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Regulation of dissolved phosphate through incorporation into schwertmannite

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Phosphate is known to absorb strongly to schwertmannite ($Fe_8O_8(OH)_6(SO_4)\cdot nH_2O$)[1] and as such, schwertmannite has been proposed to limit phosphate in solution in acid mine drainage (AMD) environments. This in turn will limit phosphate availability to the micro-organisms that live in and propagate AMD[2]. Here we have studied sediment samples from the Rio Tinto river in Spain collected during Europlanet field area visit to verify whether phosphate can be incorporated into sulphate-rich minerals in this river. The minerals were identified using X-ray diffraction. Our analyses show that the concentration of phosphate in the river is in the nM range. Digestion of modern sediments in nitric acid followed by inductively coupled plasma atomic emission spectroscopy (ICP-AES) analysis indicate that sites with sulphate-rich minerals are correlated with elevated phosphate concentrations. In addition, phosphate is also retained in ancient sediments that are dominated by goethite (FeO(OH)).

We have also conducted experiments to explore the competition between Fe^{3+}, phosphate and sulphate ions in solution as well as the effect of this on schwertmannite nucleation. UV-Vis and Raman spectroscopy demonstrate that contact ion pairs form between Fe^{3+} and phosphate or sulphate in solution. Particularly, phosphate and sulphate compete for Fe^{3+} in solution consistent with predictions by the solution speciation modelling program PHREEQC. Our experiments also show that above a critical concentration, phosphate retards the nucleation of schwertmannite. As this critical concentration is above that found in Rio Tinto river fluids, phosphate is expected to have a limited role in schwertmannite precipitation, but, its concentration is regulated by its incorporation into schwertmannite and other sulphate-bearing phases in AMD systems.

References

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