Anion exchange reactions in schwertmannite and its effects on stability

Morio Takada[1]; Keisuke Fukushi[2]; Chelo Pascua[3]; Tsutomu Sato[4]; Nonuyuki Yanase[5]

[1] Faculty of Sci.,Kanazawa Univ; [2] AIST; [3] Life and Earth Sci.,Graduate, Kanazawa-U.; [4] Inst. Nature, Environ. Technol., Kanazawa Univ.; [5] Terres. Res. G., JAERI

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Toxic heavy metal cycling is significantly controlled by minerals with anion exchange capacity in our environment. In acidic mine drainage (AMD), arsenic anion species HAsO42- is largely sequestered by the poorly-crystalline schwertmannite resulting to natural attenuation in surface waters (Fukushi et al., 2003). The efficacy of arsenic removal by schwertmannite has also been confirmed in that study. However, the potential of this mineral for application in remediation of AMD-affected environments containing other metal anionic species was not investigated the anion exchange reactions involved in the sequestration. Only a few related studies have been conducted on the toxic metal anion selectivity and its corresponding anion exchange reactions for schwertmannite. Such information will also enable the prediction of the stability of toxic metal anionic species adsorbed by schwertmannite. Anion exchange reactions with schwertmannite and the effects on its stability are investigated in this study for understanding the anion exchange reaction by schwertmannite in nature.

Sorption experiments of metal oxyanions on schwertmannite were conducted for HCrO4-, H2PO4-, H2AsO4-, and SeO42-. The schwertmannite used in this study contains 6.69 mmol/g Fe and 1.22 mmol SO4, respectively. Solutions containing 4.40mM of each metal oxyanions were prepared and made to react with schwertmannite (solid) in a 0.01M support electrolyte solution for 24 hours. Then, in order to investigate the selectivity of schwertmannite to each anion species, the re-adsorption experiment was conducted. It added and reacted schwertmannite adsorbed HCrO4-, H2PO4-, H2AsO4-, and SeO42- which prepared in the above-mentioned adsorption experiment into the experiment solution used in the above-mentioned adsorption experiment, respectively. The pH was adjusted to the stability field of schwertmannite and monitored as the reaction progressed. Reacted solutions were analyzed with ICP-MS and ion chromatography. XRD analyses were subsequently performed on the solids (i.e. schwertmannite). The effects of metal oxyanions adsorption on schwertmannite were assessed by conducting aging experiments at 50 degree centigrade with 100% relative humidity.

The amounts of adsorbed H2PO4-, HCrO4-, H2AsO4- and SeO42- on schwertmannite are 0.24, 1.04, 1.36, and 1.96 mM, respectively. Anion selectivity follows the order: SeO42- , H2AsO4- , HCrO4- , H2PO4- (in decreasing order). And the difference of the exchange nature of anion species could be checked as a result of the re-adsorption experiment. In schwertmannite adsorbed various oxyanions added in the solution of H2PO4-, HCrO4-, H2AsO4-, and SeO42- of initial concentration 4.40mM, in case of only schwertmannite adsorbed H2AsO4- and SeO42- was added and reacted into the experiment solution of HCrO4-, exchange nature was relatively bad compared with other patterns. For the aging experiments, goethite transformation was detected after one month only in the schwertmannite with adsorbed chromate.