**SLAC Groundwater Quality SFA: Describing and Quantifying Anaerobic Microsites: Impact on BGC Nutrient Cycling in Soils**

Vincent Noël,[1*] Sam Webb,[1] Kristin Boye,[1] Kate Maher,[2] Chris Francis,[2] Scott Fendorf,[2] and John R. Bargar[1]

[1]SLAC National Accelerator Laboratory, Menlo Park, CA;

[2]Stanford University, Stanford, CA

**Contact**: (noel@slac.stanford.edu)

**Project Lead Principle Investigator (PI):** John Bargar

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**Project Abstract:** Anaerobic soil heterogeneities, referred to as 'anaerobic microsites', form in aerated soils where textural contrasts create boundaries defining small (µm to mm diam) domains in which oxygen consumption exceeds inward $O_2$ flux. A widely posited function of these features is to maintain anaerobic disequilibrium within nominally oxic soil horizons. Thus, anaerobic soil microsites have been widely invoked, but rarely observed and characterized, to explain the presence of reduced products that otherwise should be absent from the soil system. BGC functions ascribed to microsites include organic carbon storage, denitrification and ammonification, manganese/iron/sulfur reduction, methanogenesis, and metal contaminant sequestration/release. Neglecting to account for anaerobic microsites in soils creates major uncertainties in model simulations of greenhouse gas emissions, stable isotope fractionation, and nutrient and contaminant transport. In spite of their importance, we know little about the physical, geochemical, and microbiological characteristics of anaerobic microsites, particularly their distributions within soil horizons and their impacts on the compositions of soil water/gas and the atmosphere.

This lack of knowledge is due mainly to instrumental limitations that constrain our ability to detect and characterize these small soil features. In a new project, we will use synchrotron-based X-ray imaging to address the question of, "When, where, how, and to what extent do anaerobic microsites contribute locally and globally to ecosystem functions (and to which ones?)". When coupled with X-ray spectroscopy, this method offers unique abilities to detect redox contrasts and the distribution of specific elements (including S, Fe, Mn, As, U, Cr, Mo) *and their oxidation states and chemical forms* within soil cores at spatial resolution extending down to micron-scale. We will adapt, optimize, and integrate existing synchrotron X-ray methods into a workflow for detecting and characterizing anaerobic soil microsites. We will work closely with DOE-ESS collaborators to evaluate the importance of detected anaerobic microsites on varying biogeochemical function in focus for ESS funded researchers. If successful, the project will inform process knowledge of, and ability to model, the broad and critical BGC roles played by anaerobic microsites across terrestrial ecosystems.