Diavik Waste Rock Project

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Acid generating potential and metal attenuation in low sulfide, waste-rock test piles

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Introduction

Type I test pile

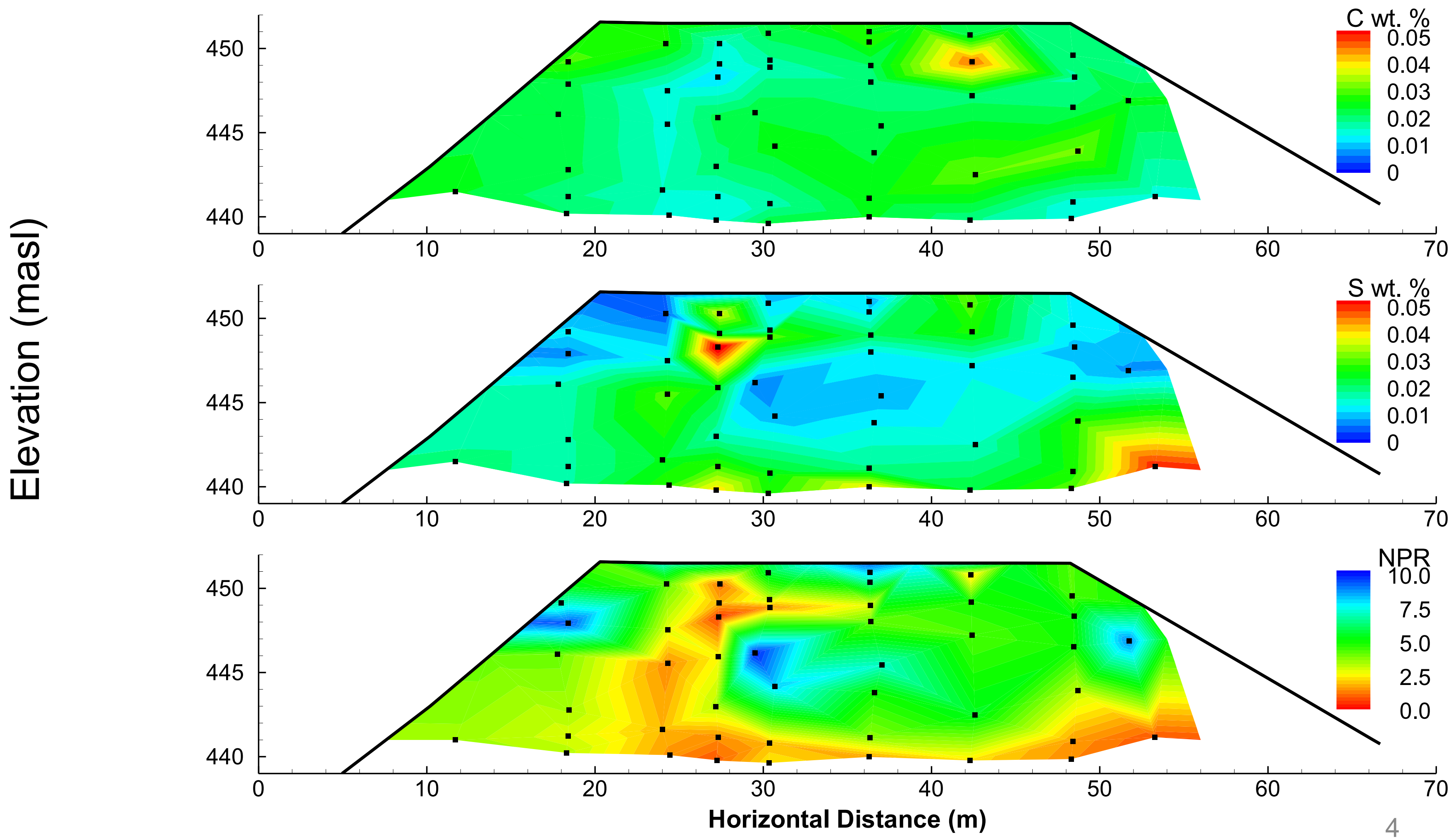
- Type I rock:
  - Granite
  - Granite pegmatite
  - Biotite schist
- Sulfide content: < 0.04 wt.% S

- Type I test pile (Smith et al., 2013)
  - Average S Content: 0.035 wt. % S (0.0028-0.26 wt.% S)
  - Average C Content: 0.033 wt. % C
  - Average NPR: 12.2

