

# ***Schaft Creek Project – ML-ARD Meeting for the Proposed Minesite, May 2008***



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# Important Notes

- This presentation discusses ongoing work for a phased study of ML-ARD at the Schaft Creek Project.
- ML-ARD is one part of many EA studies.
- “Big-picture” EA observations and conclusions are not included here. Many may not be available until the EA is submitted.

# Objectives of This Presentation

- This presentation discusses the Phase 2 ML-ARD findings for the proposed minesite.
- Ongoing (“Phase 3”) work for the proposed minesite is then outlined and discussed.

## Phase 2 Approach

- For the second phase of ML-ARD studies for the Schaft Creek Project:
  - Previous relevant information was compiled.
  - 232 samples of rock were analyzed (see next slide), generally reflecting the abundances of the individual rock units.
  - Three samples of tailings, one from each of the three ore zones, were analyzed.
  - All samples were analyzed for expanded Sobek (EPA 600) acid-base accounting, and for total-element contents using ICP-MS after four-acid digestion and using x-ray fluorescence whole rock.

# Phase 2 Rock-Sampling Objectives

- For the second phase of ML-ARD studies, we were asked to select samples based on drilling reports and assay data from 2005 and 2006. The objectives we set for this sampling were:
  - To collect samples of discrete rock units, generally reflecting the abundance of the rock units in the holes. This recognizes that many assay samples were based strictly on 3.05 m sections which crossed rock units in some places.
  - To collect samples from three-dimensional distributions in all three zones: Main (Liard), West Breccia, and Paramount. The Paramount Zone was not drilled in 2005, so the 2006 samples were the first analyzed for ML-ARD potential from Paramount. This will contribute to the three-dimensional geostatistical modelling by Copper Fox Metals, which will determine if additional ML-ARD samples are needed for reliable estimates across the three zones.

## Phase 2 Rock-Sampling Objectives (cont.)

- To collect samples with a range of assay levels, to ensure waste, low-grade ore, and ore were assessed for their ML-ARD characteristics.
- To collect a few samples that were purposely biased with elevated levels of visual sulphides, to ensure higher-sulphide rock at Schaft Creek was analyzed for its ML-ARD characteristics. Eight “biased high-sulphide” samples were collected from Teck Corp holes drilled in 1980-1981, from all three ore zones.

# Phase 2 Results – Existing Information

# Phase 2 Results – Existing Information

The compilation of existing information relevant to ML-ARD led to the following important observations.

- 1) The Schaft Creek copper-gold-molybdenum deposit is acknowledged as a porphyry copper deposit. It contains three mineral zones: the Liard (Main), West Breccia, and Paramount Zones.
- 2) During an examination of existing core, “It has been noted that the core from previous drilling programs, which is stored on site, exhibits a remarkable degree of preservation with limited visible weathering.” Thus, the oxidation rate of Schaft Creek rock may be relatively slow.

# Phase 2 Results – Existing Information

- 3) Based on 16 acid-base accounts from a previous, metallurgical study, all 16 samples were net acid neutralizing, with
  - sulphide between 0.1 and 0.9%S, and
  - Neutralization Potentials from 53 to 114 kg/t.
- 4) Flotation recovery of sulphide reduced the sulphide levels in the synthetic tailings.

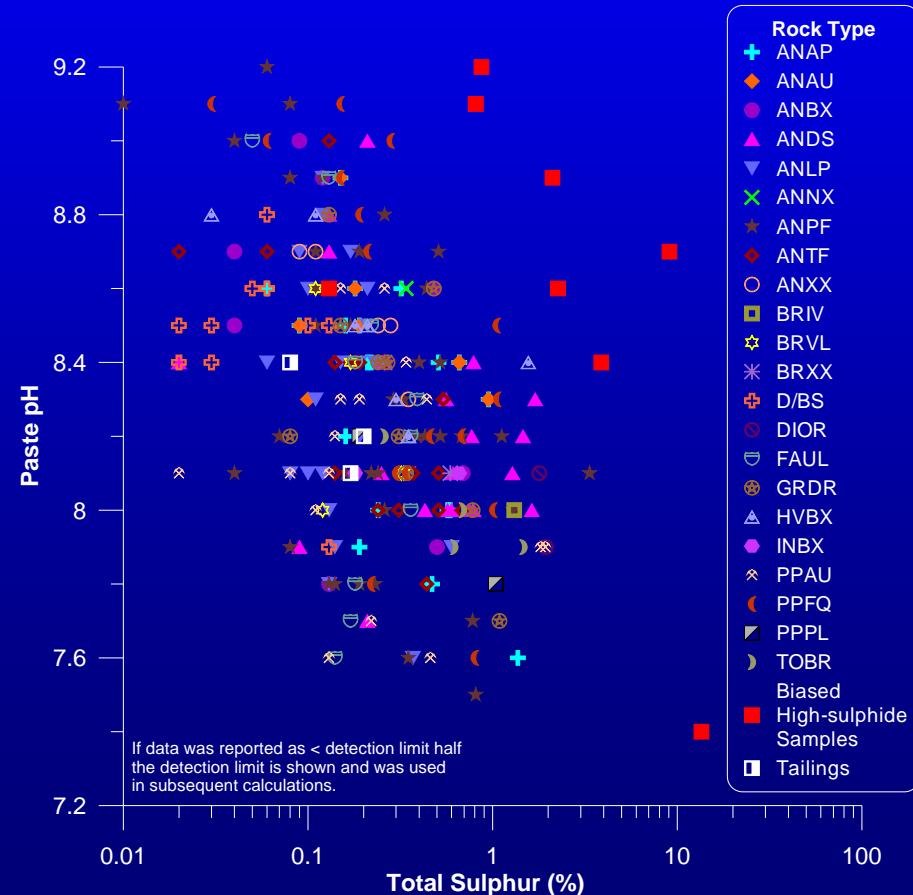
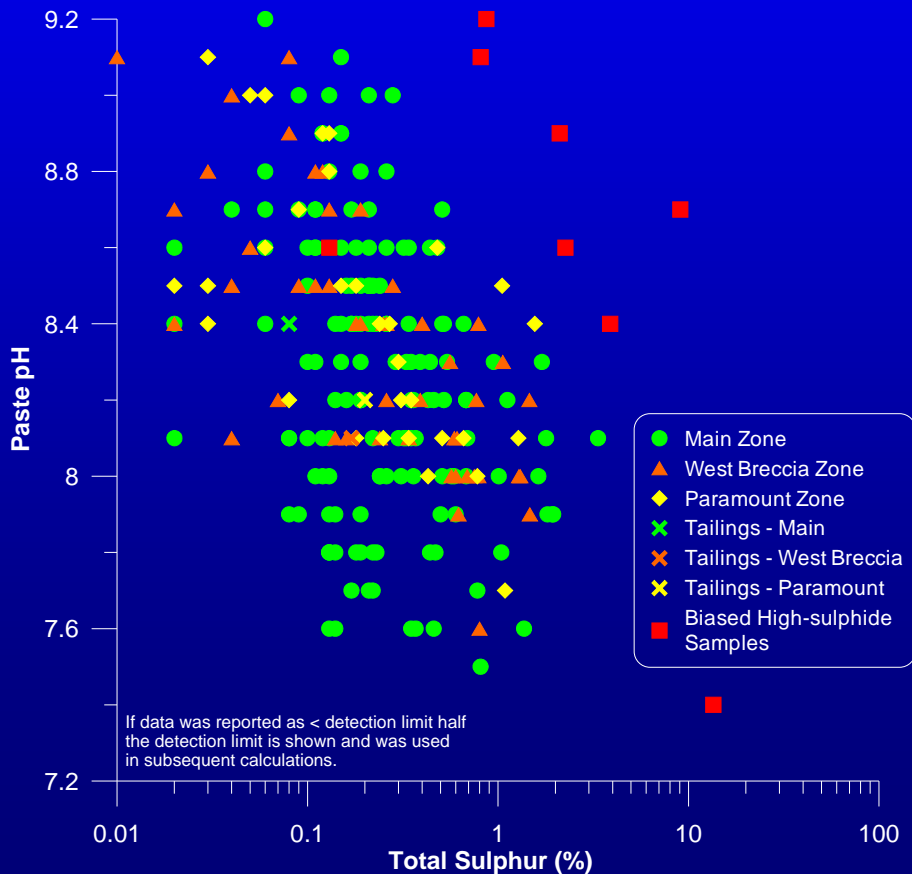
# Phase 2 Results – Existing Information

