Evaluation of Factors Affecting Porphyry Mine Drainage Chemistry

Stephen Day and Kelly Sexsmith, SRK Consulting (Canada) Inc.

20th ANNUAL BRITISH COLUMBIA-MEND ML/ARD WORKSHOP

"Challenges and Best Practices in Metal Leaching and Acid Rock Drainage"

"Building and Using Drainage Chemistry Datasets for Analog Sites"

Acknowledgements

Building analog datasets involves a lot of effort:

- Mining companies and others who sponsor the work.
- Water samplers.

- Mine operators and regulators who provide data.
- Colleagues who organize, QA and interpret the data.

- Imperial Metals, Red Chris Project

srk consulting

Today…

1. The premise of the analog approach to drainage chemistry prediction
2. Building useful analog drainage chemistry datasets.
3. Learning from analog databases - Case example: BC porphyry dataset.

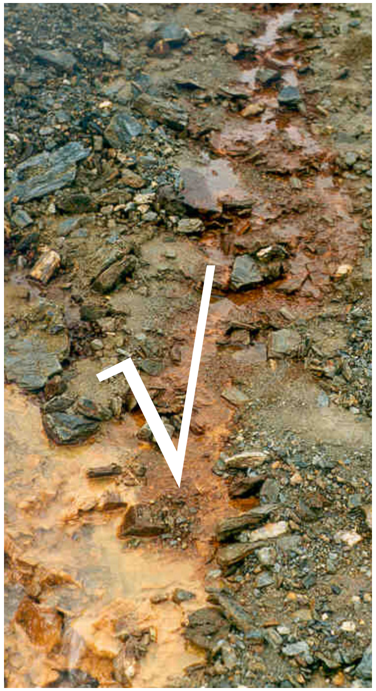
The Premise

Plumlee, G.S., Smith, K.S., Montour, M.R., Ficklin, W.H., and E.L. Mosier, 1999. Geologic Controls on the Composition of Natural Waters and Mine Waters Draining Diverse Mineral-Deposit Types. In: L.H. Filipek and G.S. Plumlee (Eds.), The Environmental Geochemistry of Mineral Deposits, Part B: Case Studies and Research Topics, Reviews in Economic Geology Vol. 6B, Society of Economic Geologists, Inc., 373-432.

- "…..static and kinetic methods are widely used to help predict the compositions of mine waters, they have several potential limitations.
- "another approach to mine-drainage prediction…. is one in which the compositions of existing mine waters draining geologically-similar deposit types in similar climates are measured empirically."

The Premise

- We have a much better likelihood of making accurate predictions from full-scale conditions than laboratory tests.



Building Analog Datasets

- Overall objective → types of data
- Sources of data.
- Minimum parameter lists.
- Data quality.

The overall objective should not only be to compile statistics on drainage chemistry….

but to understand water-rock-atmosphere-biosphere interactions.

- Analog data should be contact water chemistry.

Types of Data

- Individual results, not summary statistics.
  - Important for internal chemical consistency

- Full scale data obviously preferred, but what about smaller scale test data?

