# University-Led Research

## Induced Polarization Signature of Biofilms in Porous Media: From Laboratory Experiments to Theoretical Developments and Validation

Estella Atekwana (estella.atekwana@okstate.edu) - Oklahoma State University (PI), Marianna Patrauchan - Oklahoma State University; Andre Revil; Colorado School of Mines (Co-PIs).

We conducted three experiments to investigate the spectral induced polarization (SIP) source mechanisms in microbially active environments.

In the first experiment, we investigated the SIP response of different biofilm components. Our results show that: increasing cell concentration increases the imaginary conductivity (σ”); increasing the concentration of alginate decreases σ”however, addition of bacteria cells causes an increase in σ”; increasing the phenazine ( metabolite) concentration causes an increase in σ”. This effect is enhanced in the presence of microbial cells; increasing the DNA concentration decreases σ”. Addition of cells did not cause an increase in σ”. Preliminary modeling suggests that in the absence of conductive biominerals the σ”is a quantitative indicator of bacterial cell density.

In the second experiment, we examined the SIP response of common iron minerals associated with metabolic activity of microorganisms. Both pyrite and magnetite show high σ” and real (ï³') conductivities compared to hematite, goethite, and siderite. The σ”spectra of both pyrite and magnetite exhibit a well-defined characteristic relaxation peak below 10 kHz, not observed with the other iron minerals. The σ” of a mixture of iron minerals is dominated and linearly proportional to the mass fraction of the highly conductive (pyrite and magnetite) iron minerals. The σ”magnitude increased with decreasing grain size diameter of magnetite and pyrite with a progressive shift of the characteristic relaxation peak towards higher frequencies. Our results suggest that SIP techniques can be used to track the formation of semi-conductive mineral phases such as pyrite and magnetite.

In the third experiment, we investigated biomineralization of iron minerals by Geobacter sulfurreducens and its ΔpilA mutant. Wild type (WT) and ΔpilA mutant cultures were supplemented with acetate, Fe citrate and elevated concentrations of phosphates. The WT and ΔpilA strains promoted the accumulation of Fe(II) and decrease of phosphate in the aqueous phase. While the WT favored the formation of structurally ordered flattened prismatic crystals, composed of O, P and Fe, resembling vivianite, the deposits recovered from ΔpilA culture had a similar elemental composition but its morphology was a rosette.. The Fe/P ratio in the deposits recovered from the WT culture was higher than in deposits recovered from ΔpilA culture. The synthesis of vivianite by Geobacter is significant because vivianite has been shown to abiotically reduce U(VI). We anticipate characterizing the processes that control the biogeochemical cycling of iron and biogeophysical responses from porous media populated with iron reducing bacteria communities.