2-5% po+py, 0.03 ppm Au	8.76	0.15	0.01	0.14	4	30	26	6.9	6.5
Ulu KC-10	Altered basalt, BH96-20, 166.8-167.8 2-3%po+py, 1%Aspy, 0.03-0.10 ppm Au	8.87	0.28	0.01	0.27	8	26	18	3.1	8.8
Ulu KC-11	Altered basalt, BH96-20, 167.8-169.2 3-4%po, 1-2%Aspy, 0.655 pm Au	8.79	0.93	0.02	0.91	28	33	5	1.2	12.5
Ulu KC-12	Altered basalt, BH96-20, 169.2-170.1 3-4%po, 1-2%Aspy, 2.43 pm Au	8.75	1.17	0.01	1.16	36	33	-3	0.9	6.3
Ulu KC-13	Mineralized zone, BH96-20, 173.3-175.0 7-20% po, 15-25% Aspy, 11.0 ppm Au	8.60	2.24	0.01	2.23	70	30	-39	0.4	5.3
Ulu KC-14	Quartz vein, BH96-20, 184.4-185.9 5-10% po, 5-35% Aspy, 8.42 ppm Au	8.60	1.60	0.01	1.59	50	18	-31	0.4	5.3
Ulu KC-15	Altered sediment, BH96-20, 185.9-187.6 tr.-1% po+py, tr Aspy,0.67 ppm Au	9.43	0.28	0.02	0.26	8	24	15	2.9	1.0
Ulu KC-16	Altered graywacke, BH96-20, 198.9-200.8 tr.-3% po+py, tr-1% Aspy, 1.63 ppm Au	9.18	0.22	0.03	0.19	6	16	10	2.7	1.6
Ulu KC-17	Fresh interior of grab ore sample (7.37 g/t Au)	8.37	1.19	0.06	1.13	35	23	-13	0.6	<0.1
Ulu KC-18	Alteration rind of grab ore sample	7.23	1.29	0.03	1.26	39	26	-14	0.6	0.2
Ulu KC-19	Mafic volcanics, BH96-2, 11-12m	8.90	0.93	0.01	0.92	29	18	-11	0.6	3.5
Ulu KC-20	Biotite schist, BH96-2, 34-38m	8.96	0.11	0.01	0.10	3	22	19	7.2	1.7
Ulu KC-21	Biotite schist, BH96-2, 38-42m	8.82	0.07	0.01	0.06	2	21	19	11.3	1.2
Ulu KC-22	Gabbro, BH96-4, 3-23m	8.54	0.22	0.01	0.21	7	25	19	3.9	<0.1
Ulu KC-23	Gabbro, BH96-3, 3-40m	8.95	0.13	0.01	0.12	4	18	14	4.7	1.2
Ulu KC-24	Gabbro, BH96-1, 25-52m	9.27	0.06	0.01	0.05	2	15	14	9.8	1.0
Ulu KC-25	EBM-Ulu ARD-1, basalt	9.03	1.49	0.01	1.48	46	22	-24	0.5	3.0
Ulu KC-26	EBM-Ulu ARD-2, basalt	9.03	0.58	<0.01	0.58	18	19	1	1.1	3.0
Ulu KC-27	EBM-Ulu ARD-3, basalt	9.24	0.80	0.01	0.79	25	23	-2	0.9	6.0
Ulu KC-28	EBM-Ulu ARD-4, basalt	9.00	0.31	<0.01	0.31	10	23	13	2.4	6.0
Ulu KC-29	EBM-Ulu ARD-5, Qtz-feld porphyry +basalt	9.21	0.73	0.01	0.72	23	23	1	1.0	11.0
Ulu KC-30	EBM-Ulu ARD-6	9.18	0.37	<0.01	0.37	11	20	9	1.8	2.0
Ulu KC-31	EBM-Ulu ARD-7, basalt+ minor QFP	8.96	0.32	<0.01	0.32	10	19	9	1.9	4.0
Ulu KC-32	EBM-Ulu ARD-8	9.07	0.20	0.01	0.19	6	19	13	3.2	1.0