- 5) Detailed mineralogy was examined in 18 thin sections, representing feldspar quartz porphyry (rock code PPFQ), tourmaline breccia, pneumatolytic breccia, and volcanics.
  - Some PPFQ samples were porphyritic volcanics of felsic and intermediate composition (dacitic - andesitic), and one sample was a fine grained, feldspathic intrusive rock classified as either syenite or anorthosite, depending on the composition of feldspar.
  - Groundmass in these samples was generally around one-half of the total, with the groundmass consisting of more than 90% feldspar, and accessory amounts of quartz, chlorite, sericite, carbonate, and opaques.
  - Detailed mineralogy in the 18 thin sections showed sulphide minerals were:
    - mostly disseminated and as veinlets and clusters, and
    - mostly pyrite and chalcopyrite with less common molybdenite and bornite.
  - Carbonate minerals, mostly reported as veins, patches, and groundmass, were not individually identified and were sometimes seen as feldspar replacement/alteration.

# Phase 2 Results – Acid-Base Accounting (ABA)

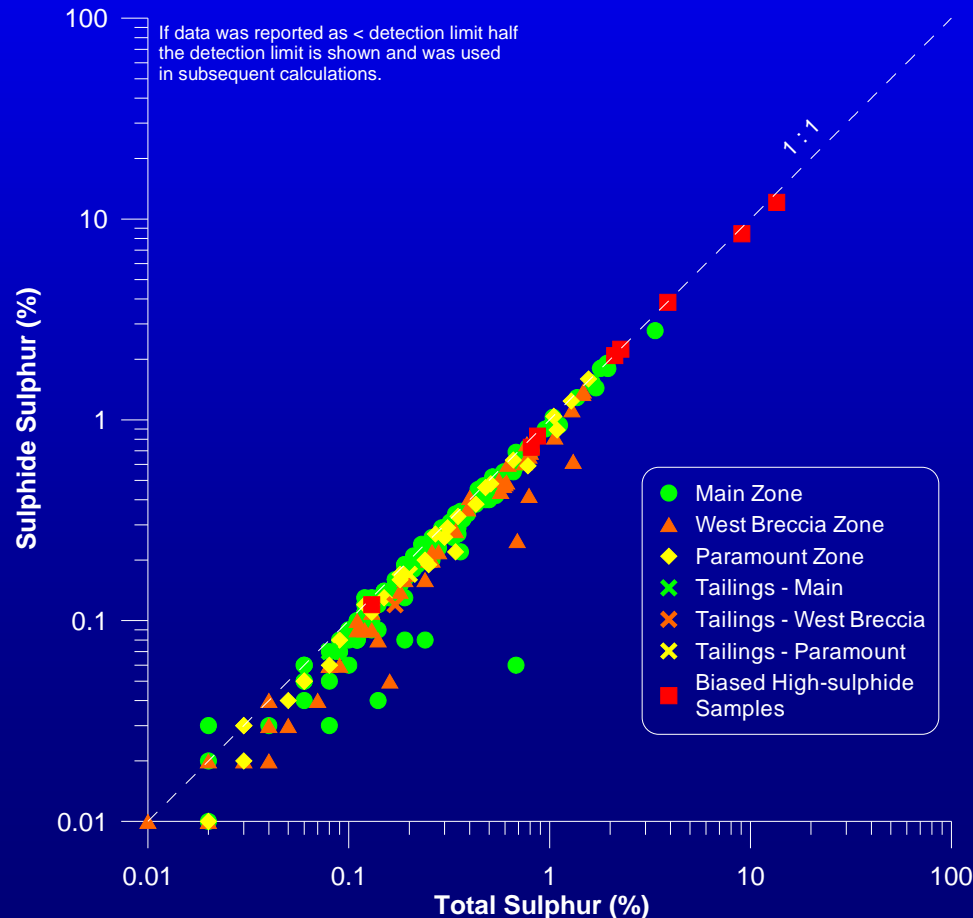
# Phase 2 Results – ABA

Paste pH in the 235 rock and tailings samples for Schaft Creek ranged from 7.4 to 9.2. Thus, no samples were acidic at the time of analysis. The sample with the lowest near-neutral paste pH also contained the highest amount of sulphur.



# Phase 2 Results – ABA

Total sulphur in the 235 rock and tailings samples ranged from 0.01 (detection limit) to 13.5%S, with a mean of 0.50%S and a median of 0.22%S. While maximum total-sulphur values can vary due to localized higher-sulphur rock, the mean and minimum values were similar for all three ore zones.



In most samples, total sulphur and sulphide were similar. Statistically, sulphide represented 85% of total sulphur on average, with a median of 87%. Thus, the two parameters were typically interchangeable, but not identical.

