Geochemical Characterization of Spilled Tailings from the Mount Polley Mine Dam Failure

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Acknowledgements

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- Colleen Hughes and the team at Mount Polley Mining Corporation
- SNC-Lavalin – Hazeltine Creek field sampling
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  - Trevor McConkey
- Minnow Environmental – lake sediment sampling
  - Pierre Stecko
- Golder Associates – overall coordination
  - Lee Nikl

Presentation Overview

1. Purpose of the study
2. Site geology and operational history
3. Sampling and analysis plan
4. Results
5. Discussion
6. On-going studies

1. Study Purpose & Approach

- As most are aware, the Mount Polley Mine (MPM) tailings dam failed on August 4, 2014 and tailings were released

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1. Study Purpose & Approach

MPM Location: 55 km north-east of Williams Lake, BC

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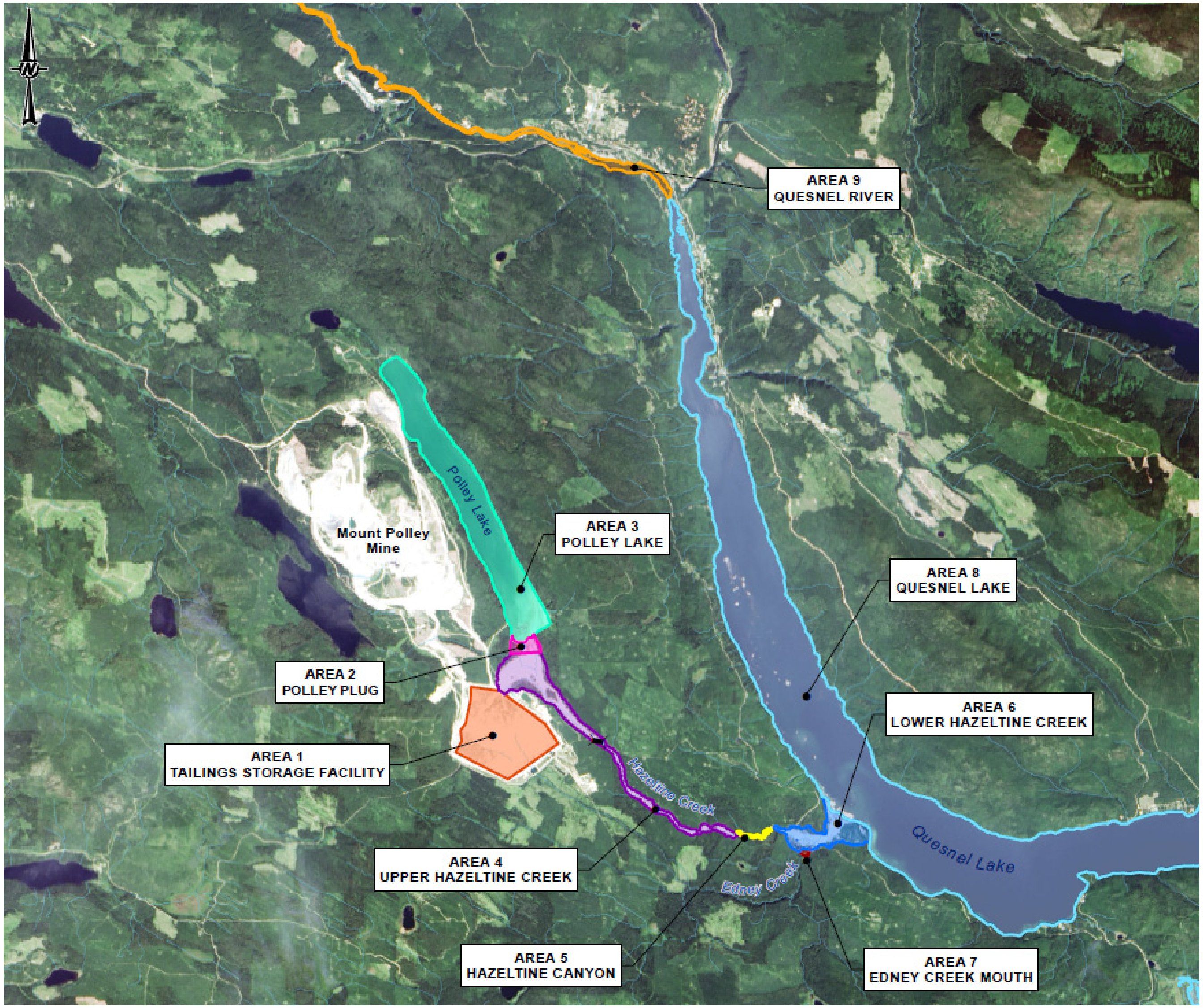
1. Study Purpose & Approach