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4. DATA INTERPRETATION

4.1 General Observations

As a group, the analyzed samples have relatively uniform paste pH and NP, very low sulfate-S and low to very low carbonate-NP contents. The relatively high paste pH measurements (8.1 to 9.4 except for the alteration rind sample, Ulu-KC-18, which gave 7.2) indicate the dominance of relatively fresh silicates with little contribution from reacting sulfides or carbonates. The very low sulfate-S contents affirm that sulfides present in the sample suite are largely unaltered. Alternatively, any alteration products, if present at all, are not retained in the samples as sulfates. However, in the northern environment, fast reacting sulfides usually give rise to efflorescent sulfates as an intermediate alteration product (Kwong and Whitley, 1993). In the sample with the highest sulfate-S content (a grab sample from an ore outcrop, Ulu-KC-17), the proportion of oxidized sulfide amounts to only 5%.

The NP of the sample suite lies within a narrow range, 13 to 45 kg $CaCO_3$ equivalent/ tonne. As depicted in Figure 3, most of the NP in these samples are due to non-carbonate minerals, which in this case are most likely mafic silicates. In only one sample (Ulu-KC-1) does the carbonate-NP exceed the contribution from the silicates. In the absence of a significant carbonate-NP, the sulfide-S content (which in this case is essentially the same as total S because of the low detected sulfate-S content) becomes the most important parameter determining the outcome of the NNP and NPR of a sample, regardless of rock type. Thus in the sample suite, any sample with a total S content >0.9% invariably gives rise to a negative NNP (Figure 4) and a NPR<1 (Figure 5). In other words, based on the current data set, any sample with a total S>0.9% is potentially acid-generating (PAG, provisionally defined as NNP<0 and NPR<1). If previous data (Table 1) are also included, the threshold value differentiating PAG from non-PAG rocks is 0.8% total sulfur (Figure 6).