# Phase 2 Results – ABA

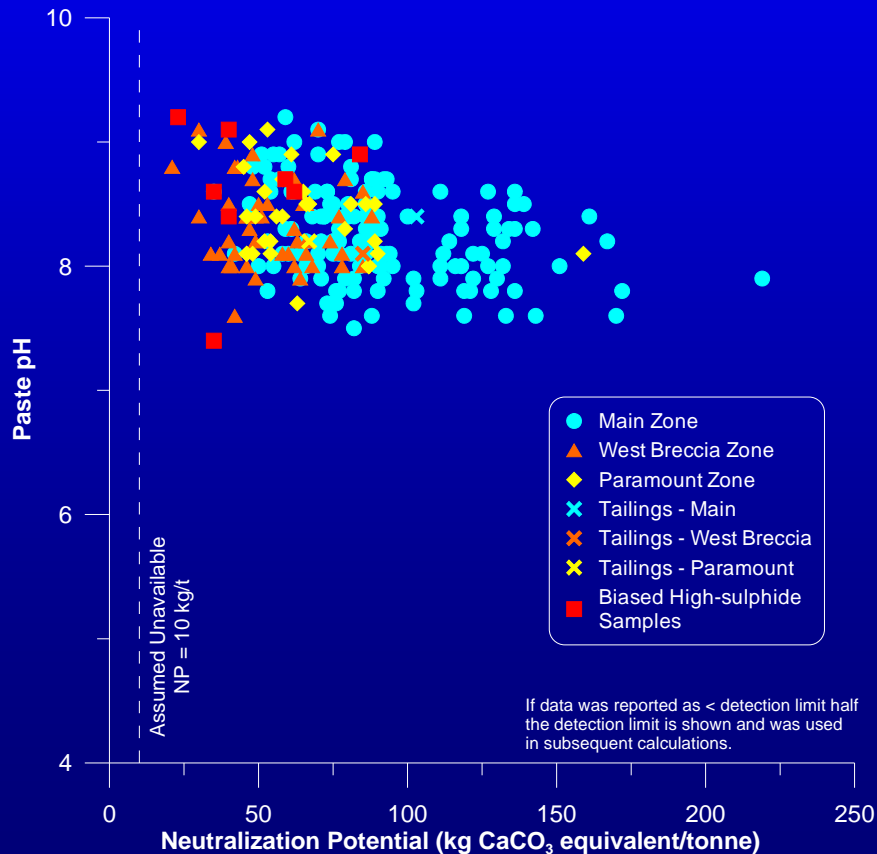
- As explained in the Phase 1 ML-ARD report, not all sulphide exists in an acid-generating form at the Schaft Creek Project. In some rock, much of the sulphide occurs with copper, which has less to no potential for acid generation, but also not all copper occurs as sulphide.
- Calculations were made in the Phase 1 report to bracket the actual acid potential by assuming
  - (1) all sulphide was acid generating and
  - (2) only the sulphide not mathematically associated with copper, zinc, molybdenum, mercury, and arsenic was acid generating.
- The former could be used for “worst-case” (sulphide-based) acid potential, and the latter, “best-case” (pyrite-calculated) acid potential.

# Phase 2 Results – ABA

- Recent comments from the British Columbia Ministry of Environment indicated the best case, pyrite-calculated approach should no longer be used. Also, total sulphur rather than sulphide should be used to calculate acid potential, because total sulphur is easier to measure on a daily operational basis and because of inaccuracies in sulphur species.
- This Phase 2 report used this MOE approach of Total-Sulphur-Based Acid Potential (TAP), recognizing it will overestimate the acid potential of most samples.
- Phase 3 work may revise this approach based on kinetic testing and mineralogical studies.

# Phase 2 Results – ABA

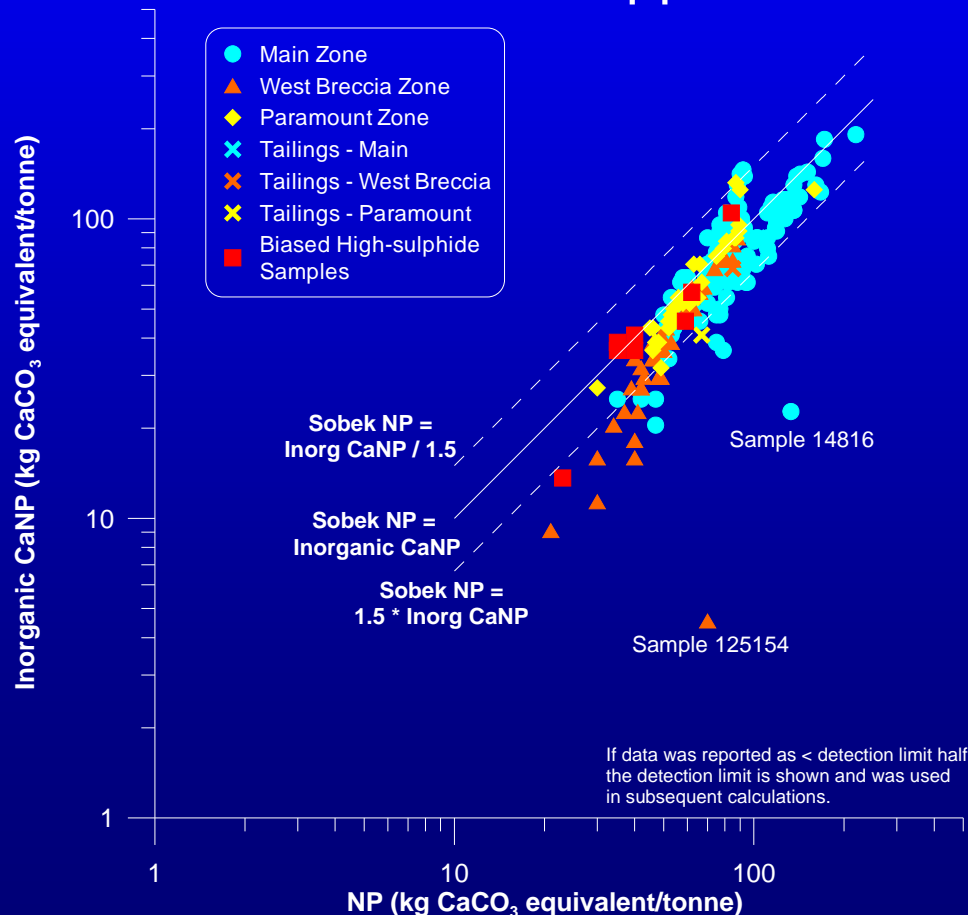
Sobek NP ranged from 21 to 219 kg/t in the 235 Schaft Creek samples of rock and tailings, with a mean of 79 and a median of 75 kg/t. These are relatively high values. They explain why no acidic paste pH values were detected, and suggest there could be a long lag time (years to decades) before any sample might become acidic.



