CAN BIOGEOPHYSICS YIELD RELIABLE BIOGEOCHEMICAL INFORMATION UNDER COMPLEX NATURAL CONDITIONS?

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Biogeophysical methods, in particular, (spectral) induced polarization (S)IP, capture the changing electrical properties of geologic media as they are modified by biogeochemical reactions. Their unique sensitivity to biogeochemically-induced changes poises non-invasive geophysical approaches at the forefront of *novel* methodologies that can revolutionize our ability to access the poorly accessible subsurface. For example, SIP has been shown to detect the polarization of bacterial cells in porous media, and thus provide information on the microbes that modulate the breakdown of harmful contaminants in groundwater, and their dynamics. A reliable ‘non-invasive’ window into the subsurface can provide key insights into the efficiency of natural attenuation reactions at larger and more refined spatial and temporal scales. However, the major challenge ahead is to transfer well-controlled, single microbial strain, laboratory-scale approaches to natural groundwater conditions and extract meaningful biogeophysical information in the face of parallel and often coupled signal contributions. Here we review the microbial controls on biogeophysical signals, the potential pit-falls when targeting biogeochemical reactions in natural media and present a case study in which we monitored SIP signals during denitrification in a flow-through experiment with natural aquifer sediment and incubated under ambient groundwater temperature (12°C) and geochemical conditions. In our case study, we recorded imaginary conductivity (*σ''*) changes of up to 140% (3.1 µS/cm) linked to an onset of microbial activity during nitrate reduction despite the presence of background polarization of the sediment. In addition, we propose an easy-to-implement Cole-Cole decomposition approach that can successfully differentiate between microbially-active and -inactive zones (and times), requiring only the complex conductivity spectrum of the natural sediment prior to the onset of microbial activity. The Cole-Cole decomposition helps to isolate the magnitude of the spectral-*σ''* contribution of the groundwater natural microbial community under varying conditions. Our recent findings open new avenues for the application of SIP as a method to quickly monitor a system’s reactivity without the need to wait for biogeochemical analysis.