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Dissolution of smectite (beidellite) in acidic solutions using flow through reactors: New insights on interface reactions and the effect of crystal chemistry.

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In the context of remediation of acid mining environments (e.g., In Situ Leaching operated mining sites), swelling clay minerals such as smectite can be considered as buffer materials with the ability to remove contaminants from water (major and trace elements) due to their high cation exchange capacity. Then, the stability of smectitic minerals present in these environments and mechanisms occurring at the clay/water interface have to be assessed in acidic conditions. Dissolution rate of beidellite (di-octahedral smectite with tetrahedral charge), a common swelling clay mineral in surface and subsurface natural environment, was studied in acidic solutions at 25˚C under far from equilibrium conditions. The $<$0.3 μm size fraction of the SBId1 beidellite ($(Si_{7.148}Al_{0.852})(Al_{3.624}Mg_{0.18}Fe^{3+}_{0.224})O_{20}(OH)_4M^{+}_{0.948}$) from the Clay Mineral Society was used in this study. Experiments were performed using flow through reactors and HCl solutions with pH ranging from 1 to 3. Several hydrodynamic conditions were tested using different flow rates with stirred and non stirred particles. Aqueous Al/Si ratios were followed as a function of time and compared to the solid stœchiometry in order to assess the mechanisms occurring at the solid/solution interface. Al^{3+} reversible sorption in the smectite interlayer space was evidenced for pH$>$1, and the presence of amorphous Si enriched layer can be reasonably assumed in some cases from interpretation of aqueous concentrations and the characterization of the solid phase (X-ray diffraction and FTIR spectroscopy measurements). Beidellite dissolution rates normalized to the sample mass ($mol.g^{-1}.s^{-1}$) were obtained from Si and Al concentrations at steady state dissolution conditions. Calculated rates were compared with those previously obtained on montmorillonite (di-octahedral smectites with octahedral charge) and reported from several published works. It appears that the beidellite dissolution rates are in average ten times lower than montmorillonite ones. This observation implies a significant effect of the smectite crystal chemistry (i.e., amount of Al^{3+} versus Mg^{2+} or Fe^{3+} substitution in the structure) on its stability. Then, the good stability of beidellite at low pH conditions is of interest in the context of environmental remediation because such behavior allows to preserve the sorption capacity of smectites towards aqueous contaminants.