Source: Golder (2015)

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1. Study Purpose & Approach

- Tailings were spilled along the banks and stream bed of Hazeltine Creek, Polley Lake, and Quesnel Lake.

- As part of remedial efforts by Imperial Metals Corporation, the metal leaching and acid rock drainage (ML/ARD) potential of the spilled tailings were assessed.

1. Study Purpose & Approach

- This presentation is a ‘highlights reel’ of publically available report:

- http://www.env.gov.bc.ca/eemp/incidents/2014/mount-polley/

1. Study Purpose & Approach

The study approach included the following components:

- Review existing data – site geology, operational history, etc.
- Develop geochemical conceptual model to guide sampling
- Develop and carry-out sampling and analysis plan

2. Site Geology and Operational History

- The MP deposit is classified as an alkalic copper gold porphyry (BC MINFILE No. 093A 008)
- The Mount Polley deposit is hosted within the Polley Stock that intrudes the Nicola Group volcanic rocks. It is variably altered and brecciated.
- The host rocks vary in composition from diorite to syenite (including monzodiorite, monzonite)

2. Site Geology and Operational History

- Rocks are composed primarily of plagioclase and alkali feldspar, with pyroxene, biotite and magnetite, and lesser garnet, epidote, calcite and chlorite. These rocks contain very little quartz.

- The main sulphide minerals are chalcopyrite ($CuFeS_2$) and pyrite (FeS_2)

- The main carbonate is calcite ($CaCO_3$), malachite ($Cu_2CO_3(OH)_2$) is also present

- A significant portion of the copper in the ore (i.e. upwards of 50%) is associated with a non-sulphide form near the surface.

2. Site Geology and Operational History

- Mine started operations in 1997, with a 5-year shut down in 2001 to 2005 due to low metal prices
- The main product is a copper sulphide concentrate
  - As a result, tailings are relatively depleted in sulphide minerals compared to ore
- Tailings deposition in the TSF included rotation of the discharge location along the embankments

3. Sampling and Analysis Plan

Conceptual Geochemical Model:

- Low ARD potential expected for tailings due to relatively low sulphide content of ore and recovery of copper sulphide

- ML potential indicated by presence of sulphide and other copper bearing minerals.

3. Sampling and Analysis Plan

- Conceptual model developed indicated that sampling needed to consider sub-aerial and sub-aqueous tailings
  - Oxidation of sulphides in sub-aerial tailings
  - Potential for subaqueous dissolution of secondary minerals due to low oxygen conditions (i.e. reductive dissolution)

