

# METAL ATTENUATION IN TAILINGS

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## Goals

Oxidation of sulphide minerals in mine waste can result in extensive release of metals, which may escape the waste via groundwater discharge. However, the metals may also be attenuated by various processes in which metal ions are re-associated with the solid matter within the tailings. The main goals of the project are to identify the minerals in mining waste that are of significance for the attenuation in short and long term perspective of heavy metals released by oxidation of metal sulphides in mine waste, and to facilitate prediction of the quality of discharging ground water in a long term perspective by quantifying the metal retardation capacity of tailings of different composition.

## Methods

The study comprises field sampling of tailings of different mineralogical composition and age, characterisation of the tailings chemical and mineralogical composition, structural investigations with respect to metals and quantification of the metal uptake capacity. The project also includes compilation of a spreadsheet model for metal retention in tailings considering chemical and mineralogical composition.

Tailings were sampled in Kristineberg, Aitik and Zinkgruvan using core drilling in which the tailings are captured within a PVC liner to avoid oxidation. Fresh tailings were sampled in the concentrator in Boliden. All samples are stored in freezer. The elemental composition of tailings and pore-water has been analysed using ICP-AES/MS. Mineralogical composition is characterised using X-ray Powder Diffraction and microscopic techniques. By spectroscopic measurements the speciation and local structure of metal ions associated with tailings are investigated: X-ray Photoelectron Spectroscopy and synchrotron based X-ray Absorption Spectroscopy. XANES analyses are made at MAX-lab, Lund. The metal uptake capacity is studied in batch uptake experiments and column experiments. Oxidation during the experiments is minimised by using an inert atmosphere of nitrogen.

Geochemical modelling are being made utilising computer software, such as WinSGW and PHREEQC. The purpose of the calculations is to better understand the geochemical processes determining the reactivity and mobility of contaminants in mine drainage.

During this last year of the project a model will be developed for estimation of metal attenuation capacity by tailings with respect mineralogy and geochemistry. This model will be based on experimental findings as well as information provided in the scientific literature.

## Results

The metal uptake capacity has been studied for Cu, As, Zn and Cd in batch and column experiments on tailings sampled in four different locations: Kristineberg, Aitik, Zinkgruvan and Boliden. In order to distinguish between adsorbed metal and precipitation of metal oxide/hydroxide, the acid neutralization capacity of the tailing was neutralized before the batch and column experiments.

The sample from Kristineberg represent tailings high in sulfide content with a large acid producing potential. Zinkgruvan tailings do also contain relatively high levels of sulphide, but are also rich in carbonate making the tailings not net acid generating. Tailings from Aitik are low in sulphide. Finally, the fresh tailings collected at the concentrator in Boliden is very high in sulphide content.

Our result for Cu at pH~5 shows that there is an initial uptake likely explain by precipitation of  $\text{Cu}(\text{OH})_2$  follow by a slower process involving phase transformation e.g. formation of secondary copper sulphide (supported by XANES analysis). The copper uptake capacity was highest, up to 50  $\mu\text{mol/g}$  of tailing, for Kristineberg and Zinkgruvan. Uptake of arsenic appears to be more strongly correlated to sulphide content of tailings with an uptake capacity similar to copper for tailings with high sulphide content e.g. Boliden and Kristineberg.

The attenuation for Cd in tailing with low  $\text{FeS}_2$  content (Zinkgruvan and Atik) seems to be correlated to pH where the Cd uptake at pH ~5 is considered lower than at pH of 6.5. This is probably caused by precipitation of  $\text{CdCO}_3(\text{s})$ . For tailing with high content of  $\text{FeS}_2$ , the cadmium uptake is considerable higher which corresponding to previous findings that  $\text{FeS}_2$  can undergo disproportionation when cadmium is adsorb to the surface and formed a secondary Cadmium sulphide precipitation that are stable1.

EXAFS and XANES measurements scheduled to autumn 2010 at MAX-Lab, Lund, were unfortunately postponed to May 2011 due to severe technical problems at the synchrotron facility.

The ongoing literature survey on geochemical processes is focussed on precipitation/dissolution of secondary phases and sorption processes involving relevant types of minerals, i.e. sulphides, carbonates and silicates. For pure adsorption processes quantitative information, such as uptake capacity in terms of mmol of metal ions adsorbed per unit area is of particular interest as well as pH dependences. Several authors have demonstrated both the ability of sulphide minerals to undergo phase transformation, which will enhance the uptake capacity beyond what is given by monolayer of adsorbed ions. This kind of transformation processes have been proven for metals like copper and arsenic(III) adsorbed to iron sulphides. Considering the high pH commonly existing in (unoxidised) tailings carbonate minerals may play a significant role for immobilisation of metals. Sheet silicates, like illite, kaolinite and montmorillonite, are known to be able to adsorb cationic metals. It is also shown that quartz has an ability to bind metal ions at high pH.

## **Dissemination**

Abstracts have been submitted to the Goldschmidt Conference, Prague, Czech Republic, August 2011 and to the IMWA Congress, Aachen, Germany, September, 2011.