Arsenic oxidation by the mighty manganese soils of Graskop

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This study characterizes the physical and chemical properties and the reaction kinetics of the extraordinary manganese soils found in Graskop, South Africa. Manganese-oxides govern many geochemical reactions due to their abundance and high reactivity. Despite their importance in cycling redox sensitive compounds in natural systems, much remains unknown about the reactivity of manganese-oxides formed under environmental conditions. In order to study how naturally formed manganese-oxides react, soils were collected from Graskop, in the Mpumalanga region of South Africa. Three soil profiles were excavated with a range of manganese concentrations. Each profile was further separated based on horizons. Some of the horizons contain up to 12% manganese by weight in the fine fraction and over 20% manganese by weight in the coarse fraction. Nodules of manganese are ubiquitous in these soils and have the greatest concentration of manganese. The soil in each horizon was analyzed to determine the cation exchange capacity (CEC), point of zero charge (PZC), and pH. X-ray powder diffraction (XRD) was used to characterize the mineralogy of the crystalline material found in the clay fraction. The nodules present in the soils were also analyzed and their crystalline composition was determined with XRD. Finally, a series of batch reactions were used to determine the capacity of these soils and nodules to oxidize arsenite into arsenate. The conditions of the reaction were varied in order to elucidate how differing pH, arsenic concentration, and temperature influenced the oxidation reaction. Aliquots collected from these experiments were analyzed by inductively coupled plasma mass spectrometry (ICP-MS). This study provides key insights to more fully understand the role of manganese-oxides in controlling redox sensitive reactions in the environment.