Unavailable NP typically ranges between 5 and 15 kg/t, but higher and lower values have been documented. Due to the lack of low-NP and acidic Schaft Creek samples, Unavailable NP cannot be estimated at this time. Thus, a typical value of 10 kg/t has been assumed for Phase 2.

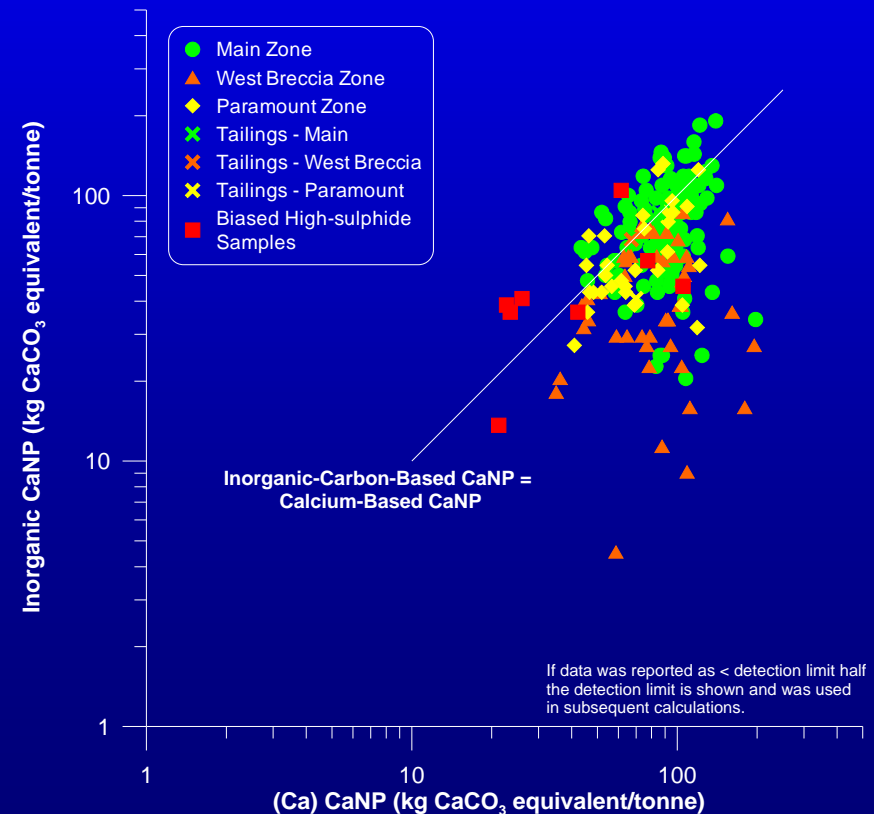
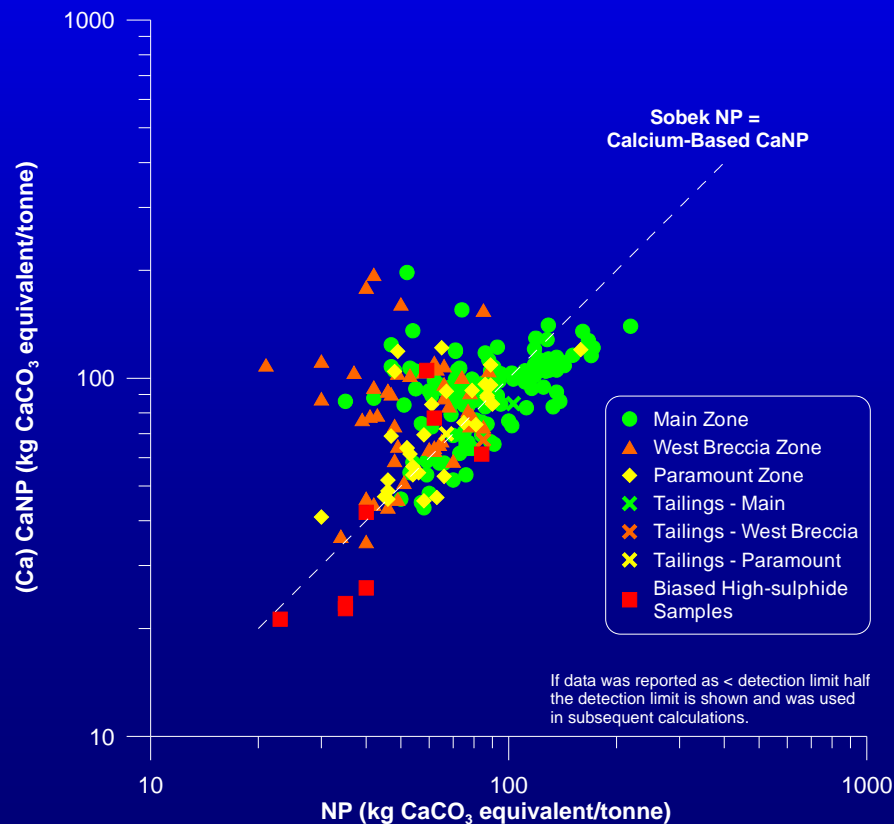
# Phase 2 Results – ABA

A scatterplot of Sobek NP with Inorganic Carbon, converted to the same units (Inorganic CaNP as kg/t), can reveal some geochemical relationships. For the 235 Phase 2 samples, this scatterplot showed that Sobek NP was greater than Inorganic CaNP in 78% of the samples. Some distinct trends were apparent.

