Arsenic and lead speciation in geothermal scalings: implications on formation conditions

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Mineral scalings are a common nuisance in geothermal power plants causing efficiency reduction up to shut-down. To set up appropriate and successful inhibition measures, a detailed understanding of their formation processes is necessary. The composition of scalings including geochemical and mineralogical heterogeneities indicate variable conditions during formation.

The investigated scaling from the Oberrheingraben, Germany, mainly consists of aragonite with halite and calcite as minor components. Thin, dark layers (<1mm) are mainly enriched in Fe and partly in As and Pb. XANES measurements show that As is present in three different redox-states (As^{5+}, As^{3+}, As^{0}). Generally, As^{5+} is dominant but nearly pure As^{0} can be found in the oldest part of the scaling. Lead exists as pure PbS in hotspots with highest Pb concentrations both in the oldest and youngest part of the scaling. In all other cases, most probably a lead carbonatephase mainly dominates but PbS is always present as a minor component.

Precipitation of carbonates under oxic conditions induced by temperature/pressure changes is the major formation process. The dominance of PbS and As^{0} species in some parts of the scaling, however, clearly indicates a temporary development of reducing conditions. Especially at the beginning and the end of scaling formation, where reduced species are mainly present, temperatures are lowered to such a degree that microbes can be active. The small scale PbS and As^{0} distribution indicates that microbes could be active at preferential spots only. As reduced species are often present when As and Pb concentrations are highest, anaerobic microbial activity can be seen as important enrichment process for those elements.