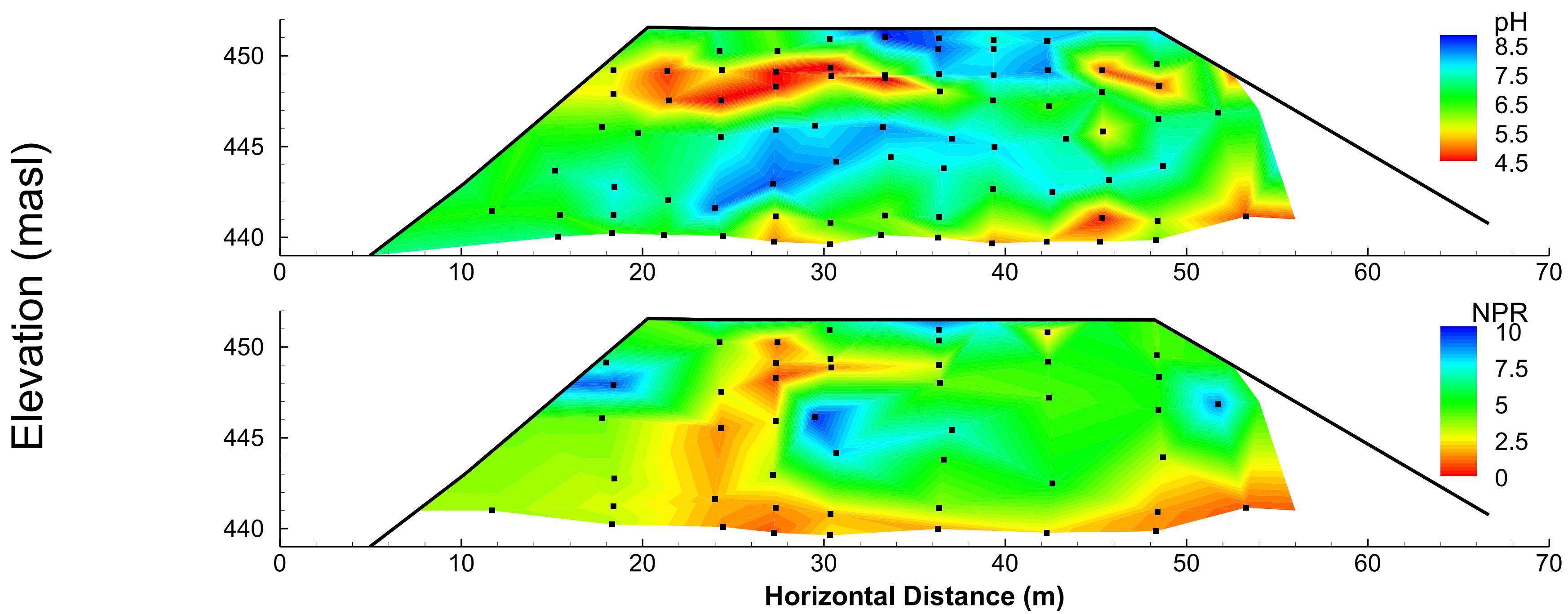
Deconstruction of the Type I test pile

- Deconstructed in 2014
- Samples collected from over 600 discrete locations
- Pore water extracted via centrifugation
- C and S analysis
- Mineralogical investigation

15 m cross section – S, $CaCO_3$ and NPR



15 m cross section – NPR and pH

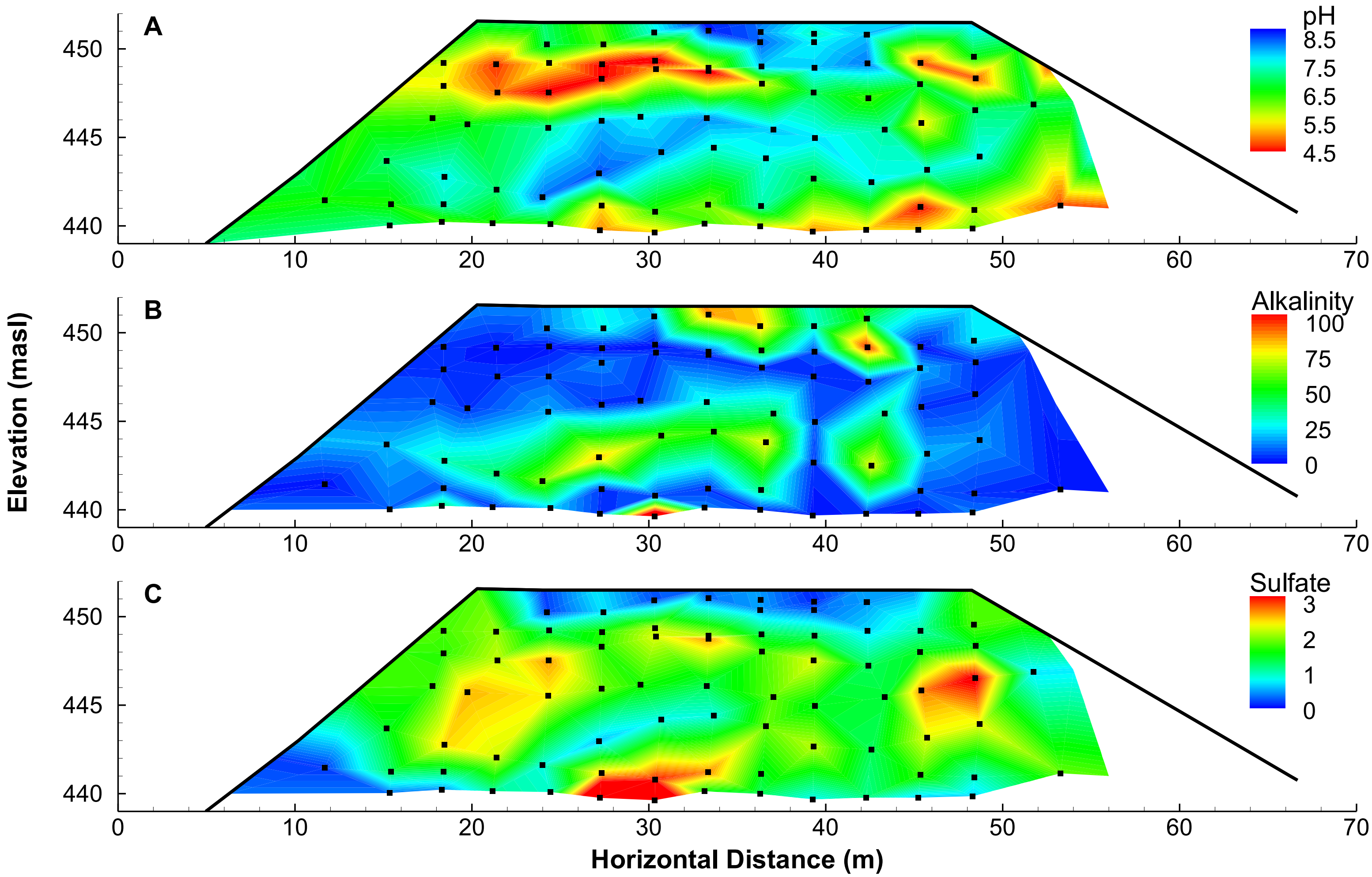


15 m cross section – pH, alkalinity, and SO_4^{2-}

pH

Alkalinity ($mg\ L^{-1}$)