3. Sampling and Analysis Plan

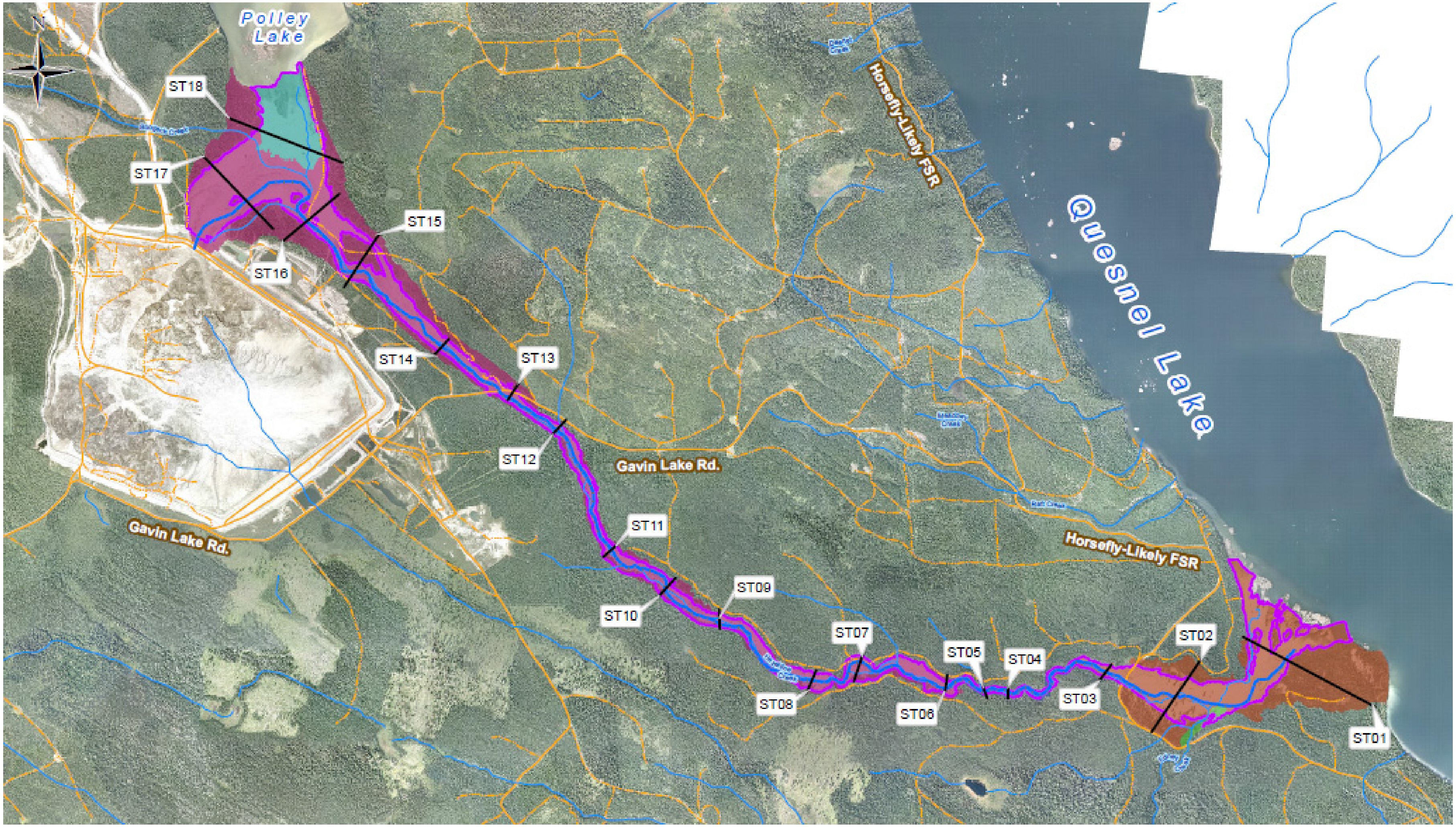
Sampling Methods

- Subaerial tailings – 18 transects along Hazeltine Creek with 68 samples in total
- Lake tailings – 78 sample from Polley and Quesnel

Analytical methods

- ML/ARD potential – mineralogy, acid-base accounting, metal analysis
- Trace element occurrence – sequential extractions
- Reactivity – kinetic tests (on-going)

