

**ADVANCES IN ENVIRONMENTAL REACTION
KINETICS AND THERMODYNAMICS:
LONG-TERM FATE OF ANTHROPOGENIC CONTAMINANTS**

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**A MULTI-SCALE ASSESSMENT OF ION SORPTION
KINETICS AT THE MINERAL/WATER INTERFACE**

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One of the most important processes controlling the fate, transport and bioavailability of inorganic ions such as metals and oxyanions in the subsurface environment is the sorption kinetics. (Scheidegger and Sparks, 1996; Sparks, 1999). The timescales of ion sorption on natural materials such as soils and sediments can range from seconds to months and years. A range of sorption mechanisms could explain the rate processes including adsorption, precipitation/nucleation and diffusion. The slowest of these is rate-limiting. Macroscopic kinetic studies have shown that residence time effects often occur with many metals and metalloids. A rapid uptake of sorbate is usually followed by a slow approach to a steady state. The rapid reaction has been ascribed to chemical reactions and film diffusion, while the slow sorption reactions have been attributed to interparticle and intraparticle diffusion, retention on sites of lower reactivity and surface precipitation. (Arai *et al.*, 2002; Scheidegger *et al.*, 1998; Scheinost *et al.*, 2001; Strawn and Sparks, 1999). With many metals it has been shown that desorption is much slower than adsorption and that the longer the residence time between the sorbent and sorbate, the more difficult it is to release the contaminant. It must be recognized that microscopic conclusions about reaction mechanisms cannot be gleaned from macroscopic investigations.

With the advent of *in situ* molecular scale spectroscopic and microscopic techniques, one can assess the mechanisms of ion sorption over time and in some cases in real-

time. This paper will review macroscopic and molecular scale aspects of metal and oxyanion sorption/desorption on mineral components and soils, with emphasis on advances in understanding the important role that time has on ion transformations and sequestration.

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