SO_4^{2-} ($g\ L^{-1}$)

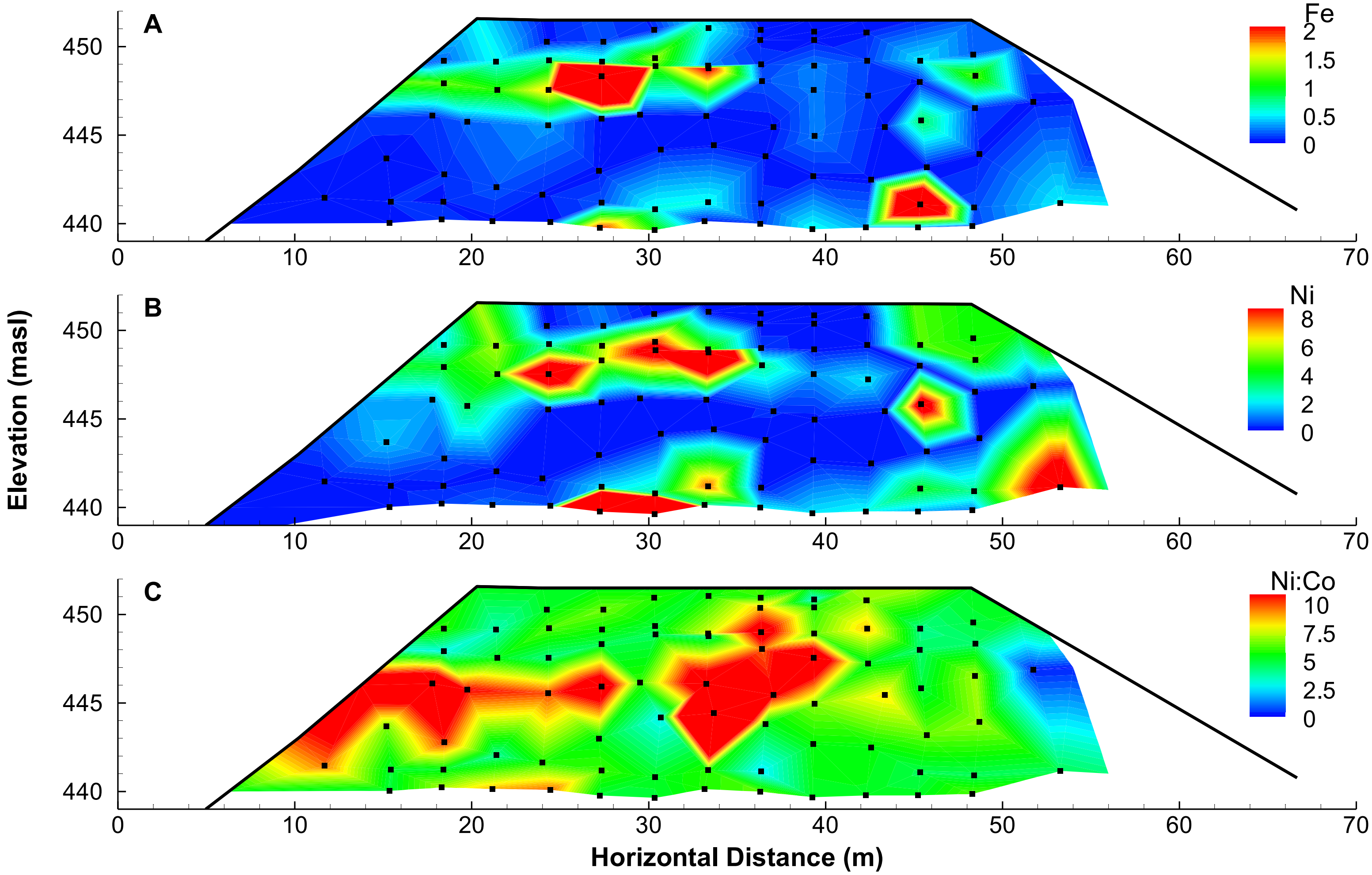


15 m cross section – Fe, Ni, Ni:Co

Fe ($mg\ L^{-1}$)