3. Sampling and Analysis Plan



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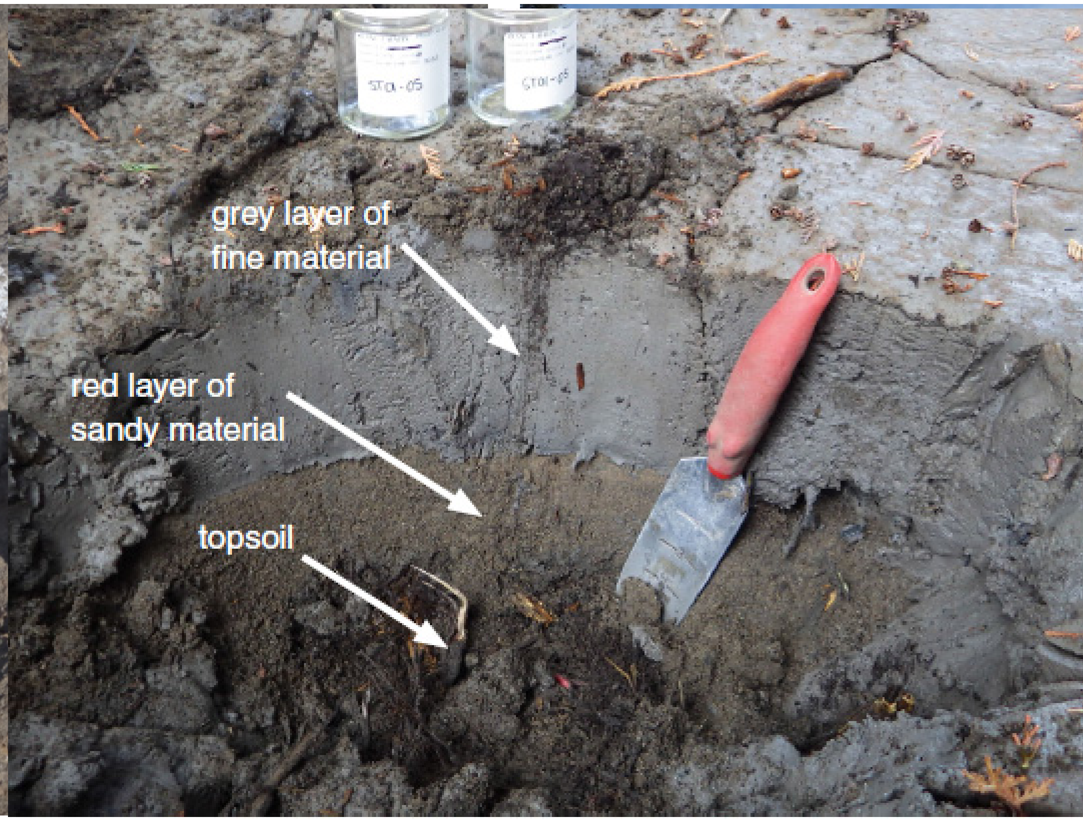
4. Results – Field Sampling