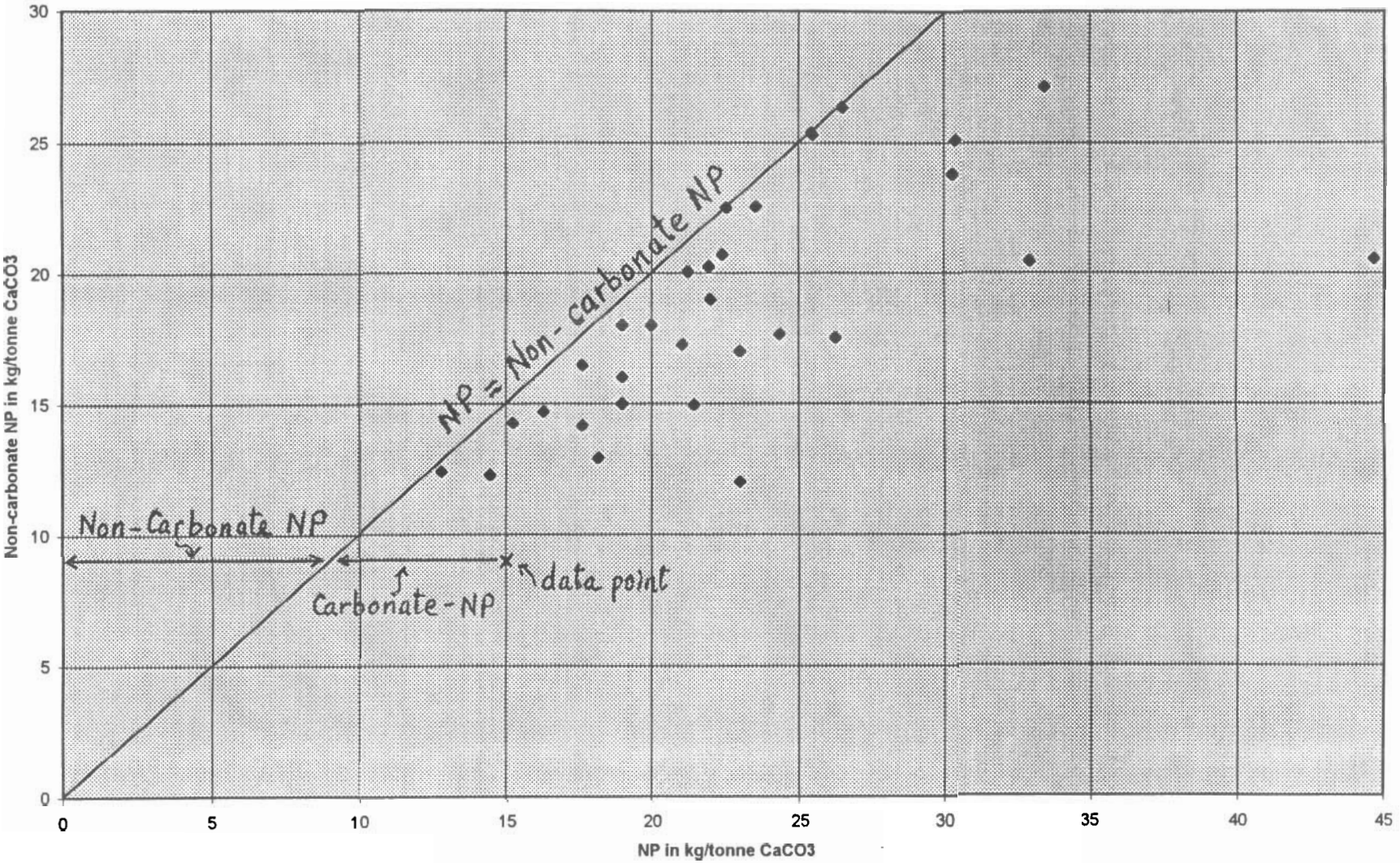

Figure 3 **NP vs Non-Carbonate NP**