Types of Data – Other than Full Scale

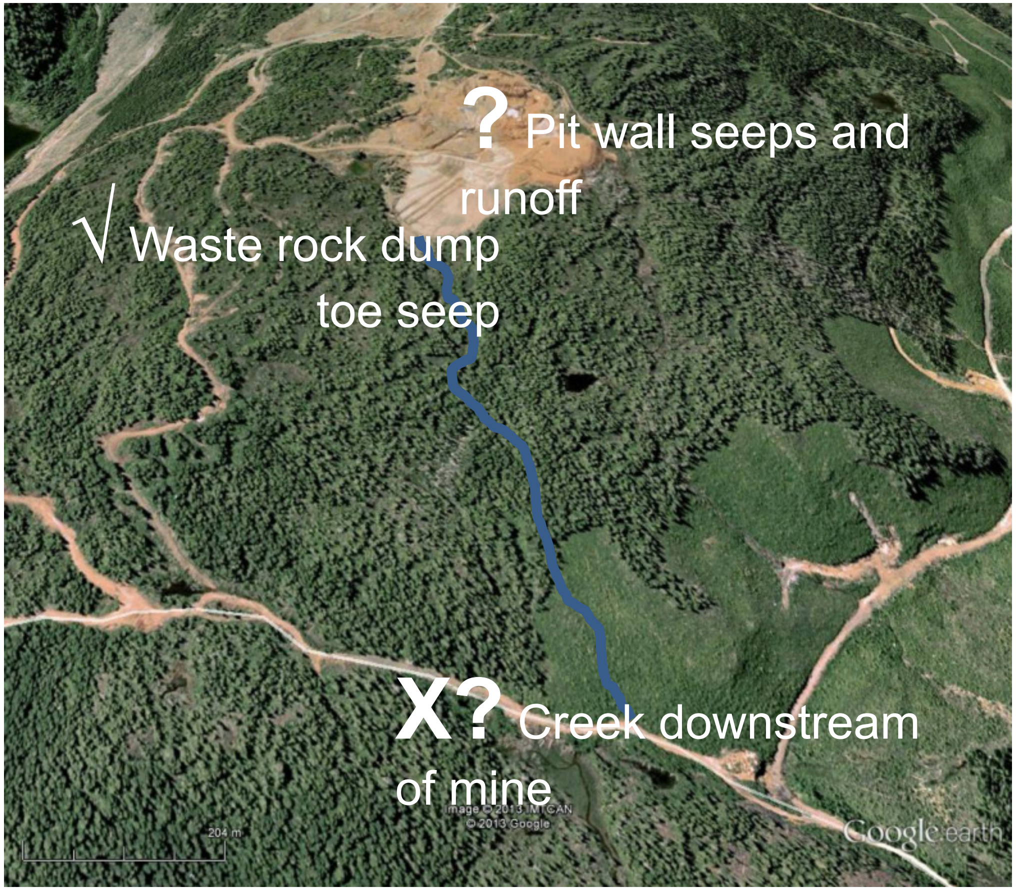
- Lab data:
  - Leach tests (e.g. SFE, MWMP), humidity cell and column leachates, columns are contact water chemistry but are highly dilute.
- Field tests:
  - Barrel tests, tests pile are contact water chemistry but have short flow paths compared to full scale.

srk consulting

Types of Data – Other than Full Scale

- Highly mobile ions (e.g. sulphate).
  - Small scale tests (including field tests) are affected by high dilution ratios and short flow paths.
- Heavy element cations (e.g. copper).
  - Small scale field tests provide useful contact water chemistry for non-acidic waters.
- Standard laboratory procedures can be modified to provide full scale analog data
  - Slower water application
  - Repeated contact (e.g. flow path experiments).

Types of Data – Full Scale



Known diluted waters are avoided.

Diluted Waters

X Underground mine drainage

X Pit lake

X Tailings pond & seeps

Types of Data – When to Sample?

Winter conditions – less dilution

Sources of Data

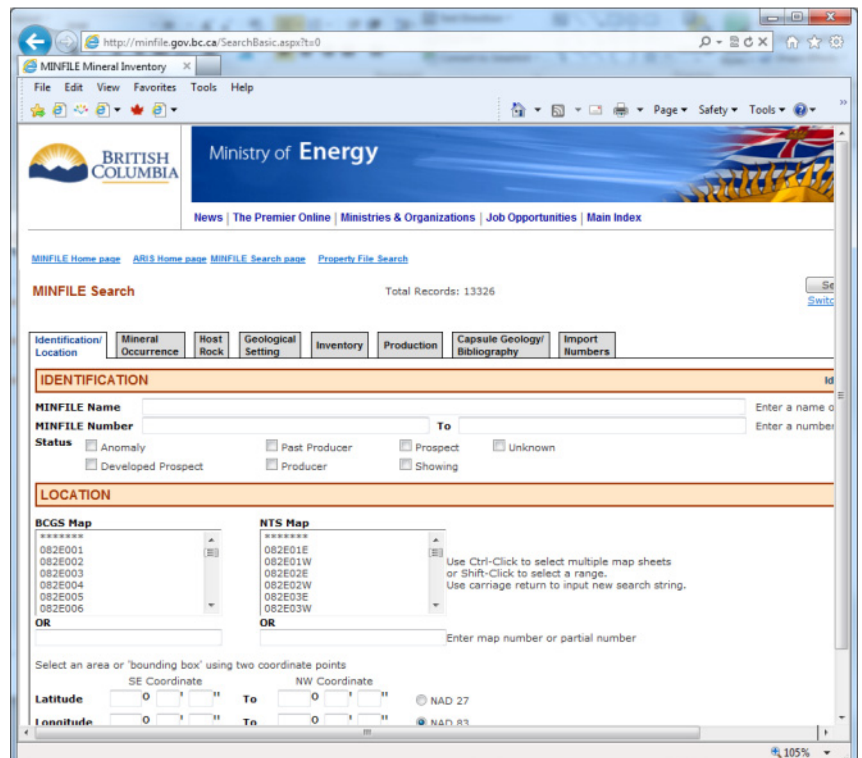
- Directly from mine site personnel.
- Environmental monitoring reports.
  - Often compliance points rather then near source.
- MEND reports
- Publications
  - Statistical summaries and charts