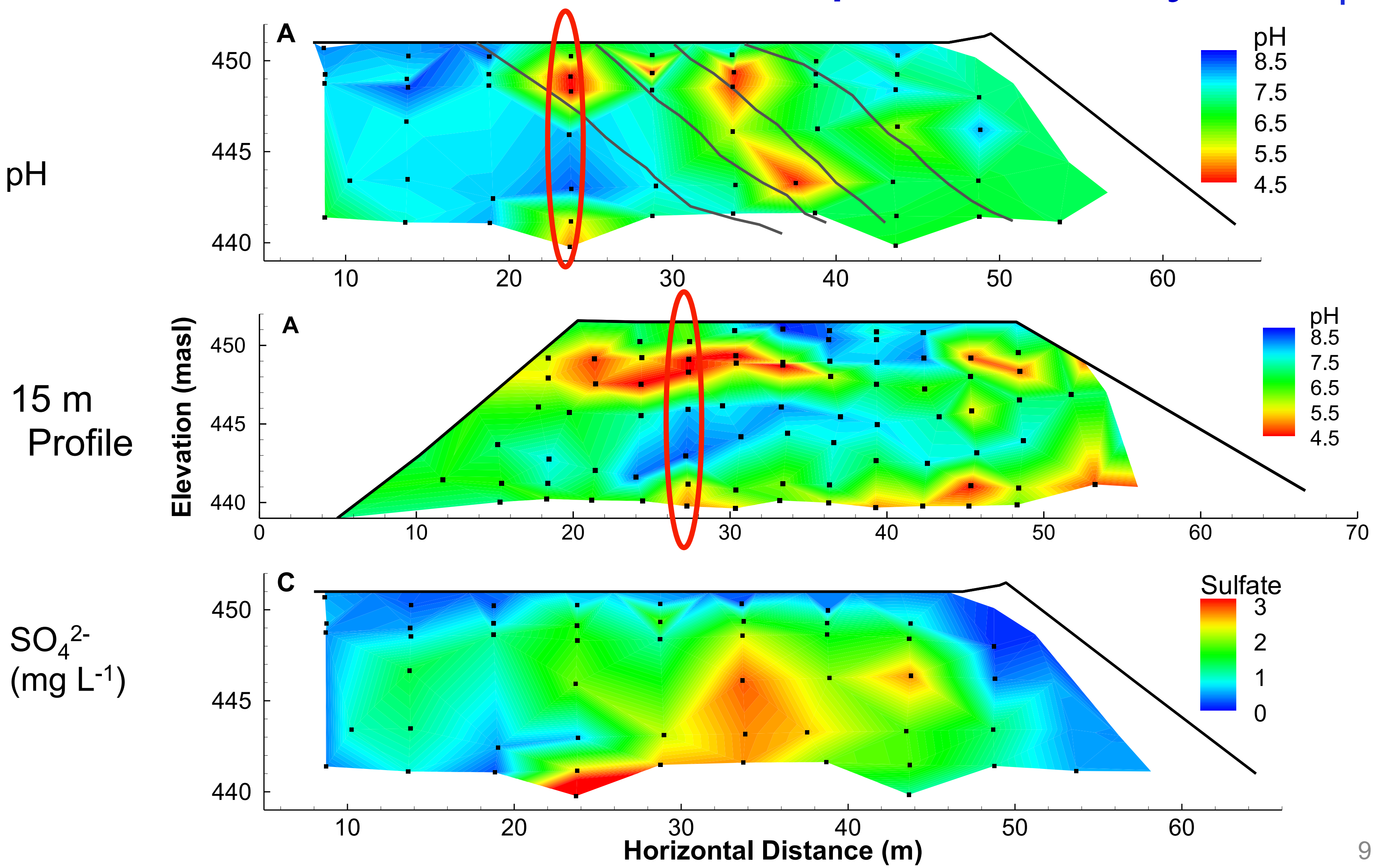
Ni ($mg\ L^{-1}$)