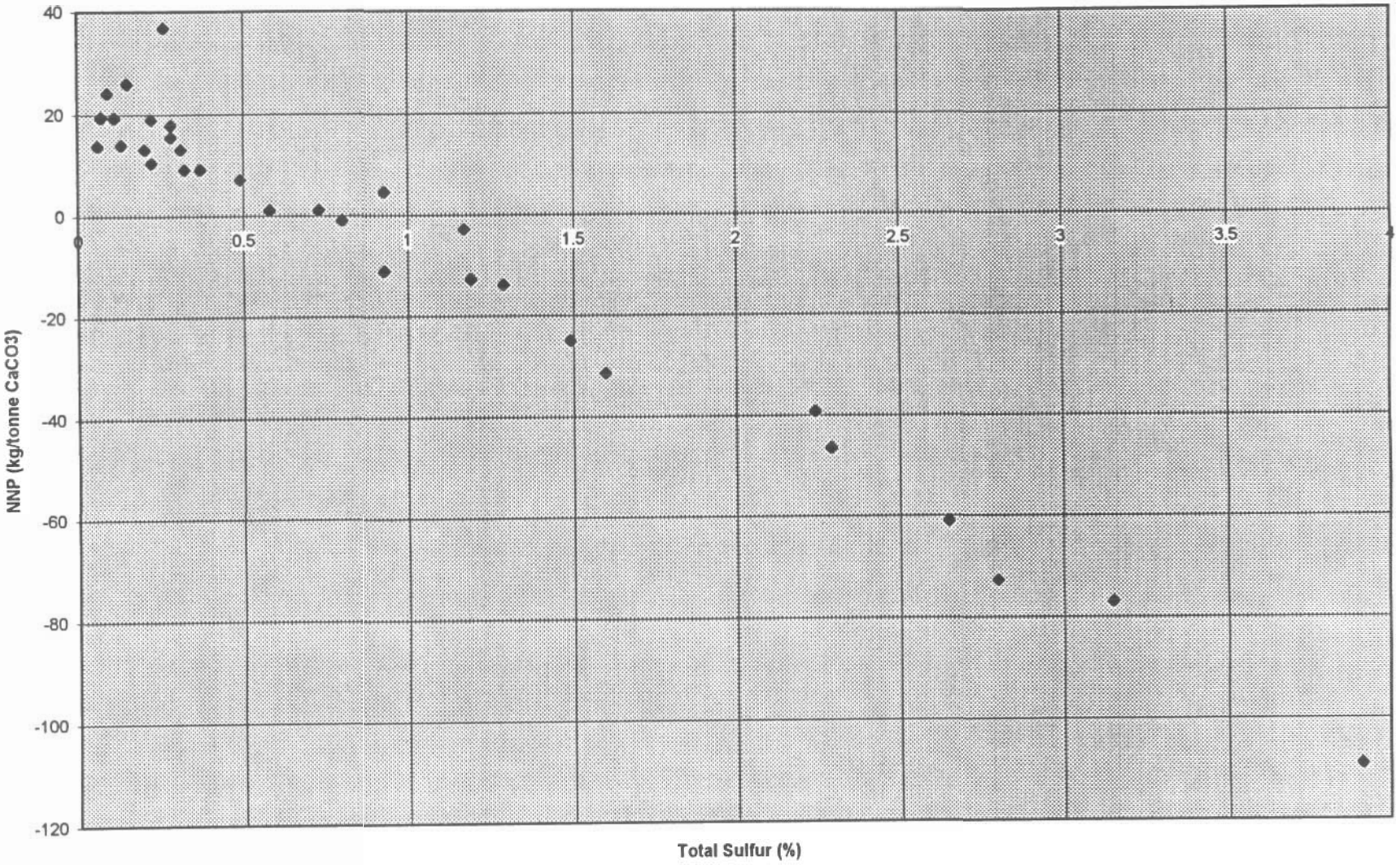

Figure 4 Total Sulfur vs NNP

