Attenuation of metals in tailings

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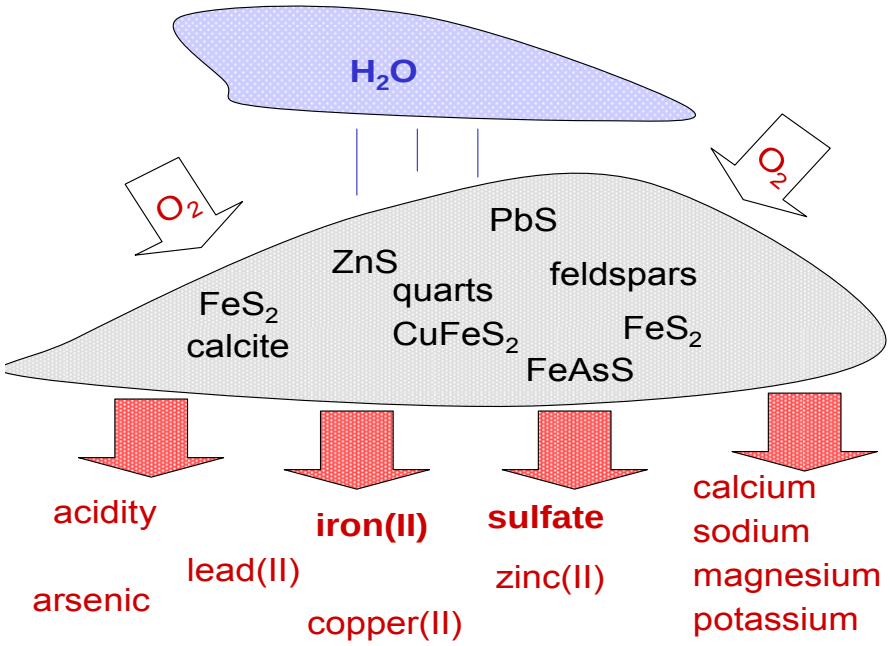
Background – Acid Mine Drainage

Weathering (oxidation) of **sulphidic** mine waste produces acidity and releases metal ions and sulphate.



$FeS_2 + 3{,}5O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + \mathbf{2H^+}$

