Hardpan formation in mine tailings: Reactive transport modelling of column experiments

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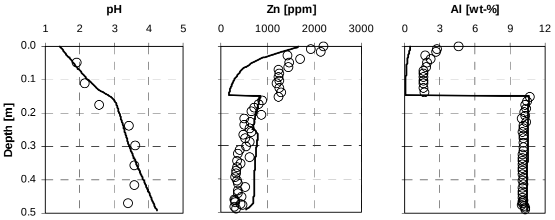
Hardpan formation in low-sulphide low pH mine tailings was studied using laboratory column experiments. The main reactive components of these tailings are metal-sulphides and sheet-silicate minerals like biotite (Graupner *et al.*, 2007). Artificial rain water was allowed to enter at the bottom of a 5 cm Ø column, which was filled with 35 cm of loamy tailings beneath a 15 cm layer of fine-grained quartz sand. Upward capillary transport of water followed by evaporation at the top of the column resulted in partially saturated conditions within the upper part of the column, an upward directed transport of solutes and colloids into the quartz sand, as well as the formation of a hardpan at the capillary fringe.

Figure 1: Bulk chemical profiles after 146 days (circles: measured data, lines: reactive transport model (single porosity model, transport of solutes only))



The reactive transport code FLOTRAN (Lichtner, 2005) was used to model the relevant reactive transport processes leading to the formation of the observed hardpan. The observed concentration profiles (Fig. 1) cannot be explained by reactive solute transport on the basis of single porosity models. A dual porosity approach, which considers mobile and immobile pores, is required to explain the observed retention of e.g. aluminium, zinc, and copper within the quartz sand layer. Furthermore, the observed extremely high transport rates for e.g. aluminium can only be explained assuming colloid and/or mechanical transport. These additional processes would positively affect hardpan formation rates.

References

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Identifying the sources of PGE, Re and Sb in road dust and soils along highways

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Automobile catalytic converters are a known source of Rh, Pd and Pt deposited in road dust and soils along highways. Since Ir is now also used in catalytic converts an increase in concentrations in the environment could be detectable. In addition Os, which can occur in toxic species, with a close to Earth mantle isotopic composition was detected in car exhaust. Thus a almost the whole range of PGE in the environment are related to anthropogenic emissions.

In this work we studied soils from an Austrian highway section sampled in 2002, 2005 and 2007. Soils, grass and road dusts where analyzed for platinum group elements (Ru, Rh, Pd, Os, Ir and Pt), Re, Sb and the ^{187}Os/^{188}Os isotopic composition. Samples where taken in 0, 2 and 10 m distance and in 0-5 and 5-10 cm respectively. In addition to trace element concentration data, magnetic susceptibility of the soils were measured.

The combination of all data and information allow the following observations. Very strong correlations between Re, Sb, Cu and magnetic susceptibility point to brake liners as the source of the enrichments observed in the top layers of the soils close to the highway. The strong increase of Rh, Pd and Pt enrichments within the last 5 years is clearly a attributed to catalytic converters. The high Ru, Os and Ir concentrations of soils close to the highway are explained by the use of serpentinite gravel from a quarry close to the sampling site used for the construction of the highway dam. Since a very strong correlation between Os isotopic composition and the inverse concentration of Os exists a mixing of two endmembers is evident. The two endmembers coincide with estimations of upper mantle and a continental crustal composition. A mixture with a third component representing the composition of catalytic converter can be excluded based on the current data. Either the concentrations of Os are too low to be detected or Os occurs in a volatile species that is easily dispersed compared to the Rh, Pd and Pt which are associated with Al-Ce bearing particles. Since Ir/Os and Ru/Os ratios are similar to mantle estimates and their concentrations relatively high, an anthropogenic source of Ir cannot be detected at this site.

In conclusion we can attribute the observed distributions of measured trace element concentrations to the following sources: automotive converters (Rh, Pd and Pt), brake liners (Sb, Cu and Re?) and serpentinite gravel (Ru, Os and Ir).