Ni:Co

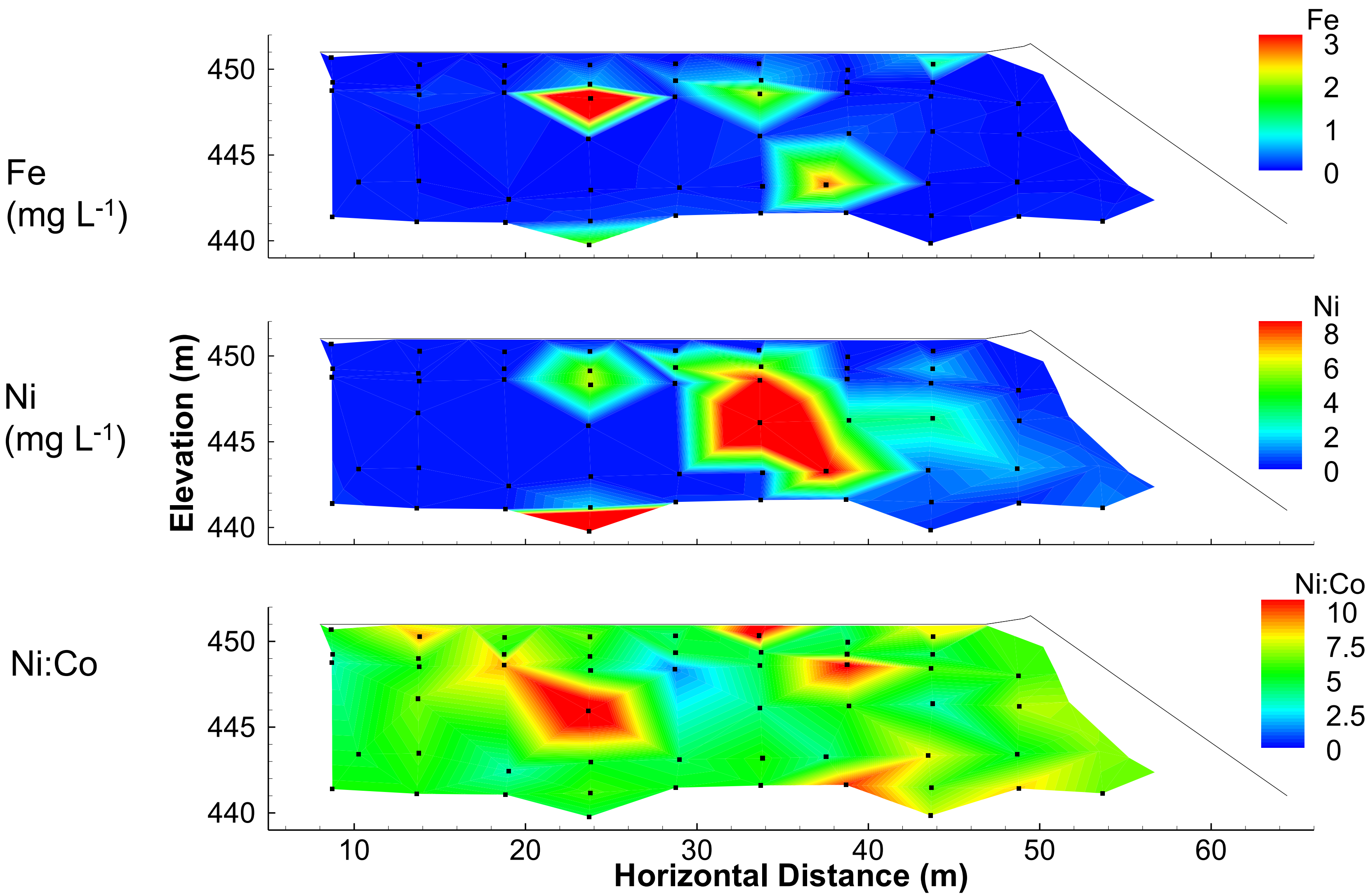


Transverse cross section

Transverse cross section – pH, alkalinity, SO_4^{2-}



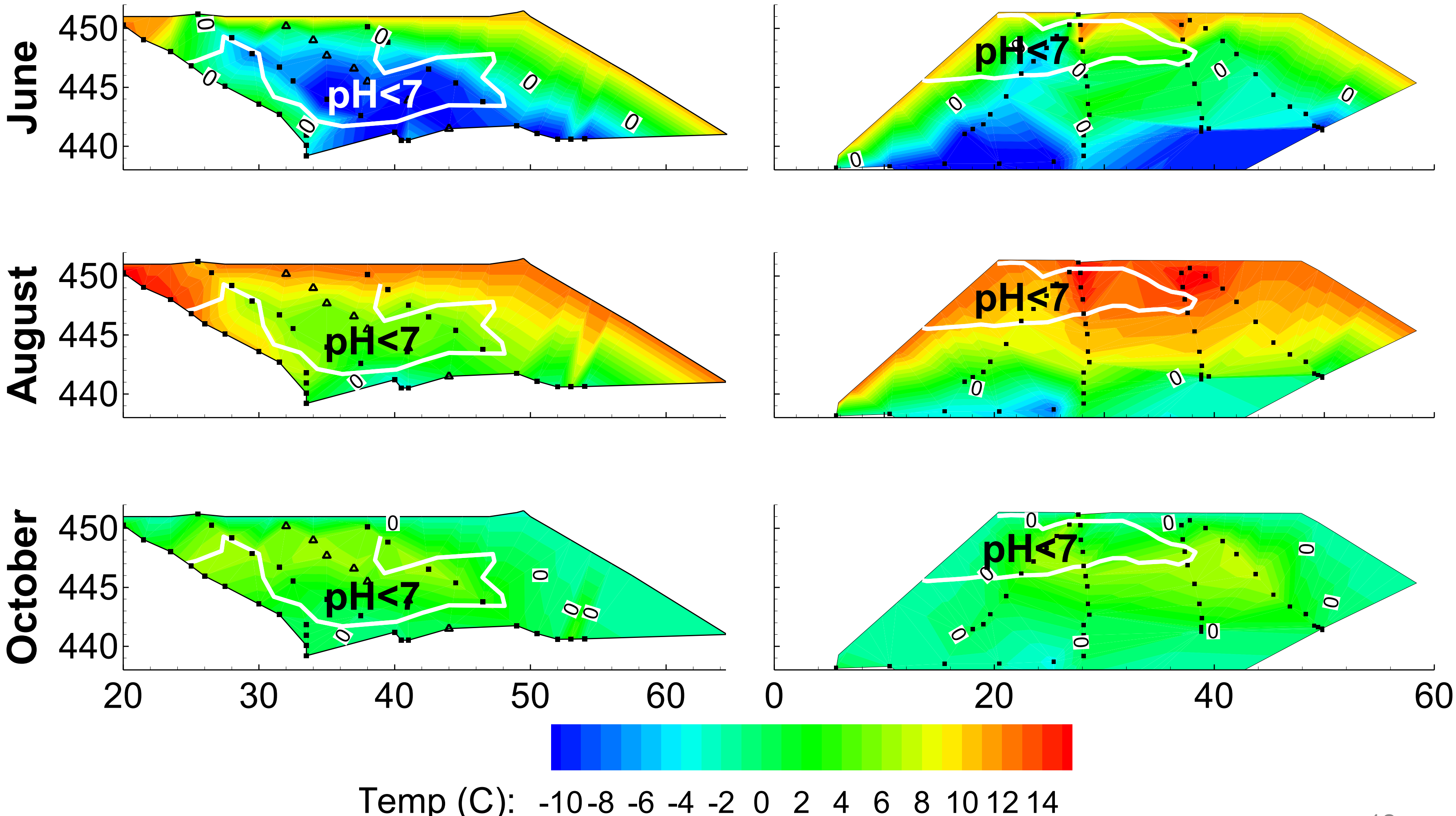
Transverse cross section – Fe, Ni, Ni:Co



