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As uptake by precursory phases: Insights from the geothermal environment

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Understanding the arsenic accumulation mechanism in geothermal scales have major implications on the (1) retrieval of useable materials from geothermal wastes, and (2) susceptibility of areas surrounding geothermal fields from toxic trace metal contamination.

In geothermal scales in the Sumikawa geothermal fields in northern Japan, arsenic accumulation is related to the formation of Mg-rich trioctahedral smectite comprising the geothermal scales. Selective extractions focused on determining As phases sorbed on the trioctahedral smectite cannot account for the total As content of the geothermal scale. Characterization of the geothermal scales by XRD, SEM-EDS and IR spectrocopy did not detect discrete As phases (i.e. orpiment, realgar or arsenopyrite) or phases usually associated with As uptake (e.g. Fe-oxyhydroxides). Geochemical modelling of the geothermal fluid does not predict precipitation of As-associated minerals.

In situ sorption experiments using inorganic solids similar to the mineral composition of the geothermal scales and possible precursory phases to these mineral phases were investigated. Results show that As sorption to the relatively stable mineral phases is minimal. However, precursory phases considered in this study almost completely removed dissolved As in the geothermal fluid.

Geochemical modelling suggests that precursory phases that are present in the geothermal fluid, uptake dissolved As in the geothermal fluid and later incorporated stably during the formation and aging of the trioctahedral smectite.

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Mobilisation of arsenic from solid phases with NOM solution

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Natural organic matter (NOM) influences the sorption of arsenite and arsenate on iron oxides [1,2]. NOM is a competitor for anion sorption sites, but functional groups may additionally affect the mobility of arsenic by changing its redox speciation [2]. The aim of this work was therefore to observe whether solute organic matter directly influences the mobility of arsenic from different matrices and whether redox transformations play a role in this mobilisation.

The studies were designed as Batch-experiments with different solid phases containing up to 6 mg/kg arsenic. Synthetic goethite with sorbed arsenic and natural samples from different contaminated environments (soil, aquifer, sediment) were incubated for 24 h with NOM solutions of 20 to 100 mg carbon/l. The amount of arsenic release was measured by graphite furnace AAS. For some experiments also the arsenic speciation was measured (HPLC-ICP-MS).

The experiments showed, that NOM solutions are able to mobilise more arsenic from the different solid phases than a reference without NOM. A maximum of 20 % of the sorbed arsenate and 60 % of the sorbed arsenite were released from the goethite. The fraction mobilised with NOM in the natural samples was 1 to 5,8 % of the total arsenic content. The amount of arsenic mobilisation varied for two different NOM types. Sorption of up to 25 % of the NOM during incubation was observed. The organic material had an influnce on arsenic speciation. The highest amount of transformation was found for the oxidation of arsenite (transformation of 20% of the initial arsenate).

The results indicate, that under the given conditions arsenic release was not primarily induced by NOM through redox reaction. In fact competition between arsenic and humic anions about sorption sites seems to have been the cause for the arsenic mobilisation. The arsenic released from iron oxides and natural samples derived mainly from the weakly sorbed fraction.

References

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