Minimum Parameter Lists and Data Quality

- Reliable field pH measurements.
- Complete major elements (alkalinity, sulphate, Ca, Mg, K, Na)
  - For acidic waters, add Fe, Al.
  - Ion balances (±10%).
- Other potentially important ions depending on setting
  - Cl, NO_3
- Filtered water analyses.
- Handling detection limits
  - Historical high detection limits add noise to datasets.
  - Accept only lowest detection limits.

Supporting Data

- Mineral deposit classification
- Geological setting
- Mineralogical and geochemical characteristics



Analog Datasets

- Porphyries (e.g. Island Copper, BC)
- Coal (e.g. Tumbler Ridge area, BC)
- Kuroko-type volcanogenic (e.g. Britannia Mine, BC)
- Sedimentary exhalative (e.g. Anvil Range Complex, Yukon)
- Pluton-related Au (e.g. Brewery Creek Mine, Yukon).
- Layered ultramafic (e.g. Duluth Complex, MN)
- Unconformity roll front uranium (e.g. Rabbit Lake, SK)

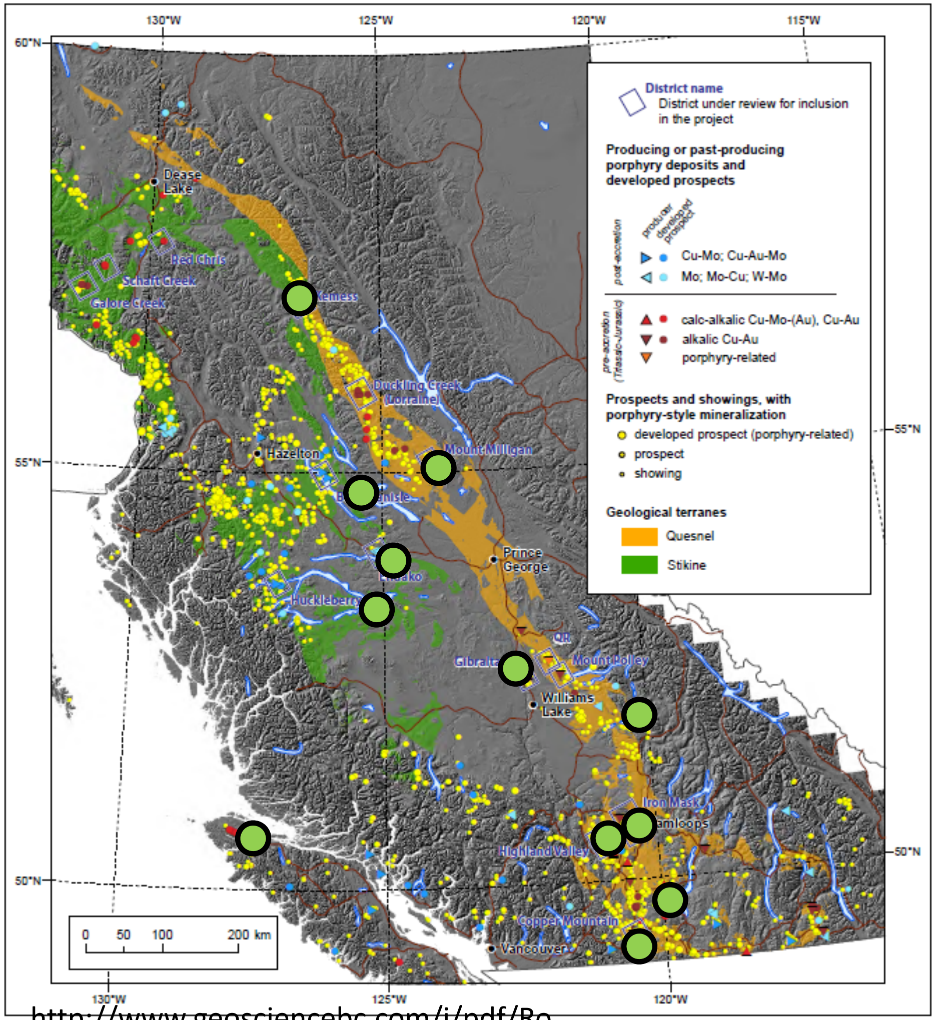
Learning from Analog Datasets

- pH is usually the strongest master variable – examine data in context of pH (Plumlee et al. 1999).
- Interpret in context of known mineral solubilities.
- Interpret slopes of pH vs concentration.
  - Low pH: $M(OH)_3 + 3H^+ \leftrightarrow M^{3+} + 3H_2O$
    - Equilibrium Constant, $k = \frac{[M^{3+}]}{[H^+]^3}$
    - $Log[M^{3+}] = -3pH + k$, Slope of -3 on log-pH graph

srk consulting

Learning from Analog Datasets

- Porphyry mines (●)