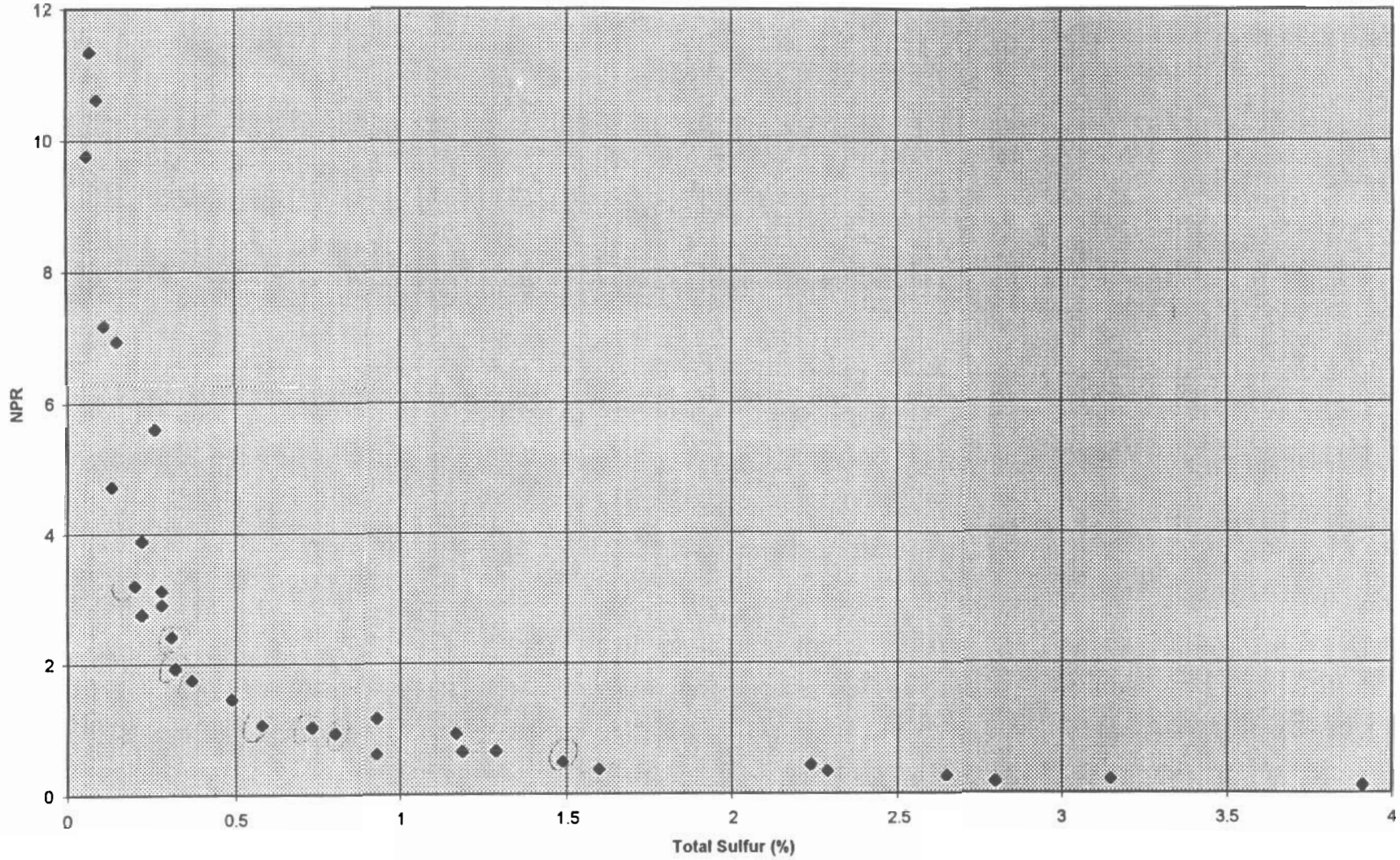

Figure 5 Total Sulfur vs NPR (1996 data set)