Grey tailings

Magnetite sands



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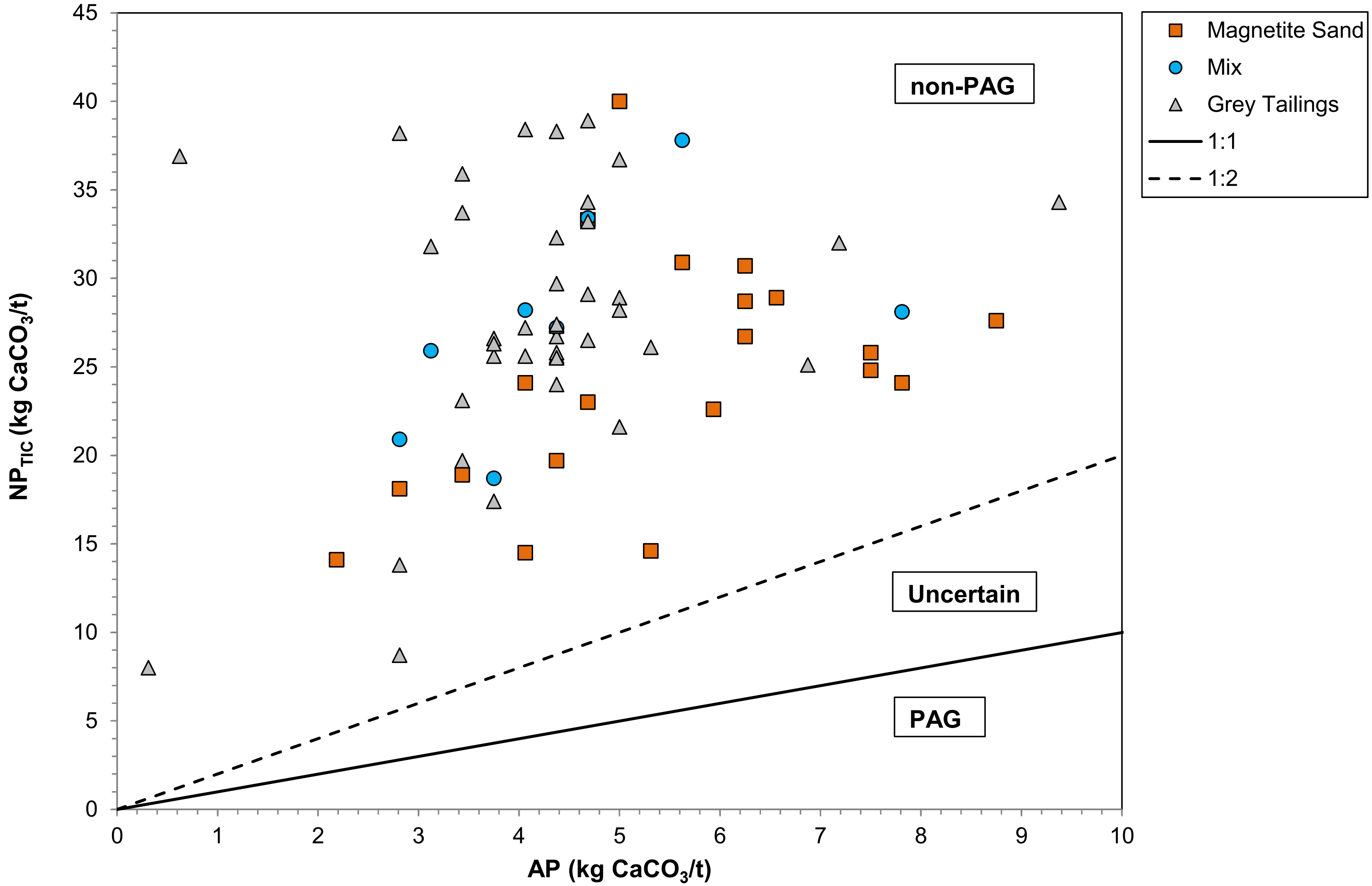
4. Results – Laboratory Analysis



