Spatial Heterogeneity of Microbial Iron Reduction Potential at the South Oyster Focus Area

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We are addressing the spatial distribution of subsurface microbial iron reducers at the field-scale, which will provide significant information required to understand and predict the effect of heterogeneity on the reduction and immobilization of radionuclides and metals by iron-reducing bacteria. In our initial research we have intensively sampled three boreholes at the South Oyster Focus Area, a DOE/NABIR analog site near Oyster, Va. The samples are being analyzed for their microbial iron reduction potential (MIRP) using a low-cost batch measurement method. We have also measured the extractable iron oxyhydroxide content, the hydraulic conductivity, the bulk density, the concentration of organic matter, and the grain size of the samples. We will also determine the detailed mineralogy of the solid mineral phases present for a subset of the samples which are representative of the different biogeochemical sediment types detected in the boreholes. High-resolution crosshole seismic data was recorded between each pair of boreholes.

Preliminary results indicate that the heterogeneity of the site is more pronounced than that of other DOE-sampled locations in the Oyster area, all of which were dominated by sandy sediments. The sediments at the site include fine-grained lagoonal and back-bay sediments as well as sand-rich sediment layers. The fine-grained sediments include both black organic-rich peat layers and light to medium gray clay beds that contain relatively high concentrations of extractable Fe(II) and organic matter. Three distinct types of sand layers appear to be present at the field site, based on differences in the presence of MIRP, the hydraulic conductivity and the concentration of extractable Fe(III).

The variations in physical properties of the sediment layers appear to be traceable on geophysical data recorded at the site, which should make it possible to predict the sediment types between the boreholes. Geostatistical analysis will be used to predict the levels of MIRP between the existing boreholes using stochastic simulation techniques that integrate the MIRP data with geological, geochemical and geophysical data. Further drilling and sampling will then test the predictions. The research will provide a model for the distribution of microbial iron reduction potential on the Atlantic Coastal Plain, and a methodology that can be applied to develop similar models for other locations.