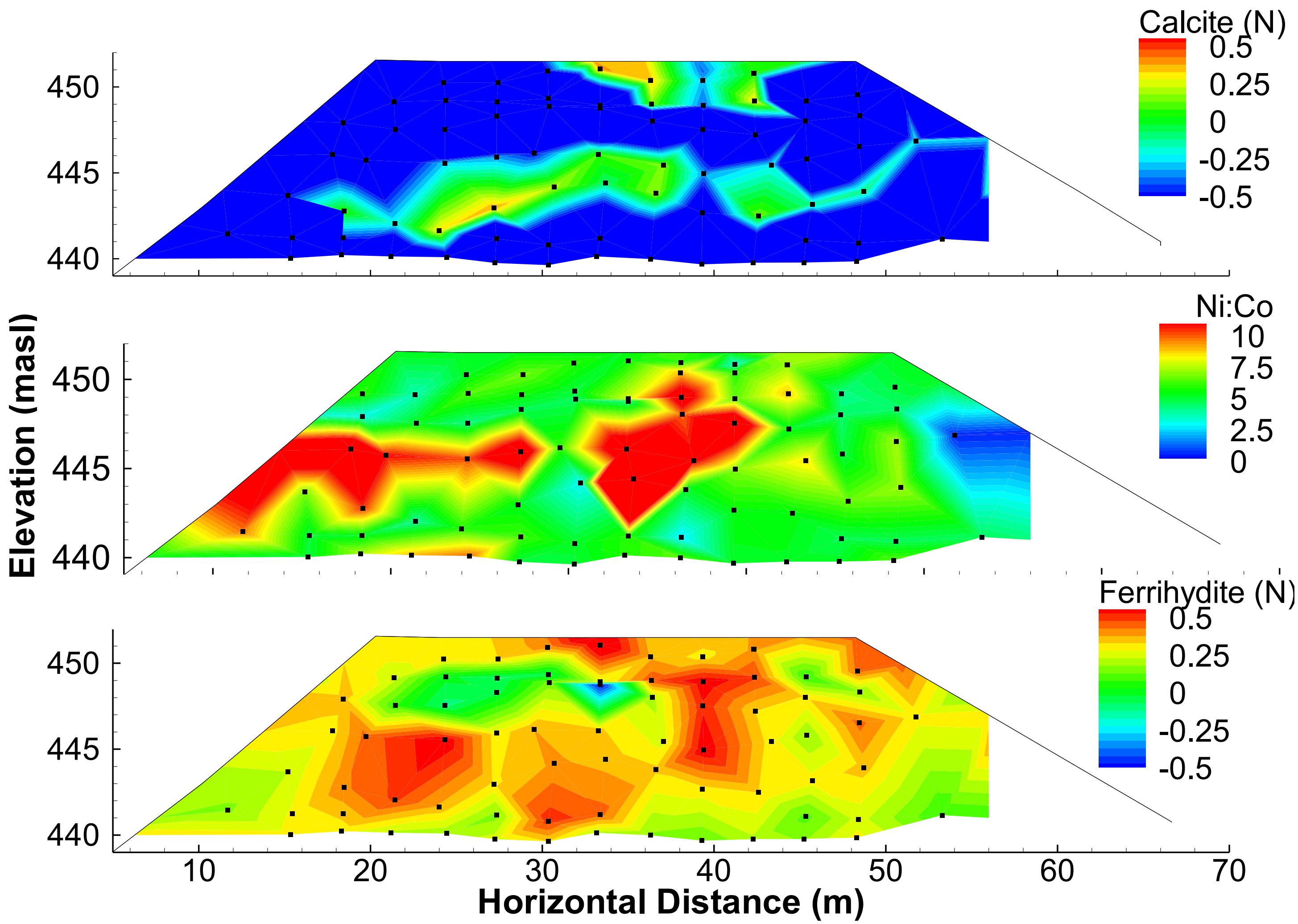
Temperature dependence of S oxidation

- T controls both abiotic and biotic S oxidation (Belzile et al., 2004)
- S oxidation ceases ~ -10° C (Elberling, 2005, Meldrum et al., 2001)
- Inhibited S oxidation at low T may reduce acid generating rates to a greater extent than acid consuming rates (Ahonen and Tuovinen, 1992)

Temperature



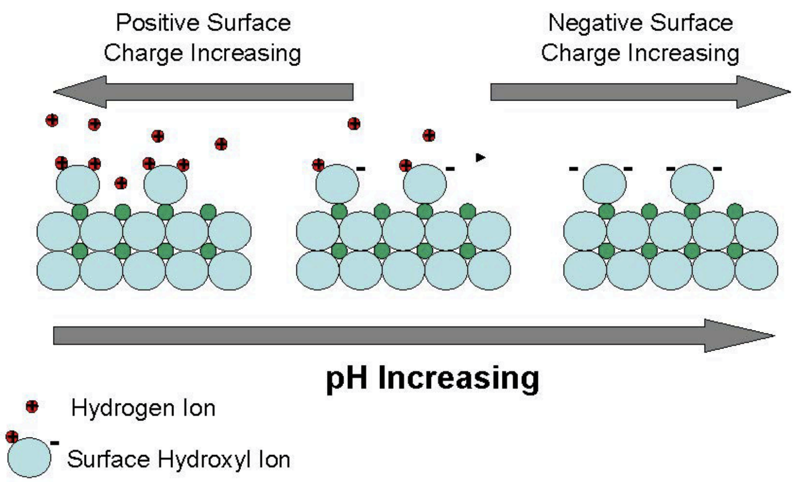
15 m cross section – saturation index

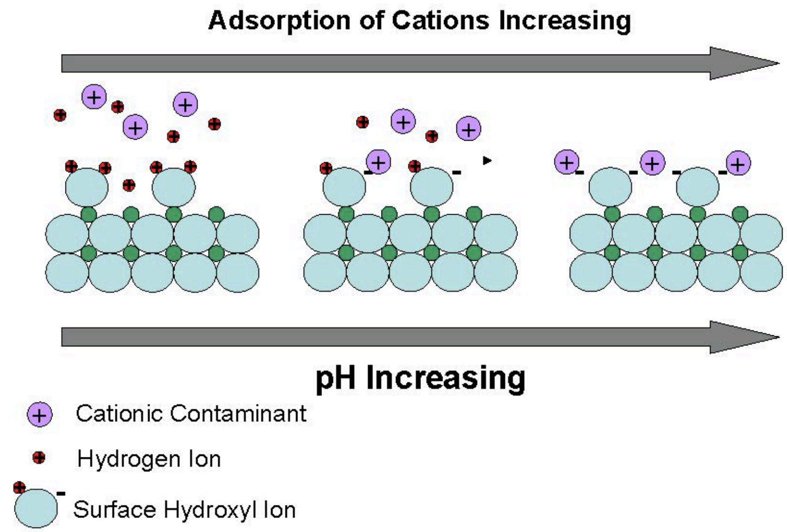


Cation sorption as a function of pH

- Excess H^+ at low pH results in net positive surface charge
- Desorption of H^+ occurs as pH increases