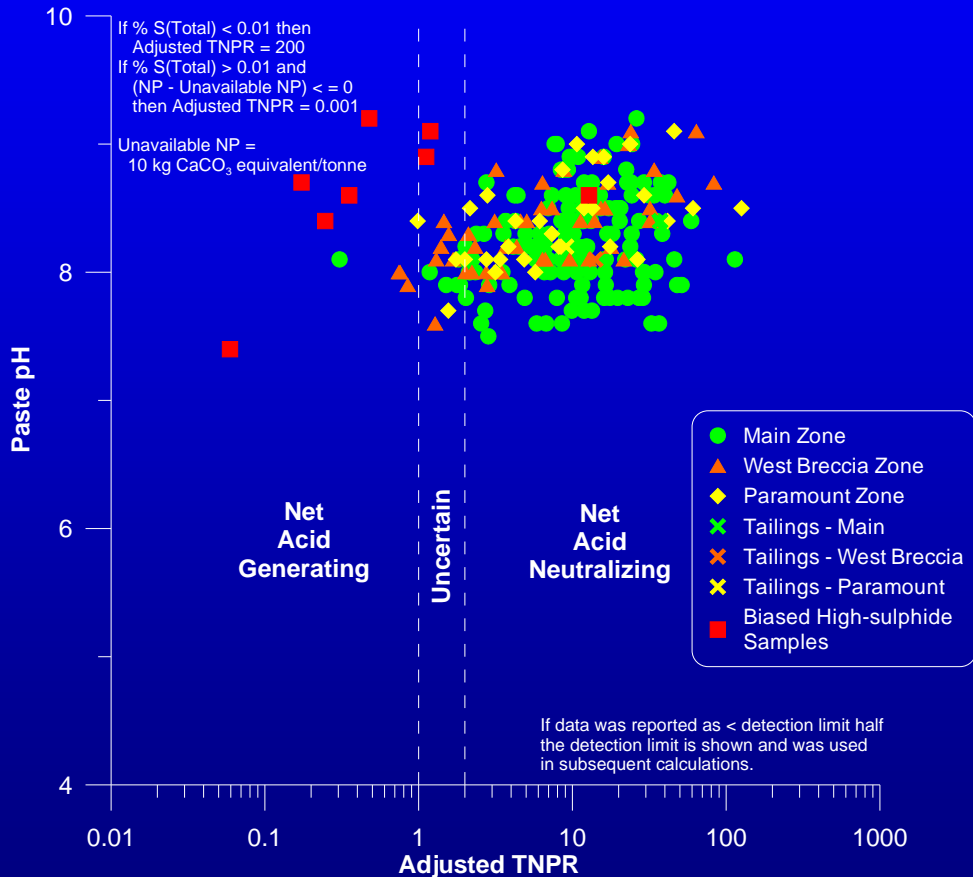


# Phase 2 Results – ABA

Scatterplots of calcium-based NP ((Ca) CaNP) with other NP parameters showed some correlations with calcium, but they were not strong and reliable. Thus, NP cannot be predicted from a simple analysis, like ICP calcium, but calcium-based minerals do play a role in neutralization. “Advanced mineralogy” in Phase 3 will help here.



# Phase 2 Results – ABA



Adjusted TNPR values, not weighted for tonnage within the deposit, ranged from 0.059 (net acid generating) to 126.0 (net neutralizing), with a mean and median of 14.2 and 9.6, respectively. Thus, most samples were net neutralizing. Only ten samples (4%) had Adj TNPR values at or below 1.0, and half were the biased high-sulphide samples. Another 15 samples (6%), from all three ore zones, were in the uncertain range.

# Phase 2 Results – ABA

Percentages of Net-Acid-Generating, Uncertain, and Net-Acid-Neutralizing Samples by NPR Parameter, Based on All 235 Samples

<u>NPR</u>	<u>Notes</u>	<u>% Net Acid Generating</u>	<u>% Uncertain</u>	<u>% Net Acid Neutralizing</u>
Adjusted TNPR	Uses total sulphur; unavailable NP = 10 kg/t	4.3	6.4	89.4
TNPR	Uses total sulphur; all NP available	3.4	5.5	91.1
Adjusted SNPR	Uses sulphide plus any unaccounted-for sulphur; unavailable NP = 10 kg/t	3.8	7.2	88.9
SNPR	Uses sulphide plus any unaccounted-for sulphur; all NP available	2.6	5.5	91.9

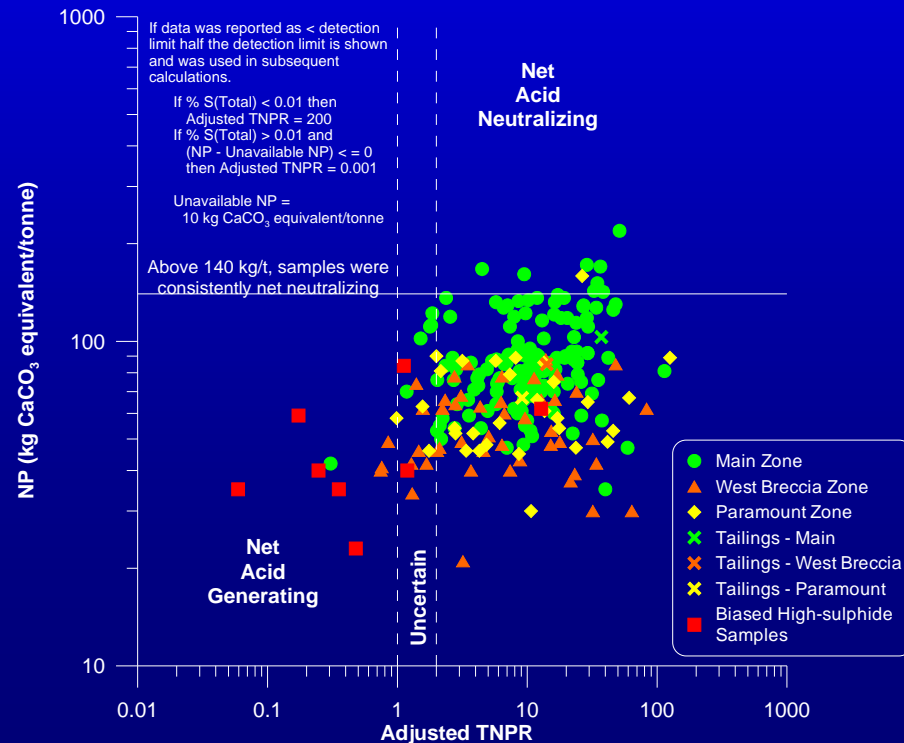
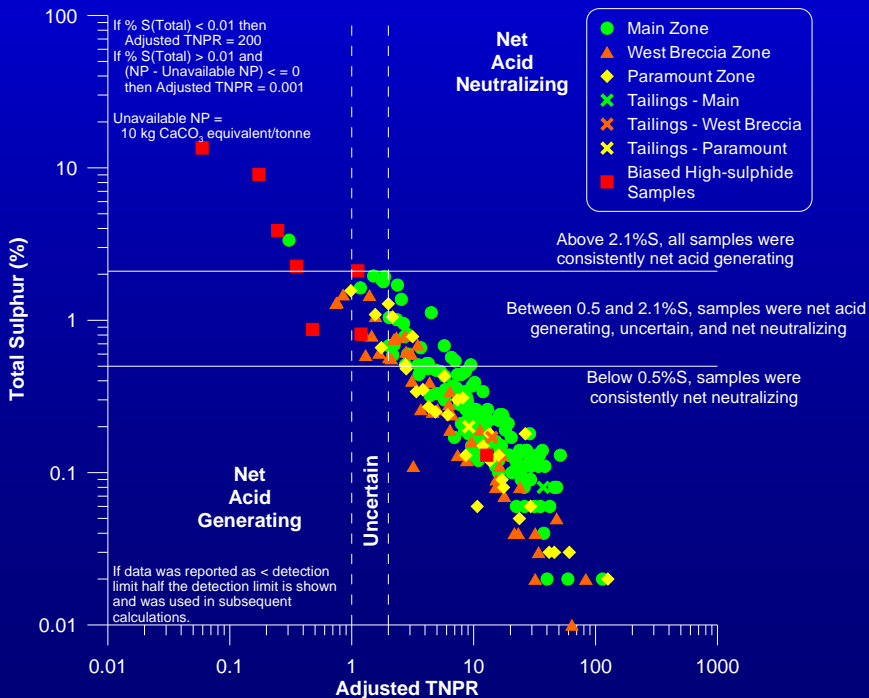
# Phase 2 Results – ABA

