

Dissolution of kaolinite using different acids and various pH-conditions

S. Schlabach
K. Techmer
A. Heydemann
H. Heinrichs

Geochemisches Institut, University of Göttingen, Goldschmidtstr.
1, D-37077 Göttingen, Germany

In recent years quite a number of investigations have been focused on the mechanisms by which acid deposition from the atmosphere is neutralized while passing through the upper horizons of a soil profile.

A large number of studies investigated mineral dissolution rates in the laboratory including data from minerals present in soils. The soils of Central Europe mostly contain quartz, feldspar, illite, chlorite, kaolinite, various mixed layer minerals, and organic material. The dissolution kinetics of some of these minerals are well documented, but the applicability of the reaction rates, measured in the laboratory, to weathering processes in the field still represents a major gap in our knowledge (Hochella and White 1990, Stumm, 1990).

Information about weathering processes in natural soil profiles are given by the composition of pore

solutions, squeezed from samples of the upper soil horizons. They show low pH values and high concentrations of a number of cations and anions, in addition dissolved organic carbon (Schlabach, 1996). The solved components are certainly influenced by the atmospheric input and their interactions with the mineral phases. The input of acids into the upper part of soils leads to proton controlled reactive processes. These processes are rather complex including ion exchange, sorption, desorption, dissolution, and precipitation, occurring either simultaneously or in a certain succession. In order to understand these complex weathering processes it is necessary to characterize and quantify the single processes. This can be done in experiments under controlled conditions using single clay mineral fractions, artificial mixtures of various clay minerals

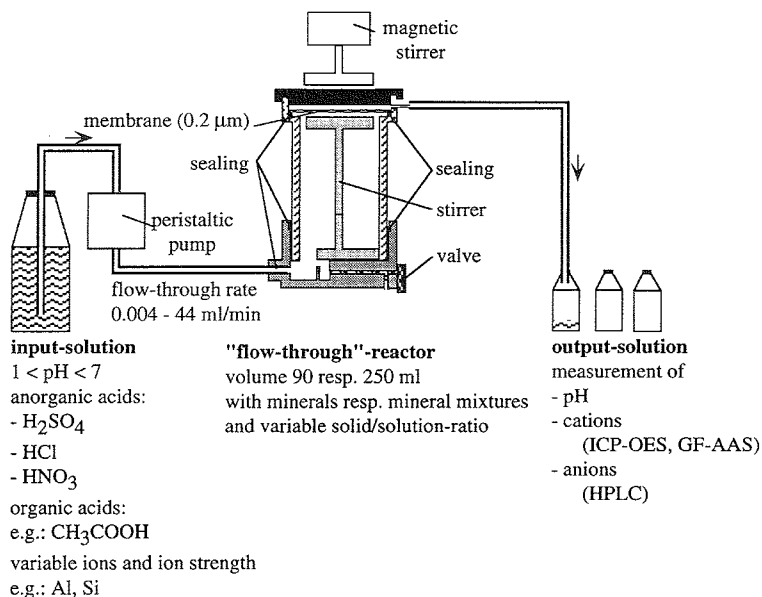


FIG. 1. Schematic structure of the flow-through experiments.

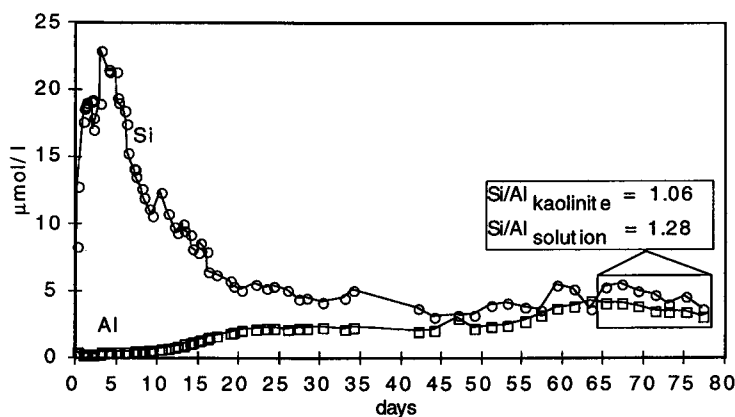


FIG. 2. Flow-through experiment with 180 mg kaolinite ($\phi = 0.63\text{--}2\ \mu\text{m}$) in 90 g sulphuric acid (pH = 2); flow-through rate is 1 ml/h; Si-content circles, Al-content squares.

or natural samples from special soil horizons. Clay minerals are characterized by their small grain size resulting in relatively large surface areas often combined with high ion exchange capacities.

The investigations of this project are mainly focused on layer silicates present in sediments and soils. During the course of the experiments layer silicates such as kaolinite, montmorillonite, and illite will be used either as pure components or in mixtures. The experiments will later be extended to natural soil samples.

Soils are open systems. Flow-through experiments offer the possibility to simulate open systems. Additionally the physico-chemical conditions like pH, composition of the input solution, solid/solution-ratio, and flow-through rate can be controlled and varied.

Figure 1 shows the experimental setting. Mineral fractions of well defined chemical and mineralogical composition are affected by solutions. The chemical composition and the pH-conditions of the input-solution is simultaneously controlled. The output-solution is collected continuously and analysed. Dissolution processes using different acids can be studied by changing the composition of the input-solution. Precipitation may be generated due to the oversaturation of the solution with defined ions.

Weathering and dissolution of minerals is a surface controlled process. The characterization of changes in the surface properties is fundamental for the understanding of weathering processes. Also changes in mineral morphology and crystallinity are significant parameters and will be studied by FEM, AFM, and TEM.

Kaolinite is a widely distributed mineral in soils and

consists of a relative simple structure and chemical composition. Therefore the experiments have been started with a well crystallized kaolinite from Zettlitz (Sedlec). This kaolinite was treated with different acids such as H_2SO_4 , HNO_3 , and HCl , which are the most important acids in soil acidification. The effect of the single acids on the weathering kinetics is investigated by varying the pH values.

For example in Fig. 2 a dissolution experiment of kaolinite in sulphuric acid (pH = 2) is illustrated. Only in the first five days Si increased significantly whereas Al shows only a slight increase. After 65 days a steady state was reached. The solution contains with a value of 1.28 a higher Si/Al ratio as the solid with a value of 1.06.

Batch-experiments with the same kaolinite in sulphuric acid (pH = 1) also results in a nearly congruent dissolution. The surface topography of the grains shows increasing roughness and rounding effects as a function of the duration of the experiment. Individual small "precipitates" were observed by AFM at the nanometer scale (Techmer *et al.*, 1997).

References

- Hochella, M. F. and White, A. F. (1990) *Rev. Mineral.*, **23**, 1–603.
- Schlabach, S. (1996) Thesis submitted for diploma, 99, unpublished.
- Stumm, W. (1990) *Aquatic chemical kinetics — reaction rates of processes in natural waters*, 545, John Wiley & Sons.
- Techmer, K., Schlabach, S., Heinrichs, H. and Heydemann, A. (1997) *EOS*, **78**, F202.