Localization of hydrocarbon contamination by measuring microbially induced changes of soil magnetic properties

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Soil contamination by crude oil and other hydrocarbons represents a severe, global environmental problem, but often the location and extent of contamination is not known. Hydrocarbons, or their degradation products, can stimulate iron-metabolizing microorganisms, leading to the formation or dissolution of (magnetic) iron minerals and an associated change of soil magnetic properties. Therefore, the screening of soil magnetic properties has the potential to serve as an efficient and inexpensive tool to localize and assess hydrocarbon contamination.

In order to identify the influence of different biogeochemical factors on the microbially influenced changes of soil magnetic properties after hydrocarbon contamination, oil spills were simulated in laboratory batch experiments. The parameters tested in these experiments included soils with different geological bedrocks, type and amount of added hydrocarbon, and microbiological parameters (sterile, autochthonous or added micro-organisms). In order to follow the changes of the soil magnetic properties, the magnetic susceptibility of the samples was measured weekly.

First results show that changes in the magnetic mineralogy are caused by microbial activity, as sterile samples showed no changes. In the microbially active set-ups, depending on the water content the magnetic susceptibility increased or decreased up to 10% in comparison to the initial magnetic susceptibility within a few weeks. In one iron-rich soil even a decrease of the magnetic susceptibility of ~40% was observed. The amount and type of the hydrocarbon source did not have an influence on the changes in magnetic susceptibility. However, DGGE fingerprints of different set-ups, performed at the end of the experiment, revealed that the amount and type of the hydrocarbon source influenced the microbial communities.

These first results show that the magnetic susceptibility changes in the presence of hydrocarbons and that this change is microbially induced. This suggests that the screening of soil magnetic properties can be applied to localize and assess hydrocarbon contamination. In order to understand the biogeochemical processes better, the change of the iron mineralogy will be followed by Mössbauer spectroscopy in future batch experiments. Furthermore, iron-metabolizing microorganisms will be isolated and identified.

Effects of calcium fluxes on authigenic carbonate formation at mud volcanoes off Costa Rica

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The Costa Rican forearc is characterized by active fluid venting related to mud diapirism and volcanism. Our study aims at thoroughly investigating the major parameters controlling authigenic carbonate formation such as fluid composition and advection rate. These efforts will help further our understanding of turnover rates at mud volcanoes and better constrain the use of authigenic carbonates as archives for past fluid flow. Pore water profiles of four sites on the southern Costa Rica margin show that all fluids are low in chloride and methane rich. Fluids of Quepos Slide and Culebra Fault are enriched in calcium, barium and bromine. In contrast, fluids of Mounds 11 and 12 are low in calcium. We present results of a numerical reactive-transport model used to quantify the effects of calcium fluxes and fluid flow rates on carbonate precipitation and methane discharge. At active vent locations of Mounds 11 and 12, 98% of the methane is released into the bottom waters due to exceptionally high advection rates (100-200 cm a^{-1}); corresponding to a low efficiency of AOM. This causes a reduced alkalinity production and hence a lower degree of authigenic carbonates formation. In comparison, moderate flow rates (0.1- 40cm a^{-1}) at Culebra Fault and Quespos Slide lead to reduced methane output (7% - 40%) from the sediment. Here, higher efficiency of AOM and Ca fluxes increase the calcium carbonate precipitation rates. Thus, higher Ca fluxes from below induce more precipitation of calcium carbonate. Further steps are in progress to better constrain the impact of calcium enriched fluids on carbonate precipitation by application of systematically simulating variations of fluid flow rate and Ca^{2+} concentrations in the ascending fluids.