- Protons on hydroxide surface result in:
  - Positive surface charge at low pH
  - Negative surface charge at high pH





From: IRTC 2010

Surface complexation

- Ferrihydrite is an efficient scavenger of cations at pH~7
- Sorption occurs on strong and weak sites
- Extent of sorption can change from 0-100% over 1-2 pH units
- Constants determined experimentally

Cu: log k_{strong} 3.74, log k_{weak} 0.89

$$HFO\equiv OH + Cu^{2+} = HFO\equiv OCu^{+} + H^{+}$$

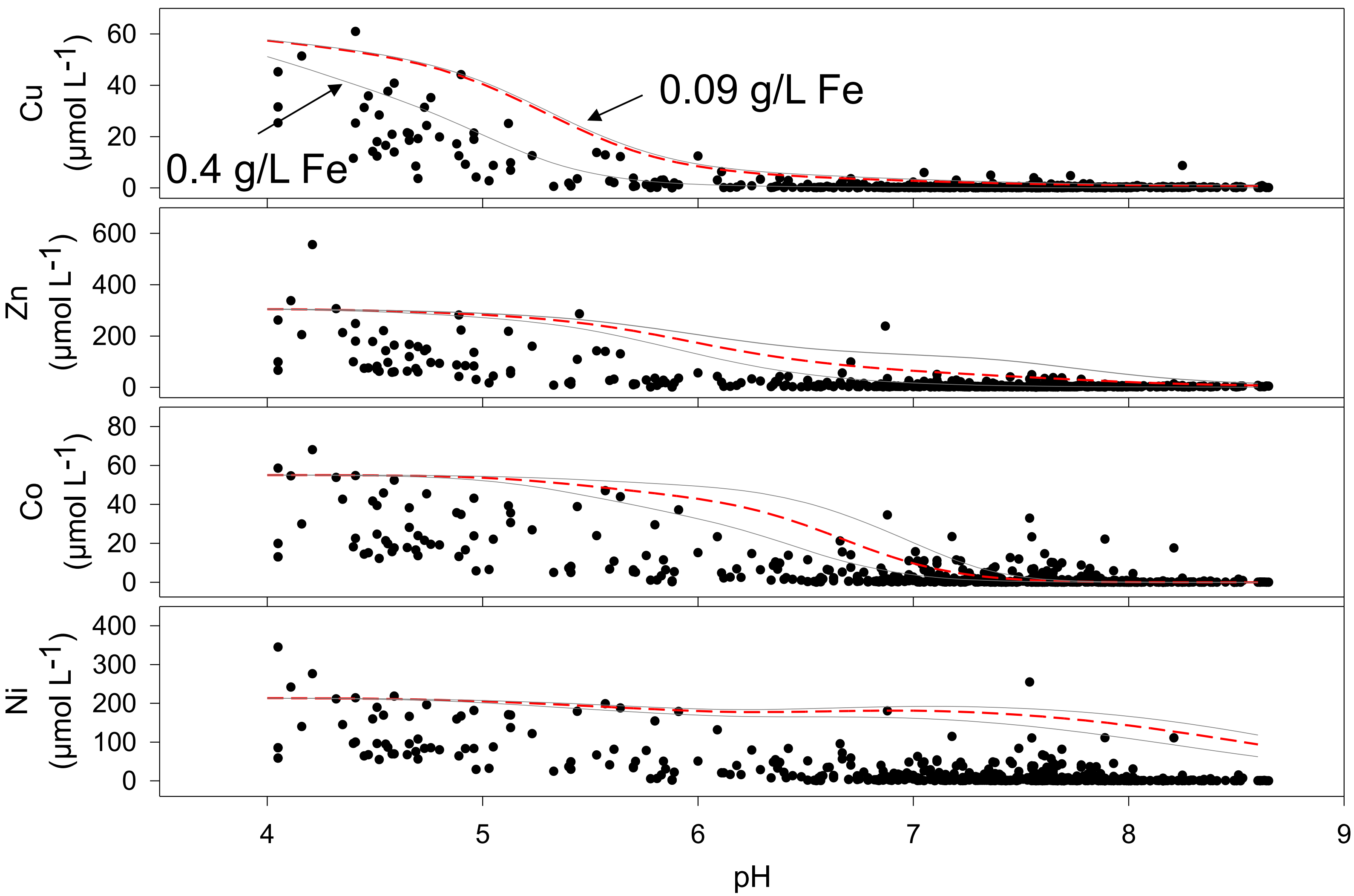
Zn: log k_{strong} 1.92, log k_{weak} -0.64