## Percentages of Net-Acid-Generating, Uncertain, and Net-Acid-Neutralizing Samples by Adjusted TNPR, for the Three Ore Zones

<u>Adj TNPR</u>	<u>Notes</u>	<u>% Net Acid Generating</u>	<u>% Uncertain</u>	<u>% Net Acid Neutralizing</u>
All Samples	Uses total sulphur; unavailable NP = 10 kg/t	4.3	6.4	89.4
Main Zone	Uses total sulphur; unavailable NP = 10 kg/t	0.7	3.4	95.9
West Breccia Zone	Uses total sulphur; unavailable NP = 10 kg/t	6.4	12.8	80.9
Paramount Zone	Uses total sulphur; unavailable NP = 10 kg/t	3.2	6.5	90.3

# Phase 2 Results – ABA

Although net balances were based on the combination of total sulphur and NP, a good correlation of Adjusted TNPR with one would allow a simpler approach, involving only one analysis. The correlation of Adjusted TNPR with total sulphur was noticeable (lower left), but still left a region between 0.5 and 2.1%S where NP analyses would be required for proper prediction. The correlation of Adjusted TNPR with Sobek NP was poorer (lower right), with only the few samples above an NP of 140 kg/t showing a consistently ML-ARD category.



# Phase 2 Results – Total-Element Analyses

## Phase 2 Results – Total Elements

- Total-element levels in the 235 Schaft Creek samples were measured by ICP-MS analysis after strong four-acid digestion and by x-ray-fluorescence whole-rock analysis.
  - The 235 samples of Schaft Creek rock and tailings were predominantly composed of silicon and aluminum, reflecting the abundant aluminosilicate minerals. Calcium, iron, potassium, magnesium, sodium, and Loss on Ignition (LOI) were also relatively abundant.
  - Compared to general crustal abundances, the 59 samples were:
    - frequently elevated in silver, bismuth, copper, molybdenum, selenium, and tungsten, and
    - occasionally to rarely elevated in cadmium, lead, sulphur, antimony, and zinc.
  - However, solid-phase levels do not typically reflect leaching rates into water, so additional testwork is being conducted on metal leaching.

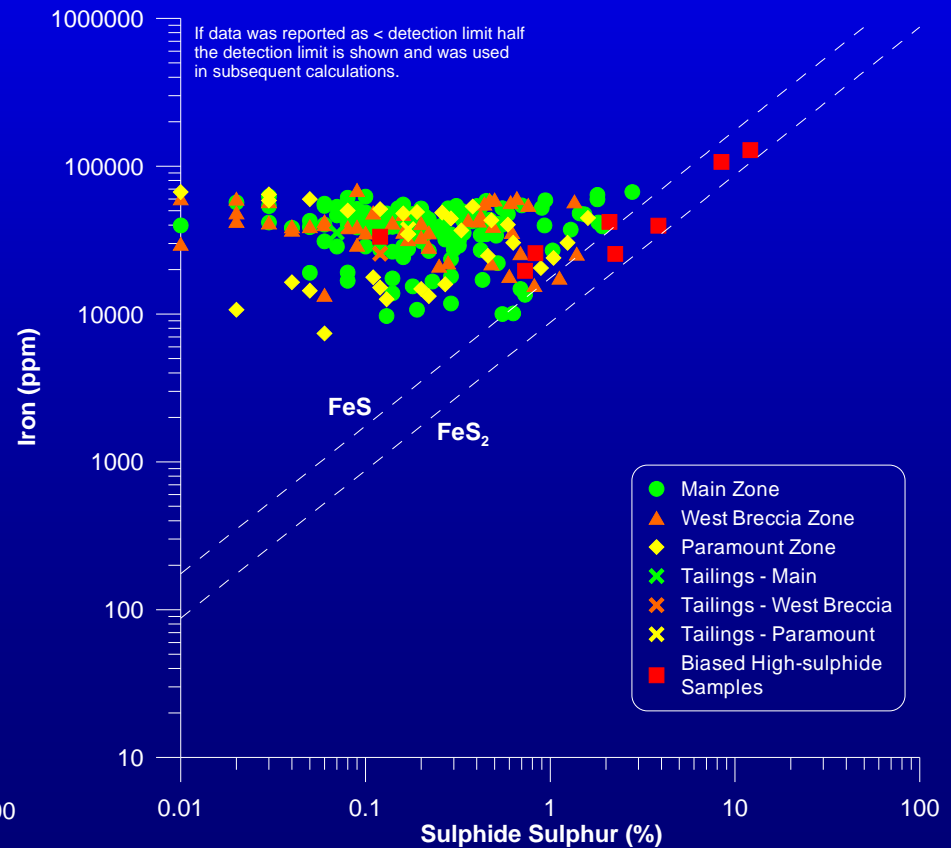
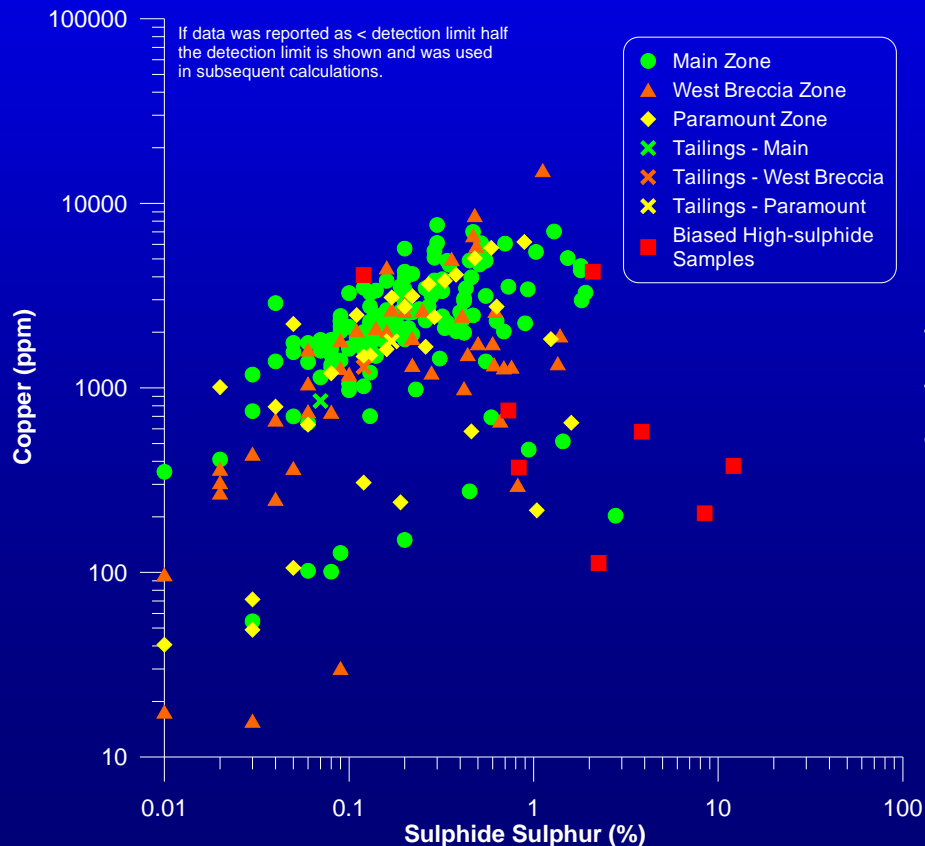
# Phase 2 Results – Total Elements

