Formation, properties and mobility of submicron-sized organo-mineral associations: A combined spectro-microscopic and experimental study

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Submicron-sized organo-mineral associations are ubiquitous in natural porous media. Their size ranges from particles of a few nanometers up to the building units of soil microaggregates. Of particular relevance are associations with sizes smaller than 1μm, also referred to as environmental colloids or nanoparticles (<100nm). Due to their small size they stay in suspension at favorable conditions and spread by diffusion and advection. They serve as mobile geosorbents for nutrients, contaminants, biota and genetic elements, provide a substrate for microorganisms and may even act as terminal electron acceptors. Their formation under the prevailing conditions in natural systems is still only poorly understood. This is predominantly due to the fact natural porous systems are challenging to study due to their divers composition and the interactions with heterogeneous biogeochemical inter-faces in a physically structured setting. From experiments under defined conditions of increasing complexity, we learned that they build response to changes in biogeochemical conditions at anoxic-(sub)oxic interfaces or as a consequences of transient conditions following changes in boundary conditions. Three principal formation processes are discussed: Neo-formation from non-equilibrium solutions via heterogeneous nucleation or co-precipitation, and the (cumulative and alternating) sorption of organic substances to predominantly inorganic sorbents. In any case a variety of organics are present during build-up and the formation results in associates that vary in composition, properties, size and mobility. Yet, these differences ultimately imply that the associations may also serve different functions. The understanding of their role and functions in the ecosystems is thus dependent on the elucidation of the formation, an in depth spatial characterization of their composition and properties, and an assessment of the mobility. Such information will ultimately require the combination of complementary spectroscopic and imaging techniques that must operate not only at very small but overlapping scales with “provocative” experimental approaches that allow for the assessment of mobility (and reactivity).