$$HFO\equiv OH + Zn^{2+} = HFO\equiv OZn^{+} + H^{+}$$

Co: log k_{strong} 1.32, log k_{weak} -1.54

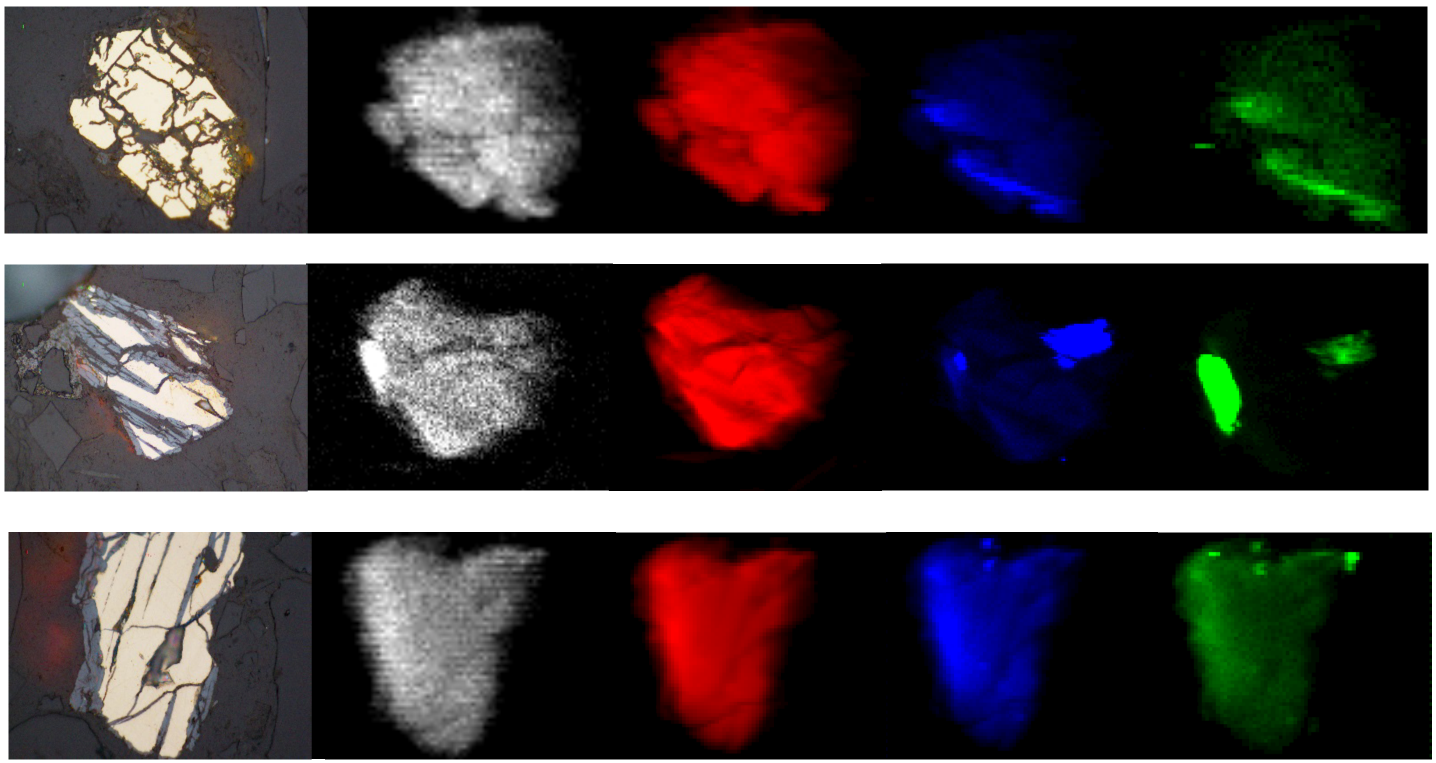
$$HFO\equiv OH + Co^{2+} = HFO\equiv OCo^{+} +$$

Adsorption isotherms



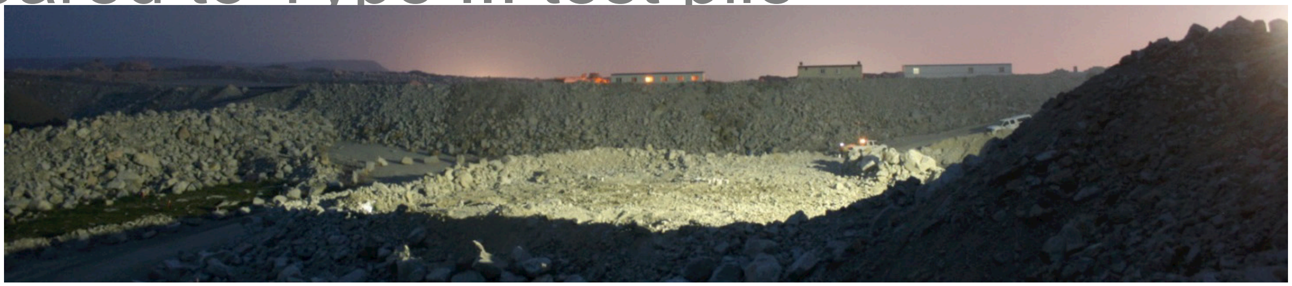
Synchrotron µ-XRF results

	Reflected light	S	Fe	Ni	Cu
1B02TWx15B pH 4.4					
1B03TW115B-dup pH 8.3					
1B06TW115B pH 5.0					

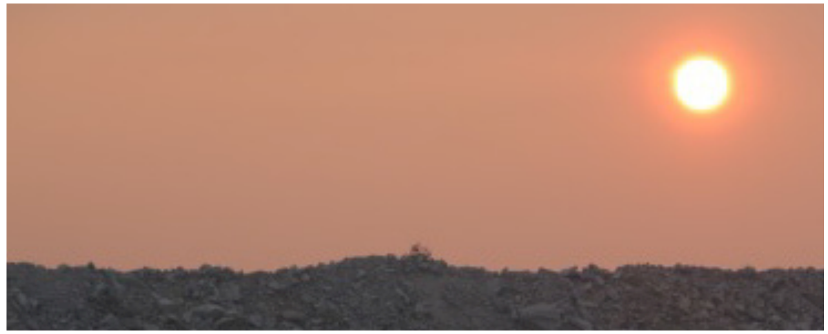


Conclusions

- Most samples (94%) NPR> 1, pH >5.5
- Heterogeneity of sulfide distribution contributes to development of isolated low pH regions
- Temperature affects sulfide oxidation rates
- Saturation wrt ferrihydrite coincides with sharp decreases in aqueous metal concentration
- Lower mass loading of metals and sulfate compared to Type III test pile



Questions?



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