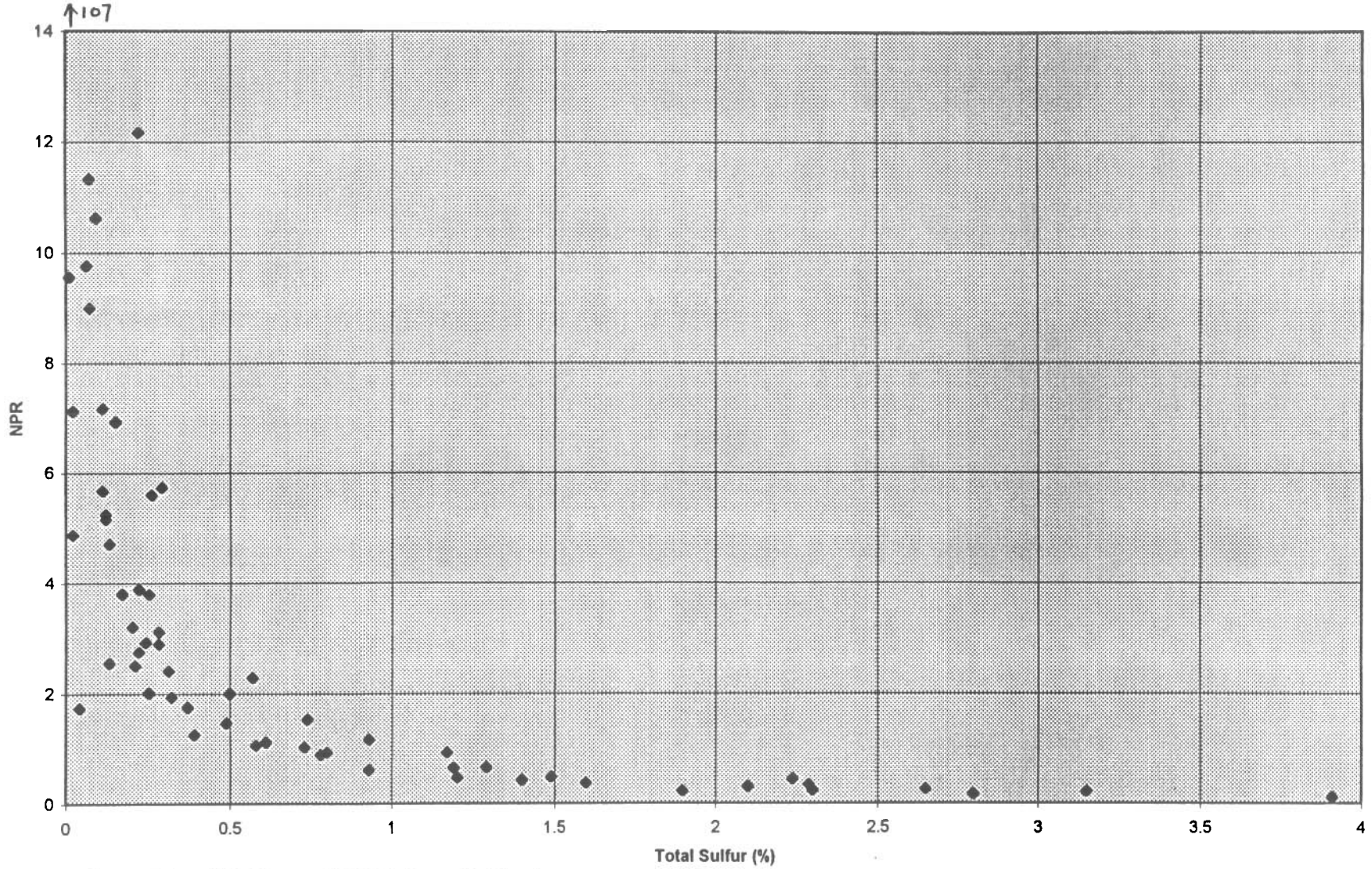

Figure 6 Total Sulfur vs NPR (all available data)

Klohn-Crippen

Given the slow weathering rate at the project site as evidenced by the freshness of both exposed silicate and sulfide minerals, it is recommended that a NPR of 1 be considered rather than a higher value to discriminate PAG from non-PAG rocks. However, as anhedral pyrrhotite, which is highly reactive in a warmer climate, occurs both in the ore zone and its wall-rock alteration, kinetic tests should be conducted to confirm whether or not such a low ratio is acceptable. Furthermore, since arsenopyrite is closely associated with the ore and arsenic is mobile even under non-acidic conditions, kinetic tests will clarify whether or not arsenic contamination will be a concern regardless of the acid-generation potential of the ore or arsenopyrite-containing mine waste.

4.2 The Ore Pad Construction

The eight samples collected from the portal under construction in the Flood Zone (Ulu-KC-1 to 8) vary widely in ABA characteristics (Table 2). While the most carbonate-rich rock (Ulu-KC-1 containing 2.4 wt.% calcite equivalent) has been identified from the working face as of August 19, 1996, the most PAG-rock (Ulu-KC-3 with a NPR of 0.1 and a NNP of -109 kg $CaCO_3$ equivalent/tonne) also occurs in close vicinity. In volume, the PAG rock constitutes only a small proportion of the north ramp a composite sample of which (Ulu-KC-2) gave a NPR of 10.6 and a NNP of 24 kg $CaCO_3$ equivalent /tonne (Table 2). However, all four samples previously collected by the EBM-Lupin staff in the earlier phase of the portal construction (Ulu-KC-5 to 8) gave negative NNP values and a NPR<0.4. This suggests that the volume of the PAG rock may be significant locally. On the other hand, out of the eight waste rock samples subsequently collected from the camp pads (Ulu-KC-25 to 32), only one is potentially acid-generating (Ulu-KC-25 with a NNP of -25 kg $CaCO_3$/tonne and a NPR of 0.5) and another one marginally so (Ulu-KC-27; NNP = -1 kg $CaCO_3$/tonne and NPR = 0.9). The overall paucity of PAG-material indicates that if the waste rock used in the camp pads construction was well mixed, the probability of net acid generation would be low.