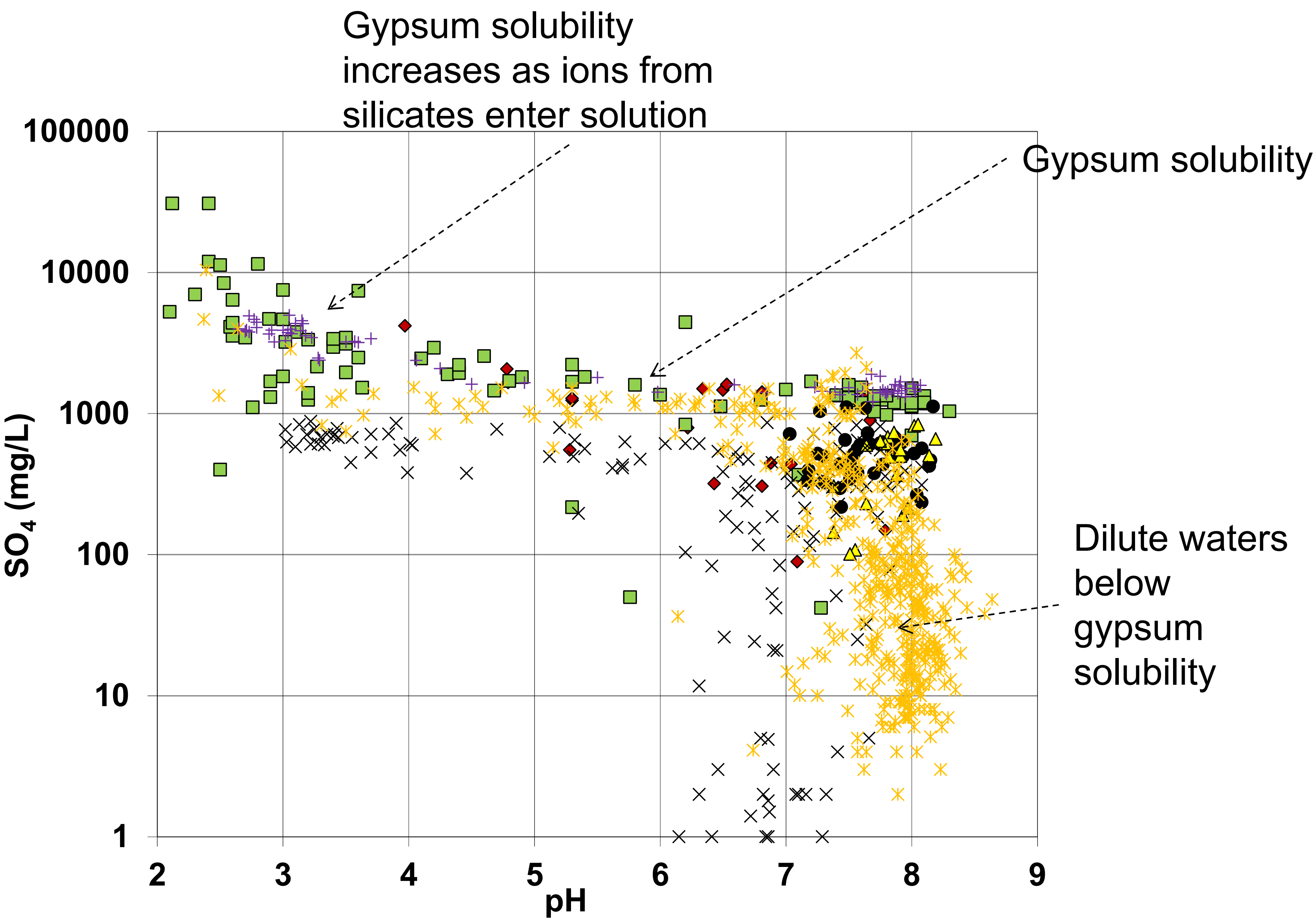


http://www.geosciencebc.com/i/pdf/Roundup2011/Devine_Roundup11.pdf

Learning from Analog Datasets

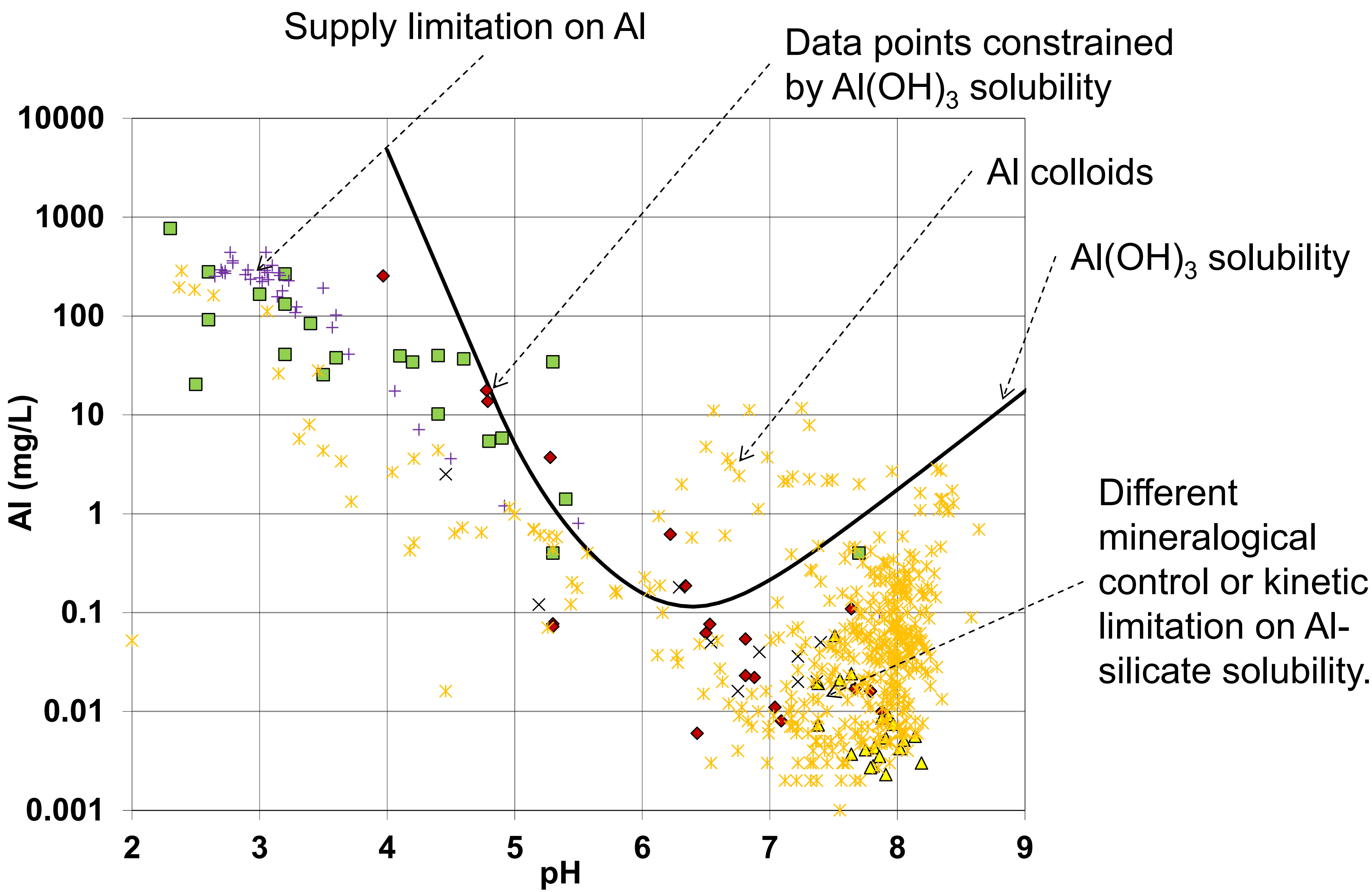
- Examples from the porphyry database
  - Strong mineralogical control – Sulphate
  - Strong mineralogical control with pH – Aluminum
  - Influence of host rock sulphide mineralogy - Zinc
  - Mineralogical control unknown but pH control – Arsenic.