Pyrite + oxygen + water → divalent iron + sulfate + hydrogen ions

$ZnS + 2O_2 \rightarrow \mathbf{Zn^{2+}} + 2SO_4^{2-}$

Sphalerite + oxygen → zinc ions + sulfate

Oxidised tailings

(weathered) silicates + iron(hydr)oxides

Oxidation front

Unweathered tailings

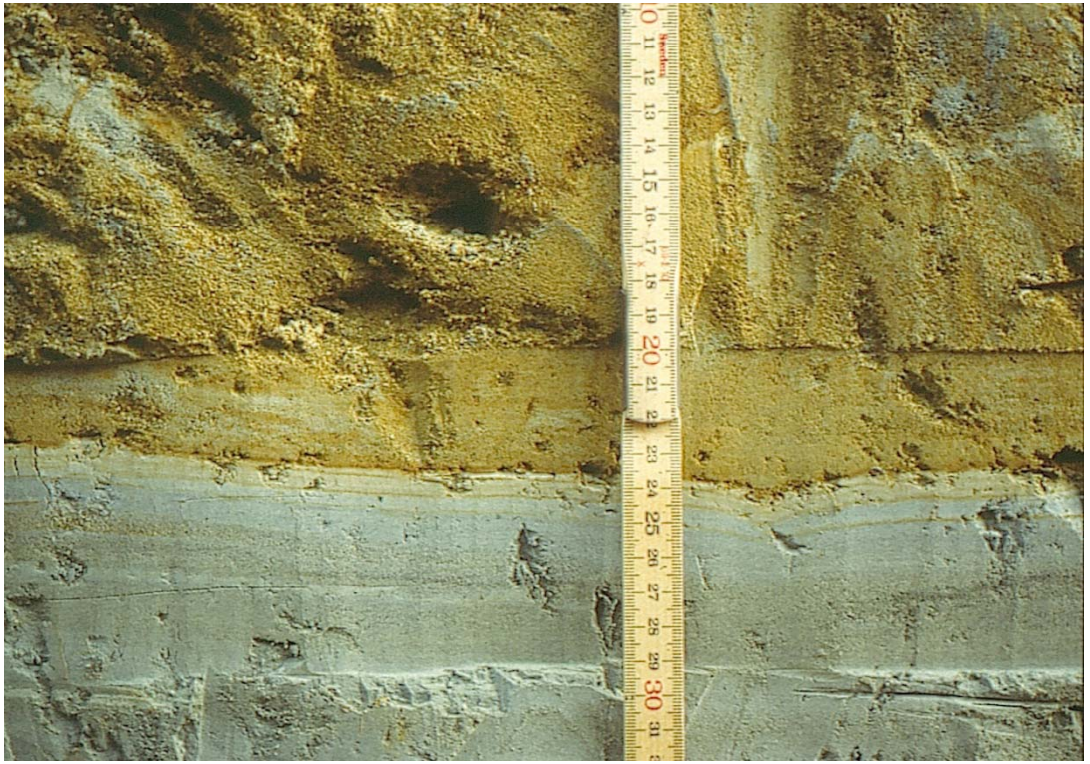


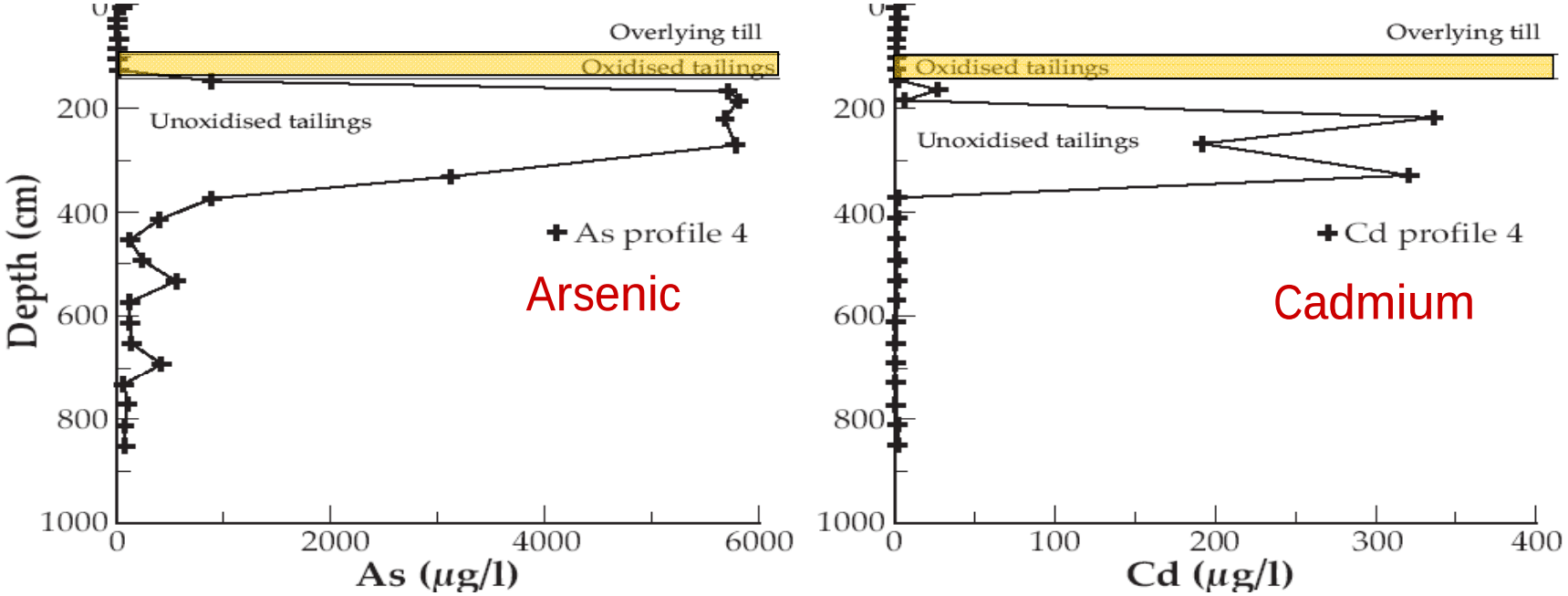
Photo: LTU

The acidity produced by sulphur oxidation is, at least partly, neutralised by weathering of carbonate minerals and more soluble silicate minerals.

Background: Previous studies (LTU/MiMi)

Metal concentrations in pore water decrease with depth.

Kristineberg, Impoundment 1



From: Holmström, Salmon, Carlsson, Petrov and Öhlander, 2001

Attenuation of metals by unweathered tailings may be significant

In absence of oxygen (unoxidised tailings):

- Adsorption of metal ions to mineral particles: sulphides, silicates etc
- Precipitation of hydroxides, carbonates and sulphates, e.g. $FeCO_3(s)$ and $ZnCO_3(s)$
- FeS and FeS_2 in tailings $\rightarrow$ formation of secondary sulphides, e.g. CuS, ”FeAsS”

Goals of the present project

The main goals are to:

- identify the minerals in mining waste able to contribute metals in short and long term, and to
- facilitate prediction of the quality of discharging ground water by quantifying the metal retardation capacity of tailings of different composition.

