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Micro- and Nano-Pore Structure and Composition of Microaggregates from a Tropical Soil

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Highly weathered tropical soils are well known for progressively retaining applied phosphate into forms that are not available to plants. Explanations for this phenomenon include strong adsorption of phosphate on the relatively abundant iron and aluminum (hydr)oxides in these soils, diffusion into nanoporous mineral defects, and diffusion into micropores of soil aggregates modified by pore blocking by organic matter [1, 2]. Our overarching goal is to determine the extent that diffusion of phosphorus into soil micro and nanopores contributes to slowly reversible retention. Microaggregates of 30 – 40 μm were physically isolated from a highly weathered soil in a forested area of São Paulo state, and subsamples were reacted for 2 h with either 1 mM orthophosphate solution or deionized water (control). Computations using a simplified reactive diffusion equation predicted that aqueous phosphate at this concentration would fully diffuse into 30-μm diameter spherical microaggregates in <2 h, depending on porosity and adsorption characteristics of the composing minerals. The microaggregates are being characterized at the CATERETÊ coherent scattering imaging and CARNAÚBA coherent X-ray microprobe beamlines of the Sirius synchrotron. Results from 2D micro-X-ray fluorescence (μ-XRF) imaging, scanning transmission X-ray microscopy (STXM), ptychography, and μ-XANES spectroscopy indicate that isolated soil microaggregates are dominated by an iron (hydr)oxide-enriched matrix with associated manganese, with discrete titanium-enriched particles distributed throughout. Our analytical and computational problem is to ultimately couple 3D micro/nanopore-structural imaging data with chemical and mineralogical imaging data to develop a physical-chemical model for explaining phosphate diffusion into and out of such complex soil microaggregates.

[1] Barrow (2021), *European Journal of Soil Science* 72, 679-685.

[2] Vermeiren, Kerckhof, Reheul, & Smolders, (2021), European Journal of Soil Science 18 (online early access).