BC Porphyry Dataset - Sulphate



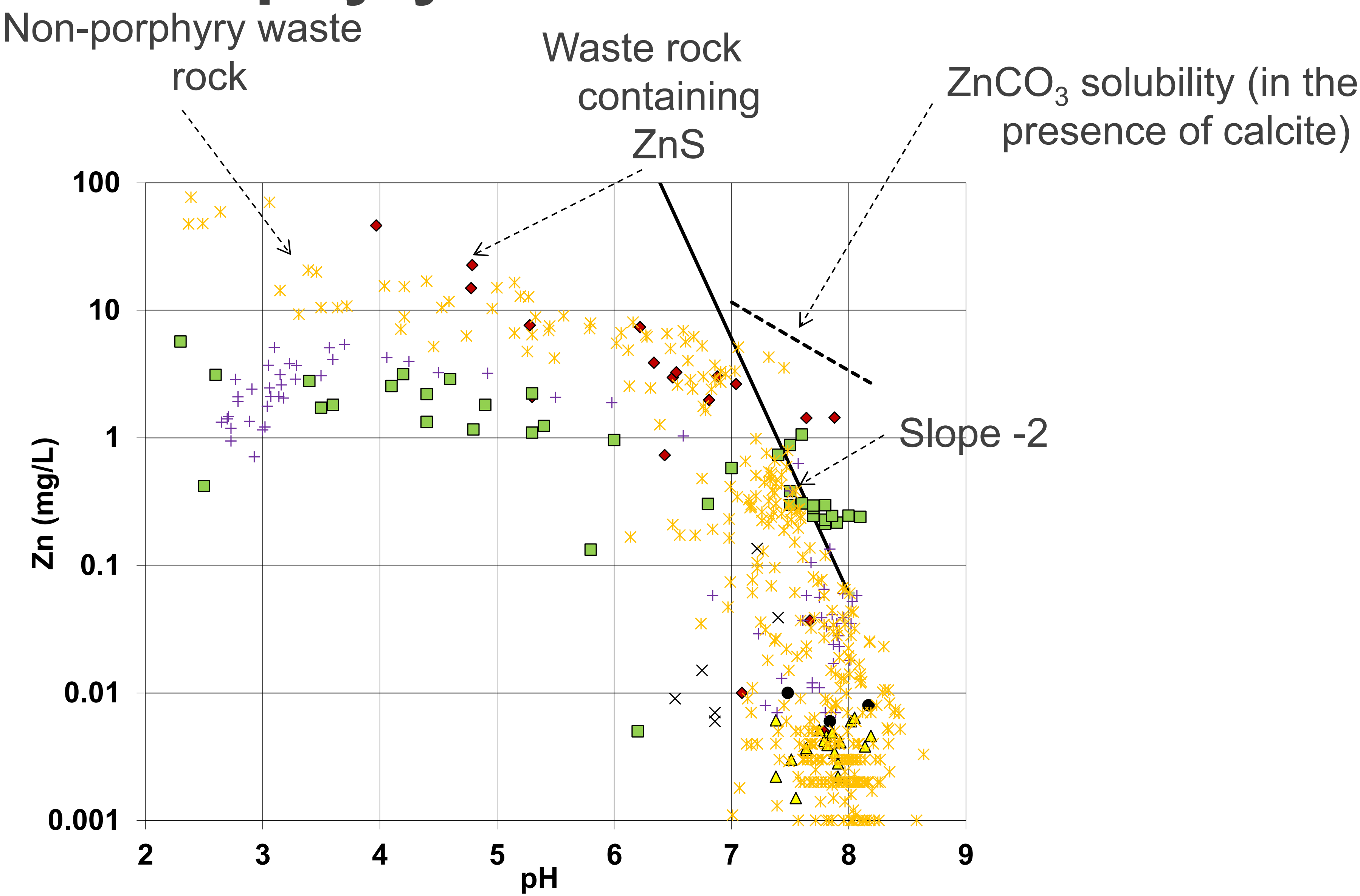
srk consulting

BC Porphyry Dataset - Al



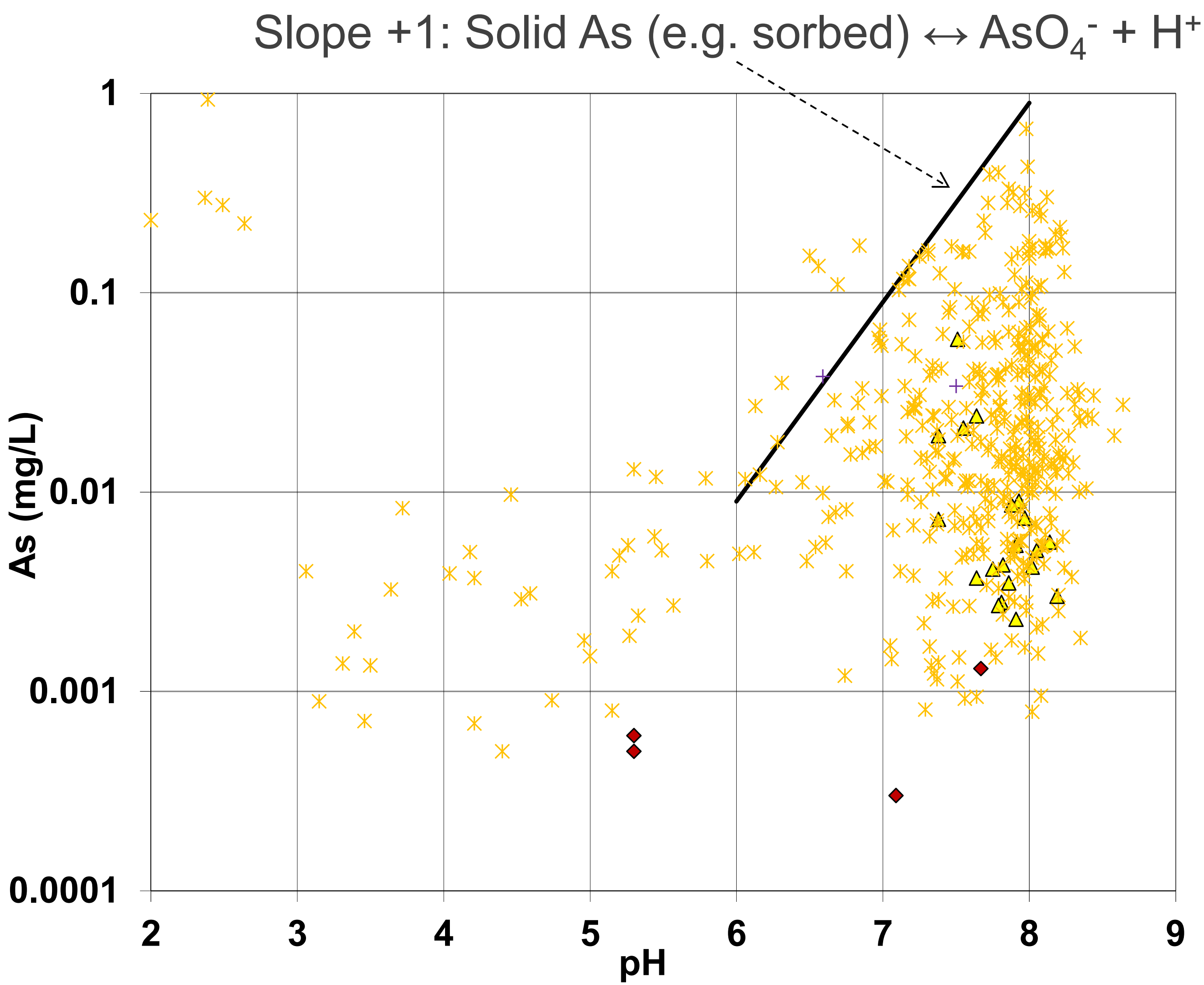
srk consulting

BC Porphyry Dataset - Zn



srk consulting

BC Porphyry Dataset - Arsenic



srk consulting

Conclusions

Analog datasets

- Selectivity about types of data – contact water.
- Minimum parameter lists.
- Quality control – ion balances, detection limits.
- Awareness of sources.
- Interpretation in pH context.

BC Porphyry database

- Consistent with primary mineralogy and mineralogical controls.