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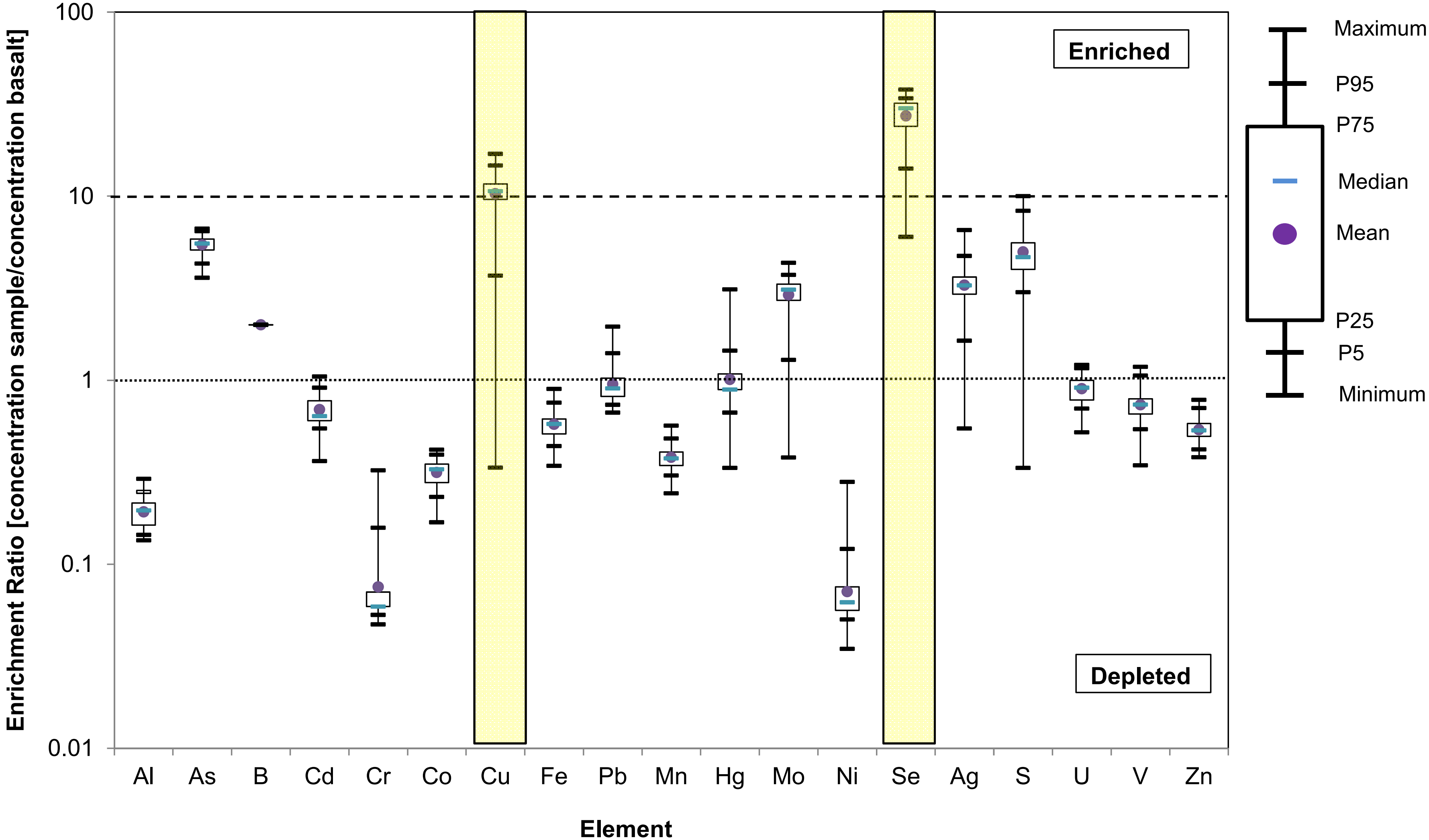
4. Results – Laboratory Analysis



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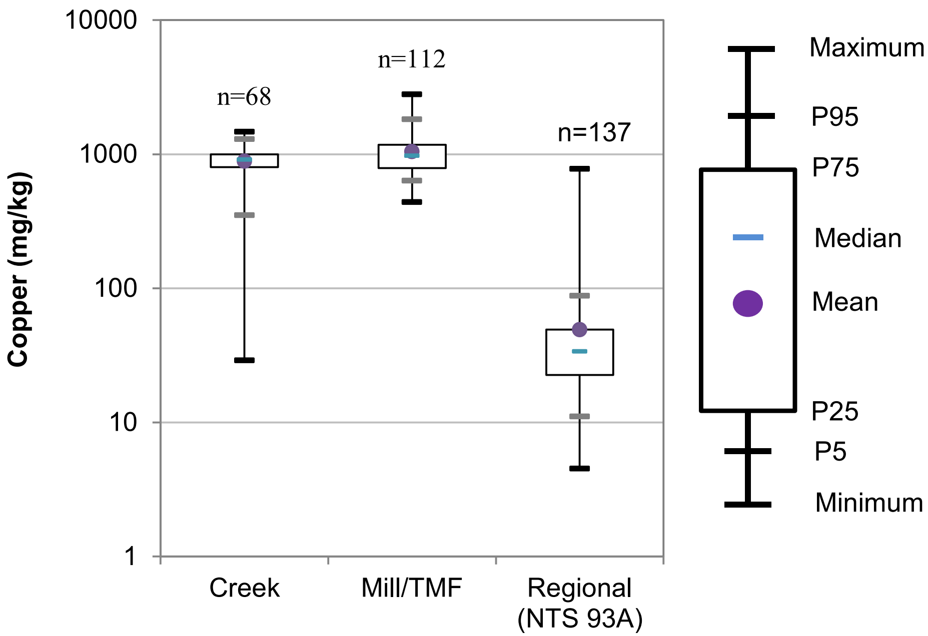
4. Results – Laboratory Analysis

