Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.14241

Laboratory for Observing Anoxic Microsites in Soils (LOAMS)

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Redox reactions essentially underlie all biogeochemical processes and are typically spatiotemporally heterogeneous, at least in soils. However, redox heterogeneity has yet to be incorporated into mainstream conceptualizations of soil biogeochemistry. Anoxic microsites, a defining feature of soil redox heterogeneity, are zones of oxygen depletion in otherwise oxic environments. Neglecting to account for anoxic microsites can generate major uncertainties in quantitative assessments of greenhouse gas emissions, C sequestration, nutrient and contaminants cycling at the ecosystem scale or even globally. However, no existing methods are capable of directly detecting anoxic microsites in the field, primarily because of the need for µm-mm scale resolution over cm-m scales. Consequently, our current understanding of microsite characteristics does not support model parameterization.

To resolve this knowledge gap, we simultaneously (i) study impact from anoxic microsites on biogeochemical cycles at the soil scale and (ii) detect, quantify, and characterize anoxic microsites directly from natural cores.

Thus, we have reviewed existing literature on the dynamic properties of anoxic microsites, including their spatial distribution, redox gradient sharpness, and temporality. Further, we have examined the influence of anoxic microsites on biogeochemical cycles of nutrients (C, S, and Fe) and contaminants (Zn, Ni, As, U), combining results from experimental columns and natural cm-scale anoxic microsites of floodplain sediments at the upper Colorado River Basin scale. In parallel, we have developed a workflow whereby natural soil cores are carefully abstracted, preserved, and analyzed by synchrotron-based multiple-energy X-ray fluorescence 2D mapping of *e.g.,* Fe, Mn, and other redox active elements at 1-100 µm resolution over cm-m areas. Rapid screening of large cores at high spatial and energy resolution, followed by systematic algorithm-driven data processing, allows for relatively quick identification, quantification, and characterization of actual anoxic microsites. To date, these investigations have revealed direct evidence of anoxic microsites in various natural soils, such size-range distribution of FeS microsites in soil cores from a transect from toeslope to floodplains, and preferential spatial distribution of redox microsites inside aggregates. We anticipate that this study will advance our understanding of soil biogeochemistry and help resolve “anomalous” occurrences of reduced products in nominally oxic soils.