Reactive transport modeling of trace metals in stratified water columns

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The cycling of Mn and Fe has been recognized to play a fundamental role in the transport of trace metals in aquatic environments. Trace metals are scavenged by colloidal and particulate Mn and Fe oxides, and it is necessary to model the dynamic cycling of these minerals to ultimately predict trace metal distributions in natural waters. We report a case study with Pb as an example of a metal scavenged by hydrous Fe oxides in the water column of a stratified lake. A 1-D reactive transport model at steady-state has been developed (Taillefert and Gaillard, 2001), which describes the cycling of these metals at the oxic-anoxic transition by integrating the entire water column. Comparison with real data is used to diagnose our understanding of the processes involved in the cycling of Fe and Pb between the dissolved and particulate phases.

Description of the model

The cycling of Fe involves diffusion of Fe(II) to the oxic-anoxic transition, where it is oxidized into colloidal Fe(III), which then aggregate to form particulate Fe(III). Both colloids and particles settle to the anoxic zone, where they are reductively dissolved. Pb is removed in a co-entrainment process that occurs during the formation of the particles (Taillefert et al., 2000), rather than an adsorption process as usually proposed by conceptual models.

The transport is characterized by a constant slow advection along the water column and depth-variable dispersion coefficients (derived from vertical profiles of temperature and conductivity) and sedimentation rates.

Results and discussion

Generally, the model can fit experimental data quite well, suggesting that the transport parameters and reaction mechanisms assumed in the model can reasonably predict the distribution of Fe and Pb in the water column. Not surprisingly, the transport has an important influence on the distribution of these metals in the water column. The simulations further suggest that omission of additional reactions may affect the determination of kinetic parameters. In turn, the use of models to predict the speciation is limited by the characterization of experimental fractions and/or chemical processes. This model could be used to predict the distribution of other trace metals in stratified water columns.

References

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Possible Occurrence of Hyperthermophilic Subsurface Lithoautrophic Microbial Ecosytem (HyperSLiME) in Subvent Biosphere

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Discovery of a population of microorganisms in deep terrestrial and oceanic subsurface environments revolutionized our view to microbial world in this planet. In the deepest terrain of subsurface biosphere, however, physical conditions are so extreme that photosynthesis-driven organic matters and even their inorganic derivatives are very scarce. Given that microorganisms, probably members of hyperthermophiles, are privileged to reside in the deep crust of the earth, various photosynthesis-independent nutrients such as hydrogen, methane, hydrogen sulfide, carbon dioxide and acetate geochemically provided from or produced in the interior of the earth's crust may serve as primary energy and carbon sources for their activities. We are now proposing that hyperthermophilic, subsurface lithoautotrophic microbial ecosystem (HyperSLiME) is present in the deepest terrain of the subsurface biosphere. Although HyperSLiME is able to occur in anywhere of the deepest terrain of the subseafloor biosphere, it seems more likely that HyperSLiME occurs in the subvent biosphere beneath active deep-sea hydrothermal seafloors.

Our recent exploration for microbial diversity in various deep-sea hydrothermal vent environments has suggested the occurrence of subvent biosphere. In a hydrothermal system in the Manus Basin hosted in the moderate sediments, potentially hyperthermophilic, hydrogen-oxidizing *Ignicoccales* members were likely major microbial components in the subvent communities. In the Suiyo Seamount hydrothermal system, a typical island-arc volcano, no enumerable population of indigenous subvent microorganisms were detected probably because of very limited input by sediments and its geohydrological settings. In the sediment-rich, back-arc type hydrothermal system in the Okinawa Trough, however, hyperthermophilic heterotrophs *Thermococcales* and methanogens *Methanococcales* were the most frequently detected components of the potential subvent microbial communities. In addition, we obtained several positive geochemical and microbiological signatures for existence of HyperSLiME beneath the active hydrothermal floors in the current expedition for the Indian Ocean hydrothermal vents. Comparative geomicrobiological analysis of microbial communities in the deep-sea hydrothermal vents and subvent habitats will be introduced among various deep-sea hydrothermal systems. Possible occurrence of HyperSLiME in the Mid-Indian Ridge and Okinawa Trough hydrothermal vent fields will be also discussed.