- Copper and selenium concentrations were compared to operational tailings and background sediments
- Copper
  - Spilled tailings slightly lower than operational samples, but higher than regional sediments
- Selenium
  - Spilled tailings were slightly higher than operational samples likely due to influence of relatively high background concentrations

4. Results – Laboratory Analysis



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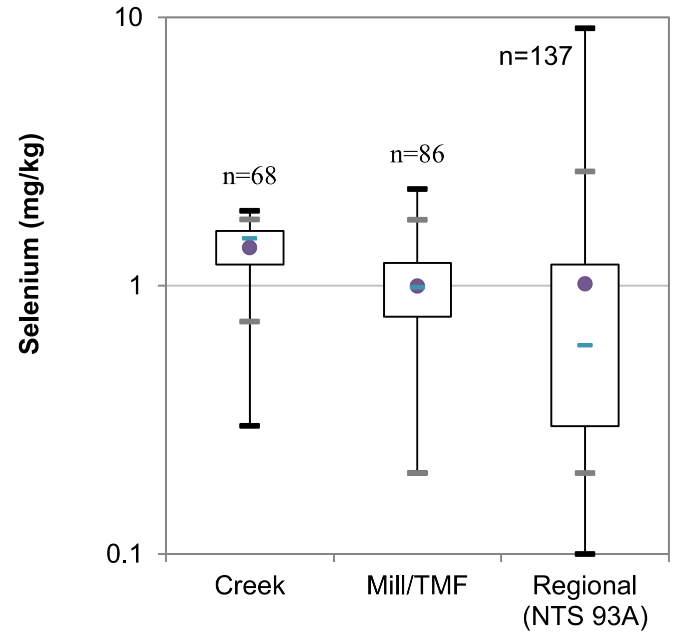

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- Sampling captured range reported in mill tailings
- Based on comparisons, good evidence that tailings collected were a mixture of tailings and native sediments

