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Magnetic mineralogy changes due to hydrocarbon contaminated sediments – a field site study and laboratory experiments simulations

Dissertation

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Abstract

Environmental magnetism is an applied science deals with rock and sediment magnetism.

Within the last three decades environmental magnetism has been become a growing field of research cumulating in a constantly high number of publications during the past ten years.

Contamination of soils and sediments by different type of pollutants has become a global problem. Magnetic methods have been widely used to detect the pollution from different sources, e.g., steel industries, mining activities, road traffic or fuel combustion.

The relationship of magnetic property changes due to organic compounds is far less researched. The present thesis mainly focus on (A) the variation of magnetic mineralogy related to hydrocarbon contamination and groundwater fluctuations in unconsolidated sediments, and its relation to bacterial activity at a former military air base at Hradčany (about 100 km north-east of Prague, Czech republic). (B) Perform laboratory experiments by simulating controlled water level fluctuations (WLF) in order to reveal the character of magnetic changes (concentration, temporal dynamics, and spatial extent) and to gain insight into the important driving processes.

The groundwater fluctuates due to remediation processes mainly air sparging caused of spreading the contaminants over high levels, and leaving fingerprints of magnetic mineral formation. The site and its vicinity are situated in the sedimentary complex of the Bohemian Cretaceous basin, which forms the main groundwater supply of the Czech Republic. Pollution of soil and groundwater by hydrocarbons was spread into the alluvial sediments of Ploučnice River and in the middle Turonian sandstones.

In our study the magnetic methods were used to examine the hydrocarbon contaminated sediments. The distribution of the total content of hydrocarbons is unsystematic and this likely not a controlling factor, we speculate that petroleum hydrocarbons are not usable for most of the microorganisms but the total organic carbon seems to be linked to the magnetic susceptibility (□) and could represent a degradation product of hydrocarbon that is bioavailable for microorganisms.

Results of the iron reducing bacteria show that the bacterial activity played a significant role in the magnetite formation as indicated by the most probable number quantification. VII

Laboratory batch experiments controlled WLF were set up, conducted on hydrocarbon uncontaminated natural sediments collected from the above mentioned field site, near to section C1 of the field study (50-100 cm in depth).

Results of the laboratory experiments revealed slight increase in in the water fluctuation zone (WFZ) during the monitoring period, under different conditions, then the increase ceased almost at the same level. The correlation between and anhysteretic remanent magnetization (ARM) of the bacterial activity conditions indicate fine magnetic grains compared to coarse grains in the iron source modified conditions. The thermomagnetic curves could show changes in the magnetic mineralogy probably due to new formation of magnetic minerals.

This work has relevance for developing simple methods for detection of hydrocarbons in the environment, e.g. due to contamination.