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Experimental study of abiotic and microbial Fe-mineral transformations to understand magnetic enhancement during pedogenesis

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The phenomenon of magnetic enhancement in many soil types has been recognized for several years, but the question of whether the enhancement process is primarily driven by microbial activity or abiotic processes is still unresolved. We present results from an on-going interdisciplinary experimental study of possible pathways of magnetic enhancement during pedogenesis of loess-derived soils. Synthetic nanoparticle preparations of the oxy-hydroxides goethite and lepidocrocite were chosen as Fe-rich precursor phases. Abiotic alteration was achieved by heating in a controlled atmosphere, under either oxidizing or reducing conditions. Heating-induced dehydration reactions in lepidocrocite produce superparamagnetic magnetite or maghemite with a characteristic nanoporous structure, while dehydration of nanogoethite produced pseudo-morphed hematite, which converts to magnetite during heating in a reducing atmosphere. The abiotic alteration experiments are compared with preliminary results from bioreduction experiments using the dissimilatory Fe-reducing bacteria *Shewanella putrefaciens* in both the synthetic minerals and in natural loess, soil and paleosol materials. The magnetic properties, microstructure, and morphology of the reaction products were characterized with a combination of low-temperature magnetic properties, Mössbauer spectroscopy, high-resolution TEM microscopy, and x-ray diffraction. The goal is to identify characteristic properties of the magnetic alteration products that may help elucidate the relative contributions of microbial and abiotic alteration mechanisms to the development of an "enhanced" magnetic signature during pedogenesis.