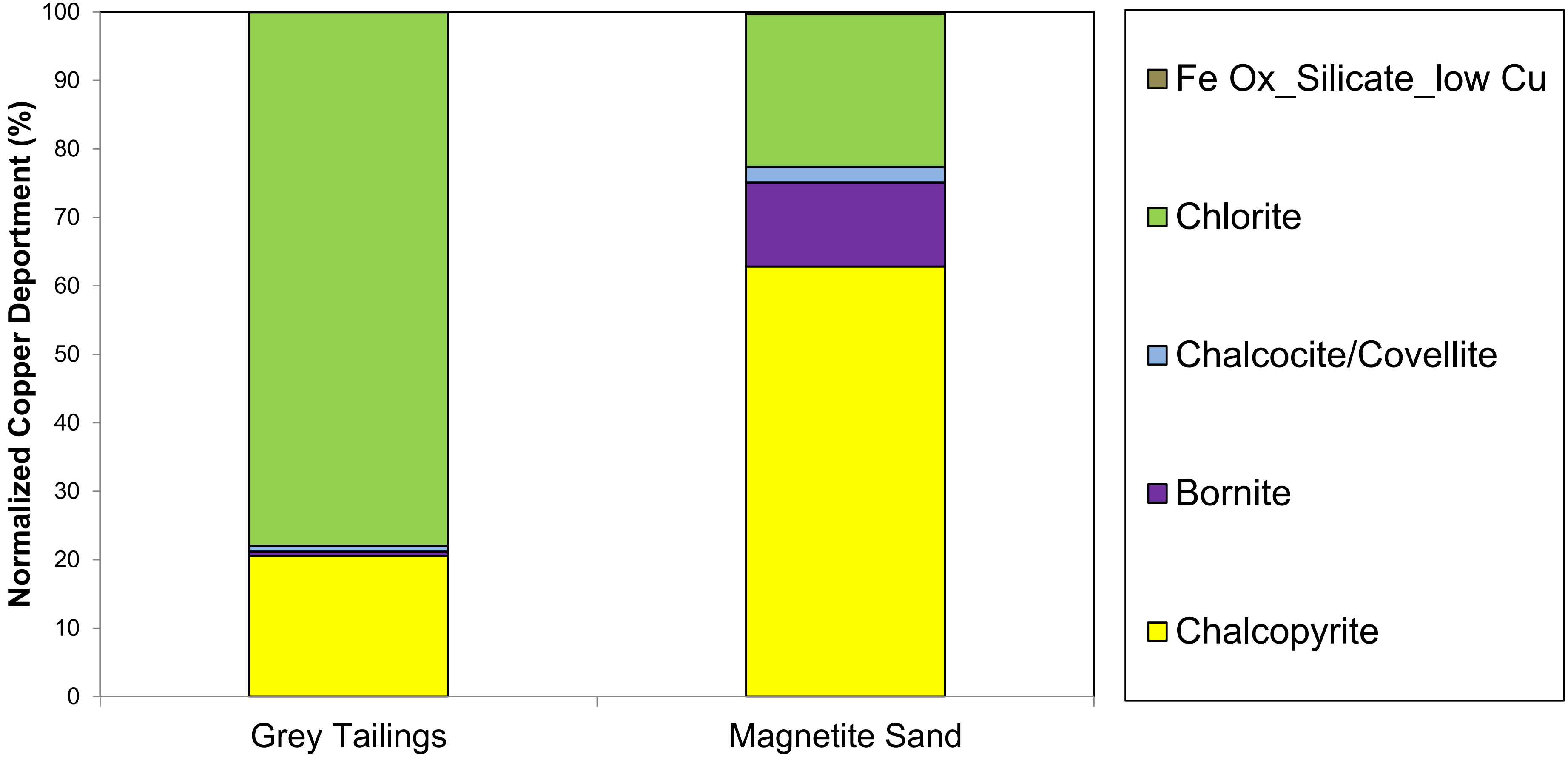
4. Results – Laboratory Analysis

Mineralogy – main findings:

- Sulphides: pyrite and chalcopyrite
- Carbonates: calcite
- Iron oxides: magnetite
- Copper ‘deportment’: non-sulphide copper – likely chlorite (see next slide)
- Quartz: high in some samples (greater than 5%) and representative of mixing with native sediments

4. Results – Laboratory Analysis

- Copper deportment as expected in sulphides, but chlorite also shown to be significant host
- Selenium concentrations too low for deportment analysis



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4. Results – Laboratory Analysis

Sequential extractions to identify mineral 'host':

- Main findings were that copper and selenium were in mineral phases not susceptible to remobilization under sub-oxic conditions

- Iron oxides present in the tailings were not easily reducible, which is attributed to the stability of magnetite (Fe_3O_4)

5. Discussion

Main findings from study:

- ARD is not expected and leaching will be under pH basic conditions – this will result in low metal solubility

- Copper and selenium were the main elements identified as leaching concerns compared to crustal averages

- Sub-aerial oxidation of sulphides will release copper and selenium, BUT….
    - Copper solubility will be limited at basic pH
    - Not all copper is associated with sulphides

5. Discussion

Main findings from study (continued):

- Selenium is soluble at basic pH, but site specific considerations are important
  - Dilution – most of the tailings are present in thin layers
  - Background sediment concentrations are similar and often higher than tailings

- Water submergence of tailings will inhibit sulphide oxidation and non-sulphide minerals are not expected to dissolve under sub-oxic conditions

- The tailings are likely mixtures of true tailings and natural sediments (e.g. lower copper and higher selenium)

6. On-going Studies

- Non-sulphide copper analysis
  - How much copper and other elements are associated with ‘non-reactive’ phase?

- Kinetic testing
  - Establishing leaching rates

Thanks for listening…

- Any questions?