A comparison of minimum-to-maximum ranges of each solid-phase element in each ore zone showed generally similar ranges for a particular element. However, some notable differences were: higher levels of antimony and lead in some samples from the West Breccia Zone, and typically lower levels of cadmium and zinc in the Main Zone.



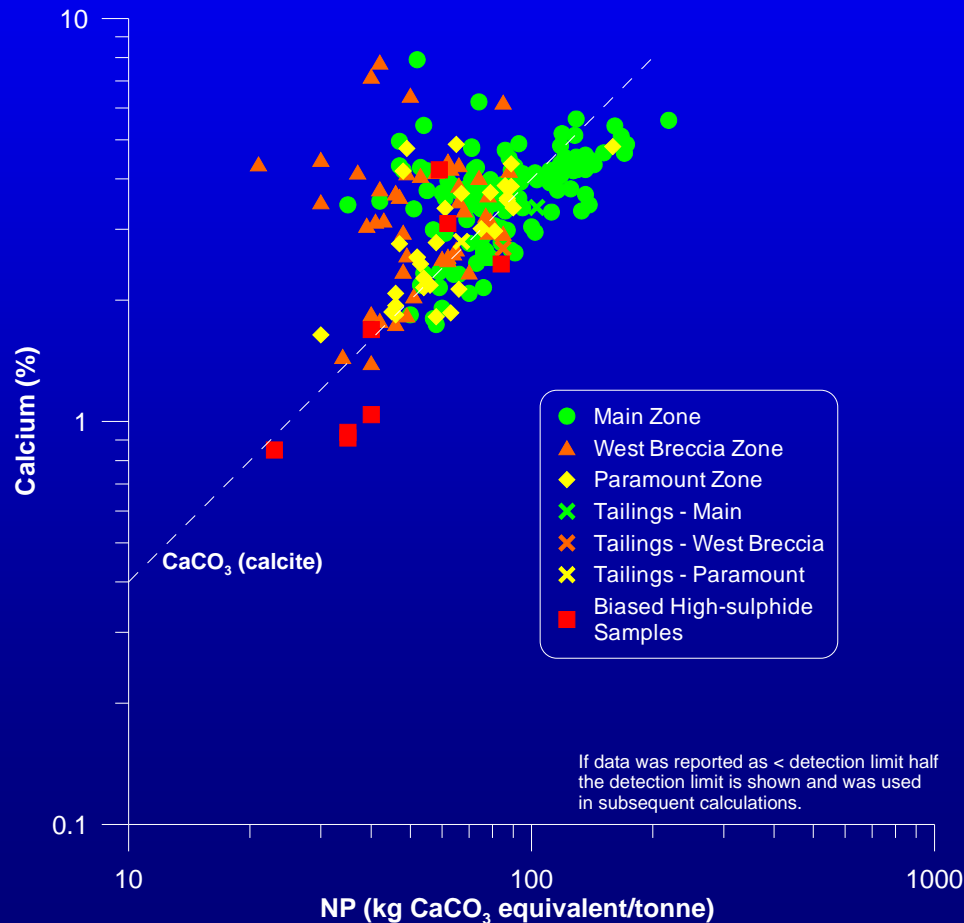
# Phase 2 Results – Total Elements

Solid-phase correlations of elements can sometimes reveal mineralogical associations. For example, elements correlating with sulphide presumably occur within the sulphide minerals, which at the Schaft Creek Project are typically pyrite and chalcopyrite. Copper and selenium showed some correlation with sulphide. The highest levels of cobalt and iron also showed some correlation.



# Phase 2 Results – Total Elements

NP showed some correlation with calcium. However, as explained above, this was not sufficient to distinguish carbonate and non-carbonate calcium-bearing minerals.



