

## Kinetics and Mechanisms of Soil Biogeochemical Processes

C. J. MATOCHA, *University of Kentucky, Lexington, Kentucky, USA*

K. G. SCHECKEL, *USEPA, Cincinnati, Ohio, USA*

D. L. SPARKS, *University of Delaware, Newark, Delaware, USA*

The application of kinetic studies to soil chemistry is useful to determine reaction mechanisms and fate of nutrients and environmental contaminants. How deeply one wishes to query the mechanism depends on the detail sought. Reactions that involve chemical species in more than one phase are termed *heterogeneous* and occur in soil and geochemical environments (Lasaga, 1981; Sparks, 1999). The mixture of inorganic and organic components with a range of reactivities that vary spatially makes the study of chemical kinetics in soils difficult. Separating the rates of biologically mediated processes from abiotic processes is an important consideration in modeling fate of plant nutrients, trace metals, and environmental contaminants in soils. A combination of kinetic and spectroscopic tools is essential to elucidate reaction mechanisms (Sposito, 1994; Bertsch and Hunter, 1998; Sparks, 1999). Analogies between surface complexes and their dissolved counterparts can be drawn to assist in proposing reaction mechanisms (Phillips et al., 1997, 1998).

Equilibrium models have provided valuable insight into predicting the distribution of chemical species likely to develop in soils under typical environmental conditions. However, most soil systems are in disequilibrium, and using only equilibrium constants for modeling purposes would be misleading because they provide no information about reaction rates (Sparks, 1989; Sparks et al., 1996). Typical soil chemical reactions have time scales that range from microseconds to days for some aqueous complexation and sorption phenomena to years for mineral precipitation processes (Fig. 6-1). The choice of experimental methodology depends on the time scale of the reaction kinetics (Amacher, 1991; Sparks, 1999). The focus of this chapter is to develop the principles of kinetics into a framework to solve problems related to soil chemistry. For additional discussions on topics of soil chemical kinetics, the reader should consult recent books and monographs (Amacher, 1991; Sposito, 1994; Sparks, 1989, 1998a, 1998b, 1999).