To avoid potential environmental problems, PAG rocks like Ulu-KC-3, Ulu-KC-5 to 8 and Ulu-KC-25 should not be used in building the foundation of the prospective ore pad or in mine road construction. As rock excavation is a slow process, a field geologist's expertise in mineral identification may be utilized in selecting the right material for construction purposes. Using the threshold value of 0.9 wt.% S as a discriminator, any rock containing more than approximately 2.5% pyrrhotite or 2% pyrite or 4.5% arsenopyrite by volume or their combined equivalents should be isolated. Such sulfide-rich material can be stockpiled on a low permeability structure and later be capped in-situ or utilized as an ore dilutent in the milling process.

A comparison of the ABA characteristics of the fresh interior and the alteration rind (Ulu-KC-17 and 18, respectively) of an ore sample exposed by trenching in 1992 suggests that the sulfide oxidation rate is very slow at the project site. In spite of the near absence of carbonate-NP, a minimum of four years' exposure to the weathering elements has only led to a depression in paste pH from 8.4 to 7.2 as a result of sulfide oxidation (Table 2). As indicated by the relatively low sulfate-S content in the alteration rind, the stable alteration product resulting from this slow weathering process is iron oxide rather than a leachable intermediate sulfate mineral. Thus, it is not expected that acid drainage will be generated from an ore stockpile temporarily stored on a surface pad for up to four years. However, such a prediction must be confirmed by kinetic tests.

As shown by the ABA characteristics of samples from drill hole BH96-20 exhibiting different degrees of mineralization (Ulu-KC-9 to 16), the total-S content is the controlling factor determining whether or not a sample will be classified as PAG. Given the fact that a neutralization pond has already been included in the mining plan to treat prospective acid drainage from the ore pad (Figure 2), sub-ore material containing greater than about 2.5% pyrrhotite or 2% pyrite or 4.5% arsenopyrite by volume or their combined equivalents

could be stockpiled together with the ore. Pending confirmation by kinetic tests, the inclusion of such sulfide-rich material in the ore stockpile is unlikely to lead to acid generation in a few years because of the extremely slow sulfide oxidation rate apparently occurring at the site.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on a synthesis of field observations, new ABA data acquired in the current sampling event and a review of available information, the following conclusions can be drawn with regard to the acid rock drainage potential of rocks hosting the gold mineralization at Ulu:

1. With few exceptions, most rocks in the Ulu property do not contain any significant carbonate content but mafic silicates may contribute a neutralization potential in the order of 20 kg $CaCO_3$ equivalent/tonne.

2. Regardless of rock type and extent of mineralization, the total sulfur content is the most important parameter determining whether or not a sample is classified as potentially acid-generating (PAG).

3. Because of the apparently very slow sulfide oxidation rate occurring at the site, a threshold total sulfur content of 0.9 wt.% and a NPR of >1 are recommended as appropriate discriminators to differentiate PAG from non-PAG rocks.

4. Both PAG and non-PAG rocks occur in the vicinity of the portal under construction. Care should be taken to isolate sulfide-rich rocks and not to use them for construction purposes.

5. Based on the apparent paucity of sulfide-rich material and very slow sulfide-oxidation rate, the waste rock used in construction of camp pads from underground is unlikely to be acid generating, especially if the waste rock was well mixed in the process.

To confirm the preliminary ARD assessment based on the results of ABA testing as well as to identify and help avoiding potential metal leaching problems, the following tests and interim practical actions are recommended:

1. Design and conduct kinetic tests to substantiate (a) the slow sulfide oxidation rate apparently occurring at the site; and, (b) the appropriateness of using a lower than recommended NPR as a PAG discriminator for the site; as well as to elucidate potential metal leaching problems, especially arsenic.

2. Involve field geologists in ARD assessment; in this case, especially utilize their expertise in mineral identification to avoid employing rocks with more than 2.5% pyrrhotite or 2% pyrite or 4.5% arsenopyrite by volume or their combined equivalents in the construction of the prospective ore pad.

3. Continue to collect samples for ABA analysis as the project progresses until a database is built up that will allow the identification and application of more readily acquirable surrogate parameters for ARD assessment.

Yours truly,

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