Methods

- **Sampling** - *Core drilling*
- **Chemical characterisation** of tailings and pore water – *Inductively Coupled Plasma-AES/MS, Scanning Electron Microscopy*
- **Physical characterisation** of tailings - *Porosity, Specific surface area*
- **Mineralogical characterisation** - *X-ray Powder Diffraction, Mineral Liberation Analysis*
- **Structural investigations** - *X-ray Absorption Spectroscopy (XAS/XANES) at MAX-lab, Lund, X-ray Photoelectron Spectroscopy*
- **Quantification of uptake capacity** – *Column and batch experiments*
- Construction of a **spreadsheet model** for metal retention in tailings considering chemical and mineralogical composition.

Sampling sites

- **Kristineberg**: Cu-Zn-mine with a high content of FeS_2 (ca. 30%). Background information available in large amounts.

- **Aitik**: Cu-mine with low sulphide content (<1%), but net acid producing.

- **Zinkgruvan** (Askersund): Zn-mine, moderate sulphide content. Not net acid producing.

- **Boliden**: Fresh tailings from the concentrator.

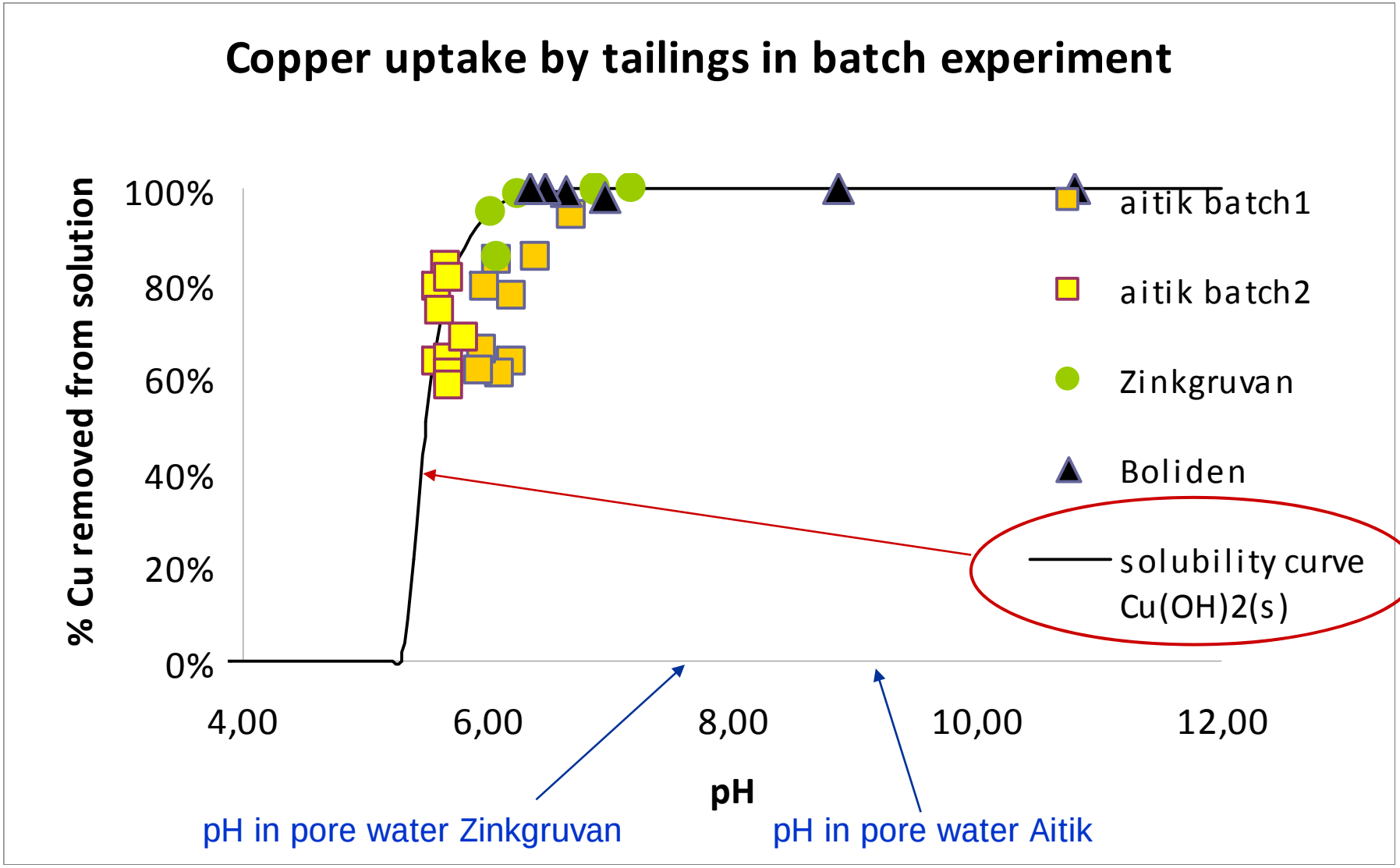
Sampling of tailings late autumn 2008

Kristineberg

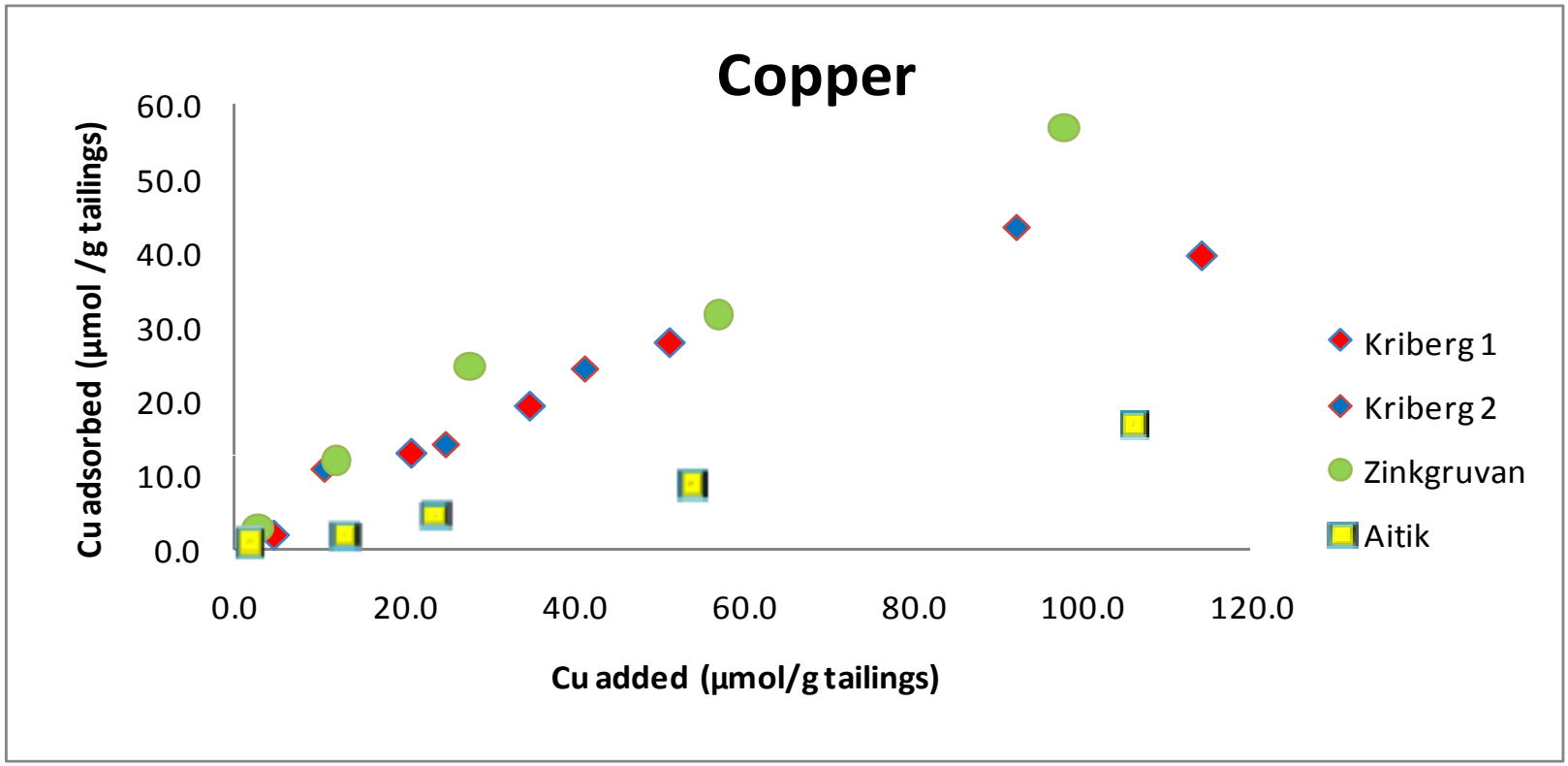
Aitik

Enemossen,
Zinkgruvan

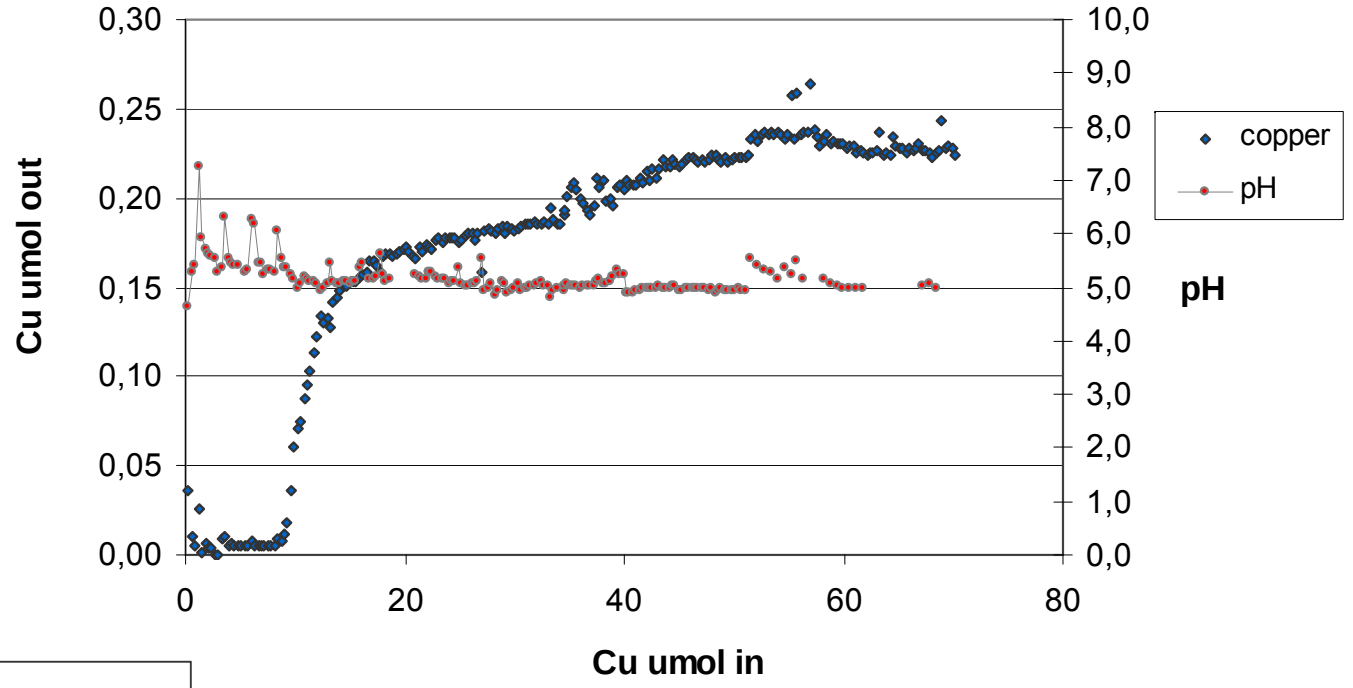
Results – Copper is removed from water at pH > 5



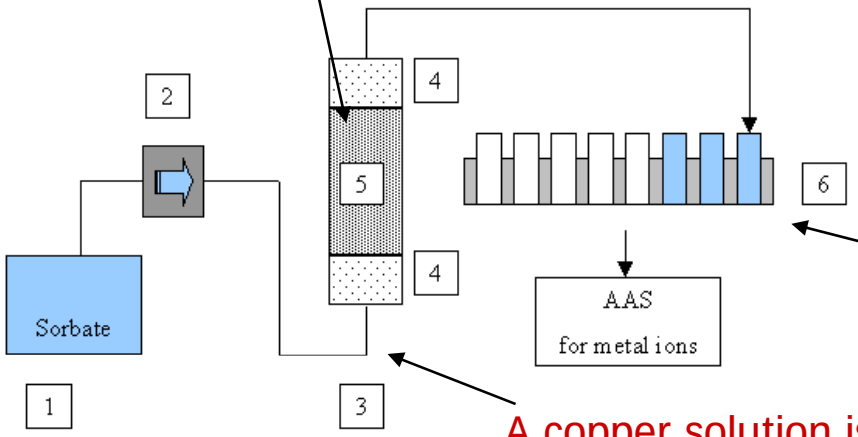
Results – Copper removal by tailings at pH 5