# Tailings Testwork for ML-ARD

# Tailings Supernatant (Water)

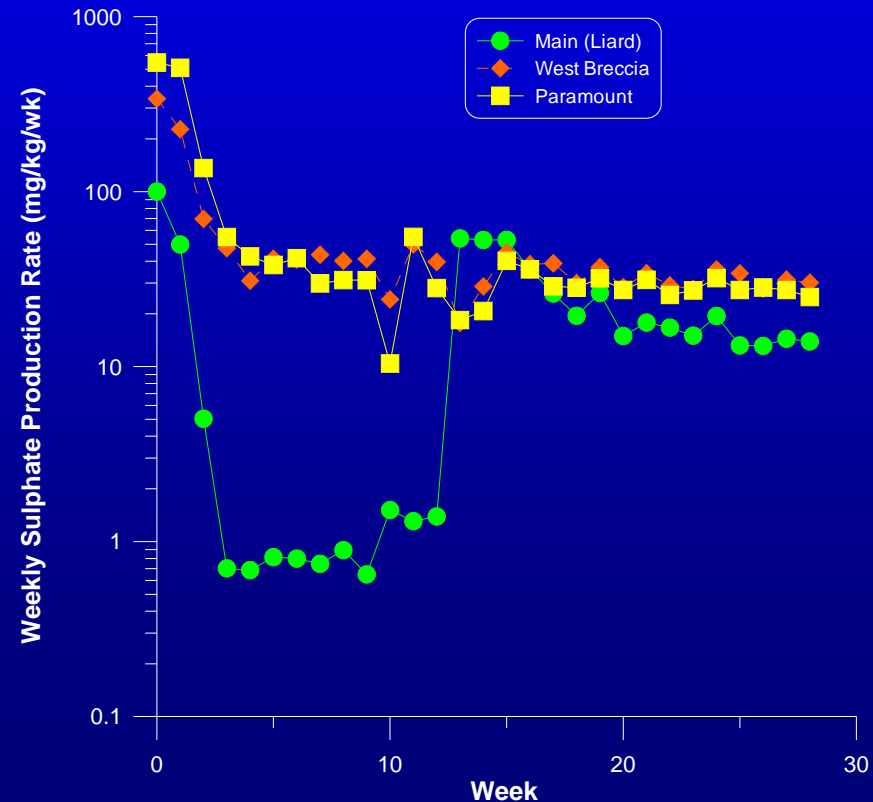
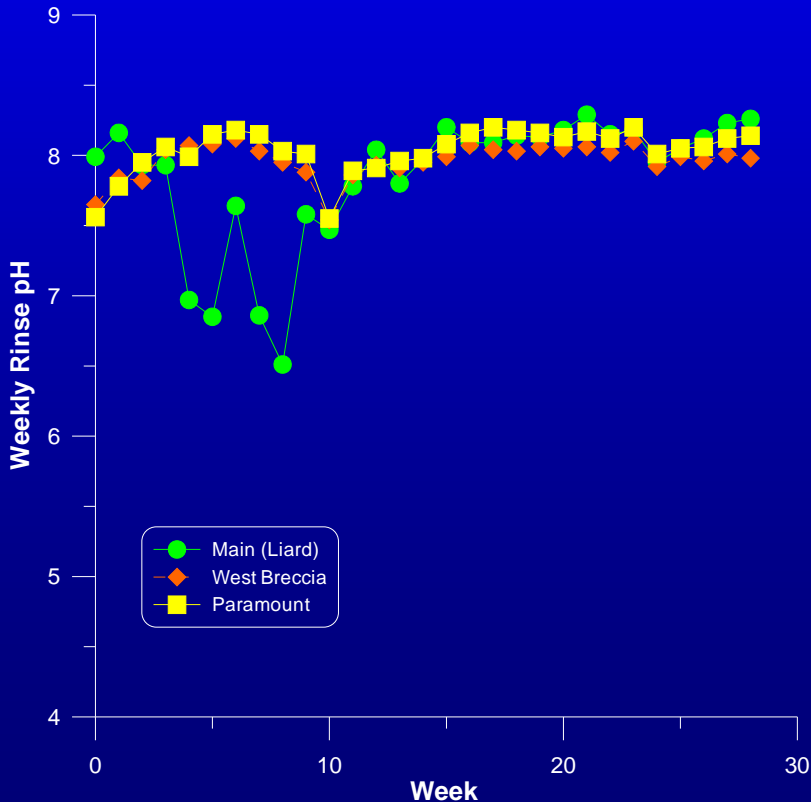
As part of metallurgical testing for the Schaft Creek Project in 2007, the aqueous phase (the “supernatant”) was separated from the tailings solids, and analyzed. Overall, the supernatants were near-neutral calcium-sodium-potassium-sulphate waters. Alkalinity was relatively low, indicating relative low pH-buffering capacity, but greater than acidity.

Examples of Aqueous Concentrations in the Tailings Supernatants for the Schaft Creek Project, from the 2007 Metallurgical Testwork

<u>Parameter (mg/L unless noted)</u>	<u>Main Zone</u>	<u>Paramount</u>	<u>West Breccia</u>
pH (pH units)	8.35	7.78	6.83
Total Alkalinity	36.8	18.6	20.7
Sulphate	191	856	397
Dissolved Aluminum	0.378	0.071	0.154
Dissolved Copper	0.00022	0.00186	0.00049
Dissolved Calcium	24.3	318	142
Dissolved Selenium	0.00408	0.00714	0.00839
Dissolved Zinc	<0.001	<0.005	<0.002

# Tailings Humidity Cells

Solid-phase geochemistries of the three tailings samples were similar to rock, which is why they were included in the previous rock diagrams. All three were predicted to be net neutral, with low total sulphur of 0.08-0.20%S and high NP (calcite and dolomite). After more than a half year (and still going), the tailings cells have remained near neutral with respectable ongoing sulphide oxidation. In the first 10 weeks, sulphide oxidation in the Main Tailings was very low, so its pH more closely reflected that of the deionized rinse water (~pH 6).



# Recommendations from the Phase 2 ML-ARD Study

# Phase 2 Recommendations

- Recommendations for Future ML-ARD Studies
  - The specific carbonate and sulphide minerals in Schaft Creek rock should be better identified (“Advanced Mineralogy”). This has already been done on samples of Schaft Creek tailings, which showed carbonate was mostly calcite and dolomite, and sulphide was pyrite.
  - Three-dimensional modelling, possibly including geologic, alteration, and/or assay data, should be undertaken by Copper Fox Metals Inc. Total sulphur and available NP should be modelled separately, then locally combined to calculate Adjusted TNPR. In this way, the spatial distribution of ARD categories, the year-by-year production of net-acid-generating and net-neutralizing rock, and the potential to segregate ARD rock during routine mining can be assessed. This may require additional ABA analyses, at the discretion of the modeller.

## Phase 2 Recommendations (cont.)

- Recommendations for Future ML-ARD Studies (continued):
  - Laboratory-based humidity cells should be initiated on various types and ARD categories of Schaft Creek rock. These will provide bulk reaction rates under standardized conditions, to allow scaling of rates to full-scale conditions. Nine such cells have already been started for Schaft Creek rock, and three tailings cells are continuing.
  - On-site leach tests should be started after spring thaw in 2008. These tests, each with hundreds of kilograms, will provide data for larger-scale equilibrium conditions.
  - Water quality predictions should be developed for various drainages, including tailings discharge and seepage, waste rock runoff, pit walls, and rock exposed during road and airstrip construction.

**ML-ARD Work Already Underway**

# ML-ARD Work Already Underway

- More detailed (“advanced”) mineralogy has been carried out. Rietveld XRD was conducted on 21 samples from the various NP groups and dominant rock units, with 9 of these 21 also submitted for visual petrographics.
  - Most of the samples were predominantly plagioclase, quartz, and clinocllore, typically 50-90% combined.
  - No sulphide minerals were detected in many samples, because of the low sulphur levels. Where sulphide was detected, it was pyrite.
  - Carbonate mineralogy varied by sample, with calcite, dolomite, and ankerite being dominant in various samples.
- Nine humidity cells containing rock have started. There are three cells from each of the three ore zones, containing various rock units and various levels of geochemical concentrations.

THE END