Results – Column experiments with Cu at pH 5



Column with tailings



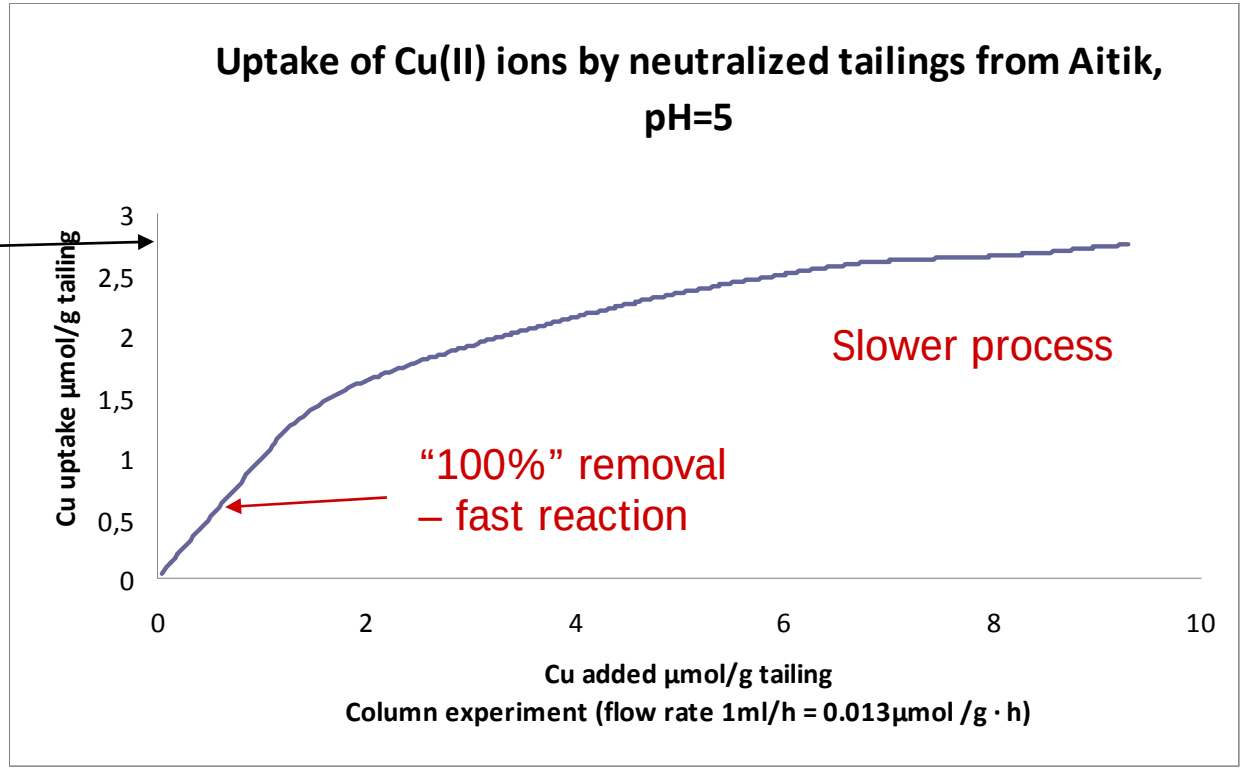
Outgoing water is collected and analysed

A copper solution is pumped through the column

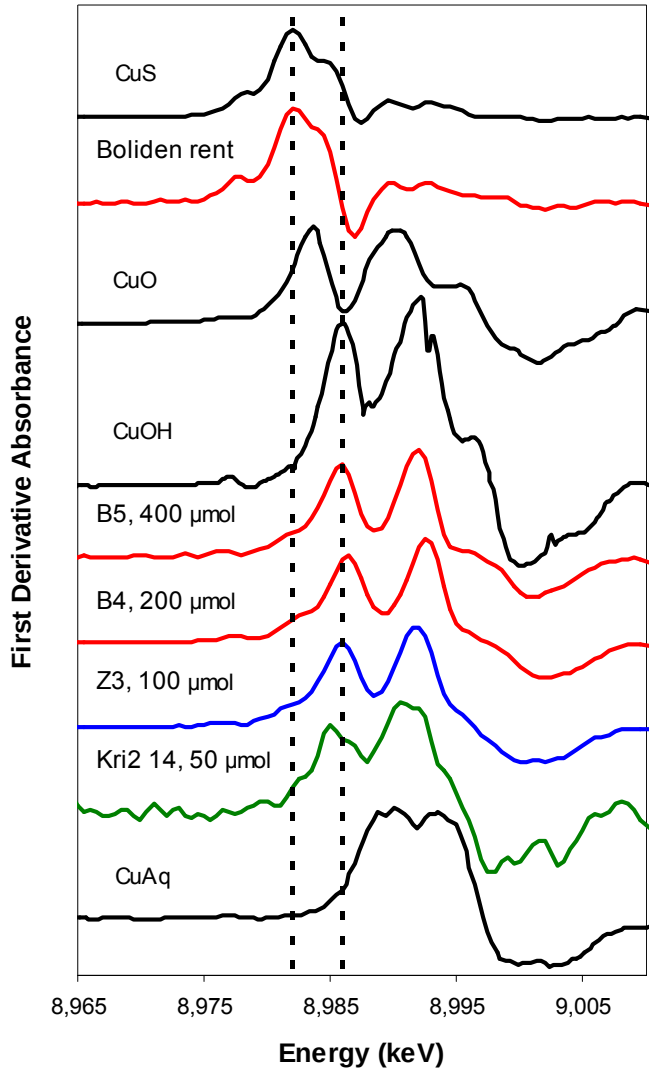
Results – Column experiments with copper at pH 5:

Uptake of Cu: ca. 0.2 g/kg

Conc. of Cu in Aitik tailings: ca 0.2 g/kg



Results –XANES: Added Cu does not bind to sulphide on mineral surfaces – at least not initially



Copper sulphide – pure substance

Fresh tailings from Boliden

Copper oxide – pure substance

Copper hydroxide – pure substance

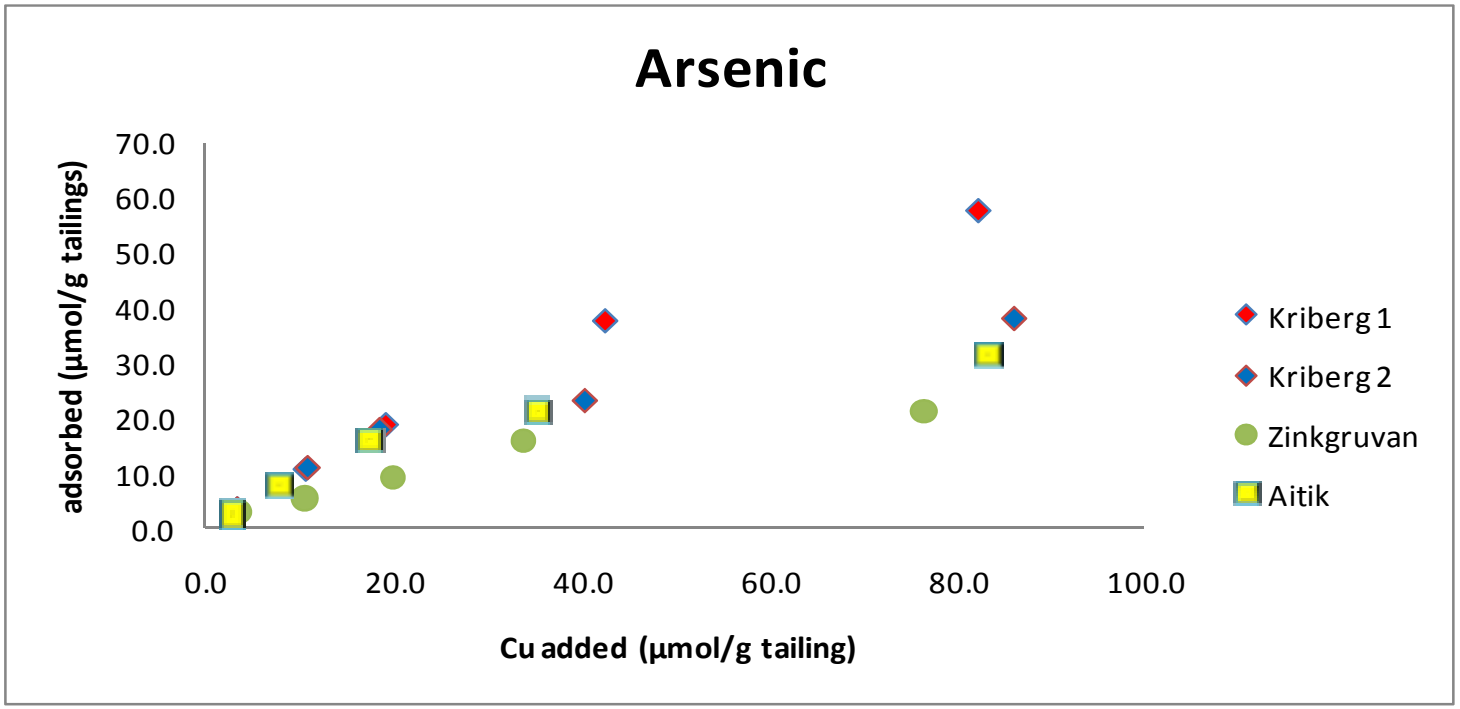
Fresh tailings from Boliden + Cu added

Tailings from Zinkgruvan + Cu added

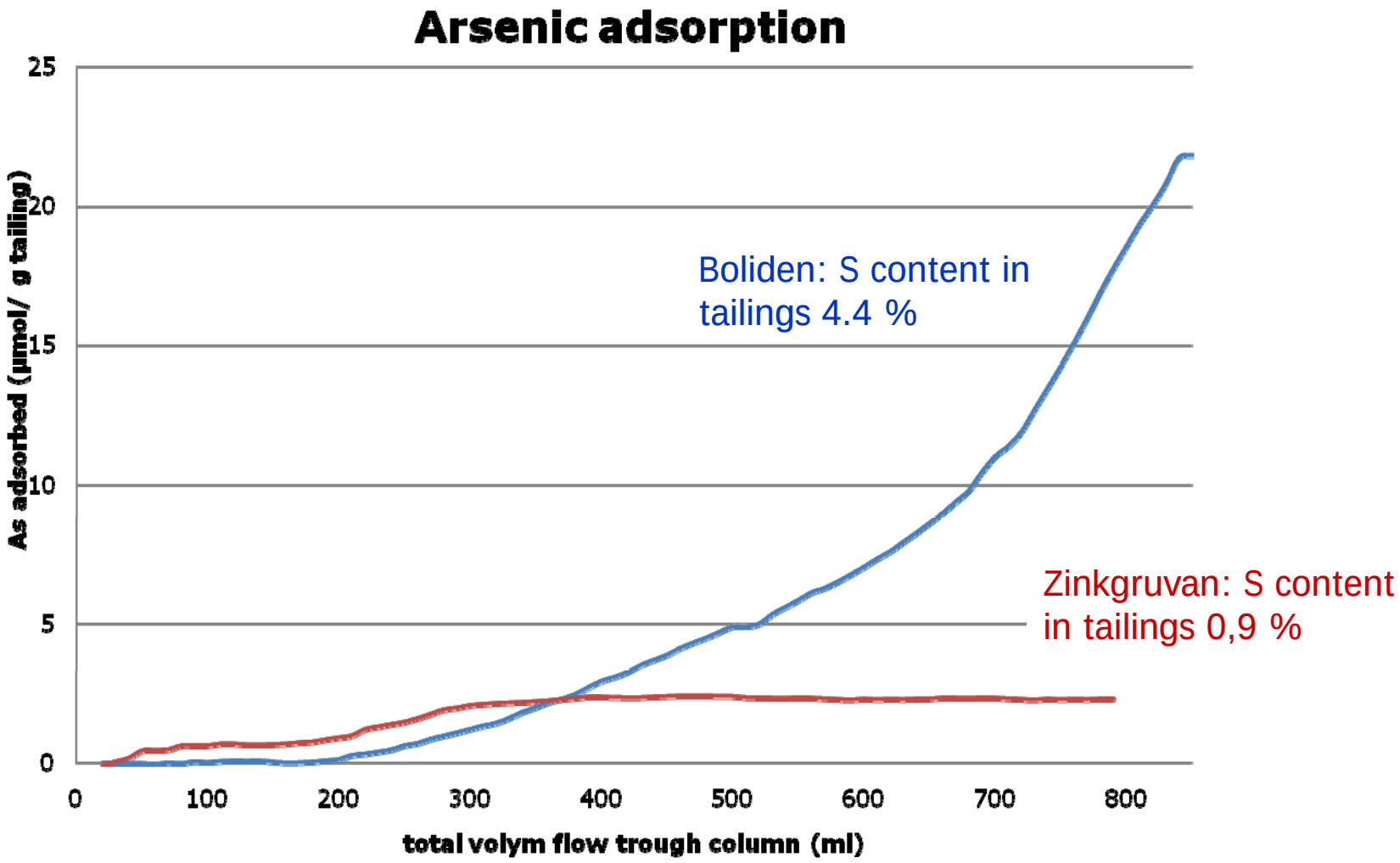
Tailings from Kri-berg + Cu added

Copper dissolved in water – pure substance

Results – Arsenic removal by tailings



Results – Arsenic removal at pH 8



Summary

- Metals are removed from water by tailings
- Copper is taken up at pH>5
  - Initial uptake is likely explained by precipitation of $Cu(OH)_2$. Supported by XANES analysis.
  - A slower process may involve phase transformation, e.g. formation of secondary copper sulphide. To be shown.
  - As long as pH can be maintained (at least) neutral Cu will be retained ion the tailings.
- Uptake of arsenic appears to be more strongly correlated to sulphide content of tailings.