Microbial biomineralization and redox transformation of As and Fe in an acid mine drainage

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Bulk chemical and mineralogical data (bulk XANES, EXAFS and XRD) showed that indigenous bacteria living in the As-rich Carnoules Acid Mine Drainage ([As] = up to 350 mg.l-1) play an important role in the nature and composition of the solid phases that sequester arsenic at the site: some bacteria oxidize Fe(II) but not As(III) and promote the precipitation of a rare ferric arsenite sulfate oxy-hydroxide mineral, called tooeleite (Morin et al. 2006), while other bacterial species catalyze As(III) to As(V) oxidation leading to the formation of amorphous As(V) rich ferric oxy-hydroxides (Morin and Calas 2006).

In order to better document the interactions between microbes and Fe and As redox processes in the Carnoules AMD, we combined Scanning Transmission X-ray Microscopy (STXM) and Transmission Electron Microscopy (TEM) to collect near-edge x-ray absorption fine structure spectra (NEXAFS) at high spatial and energy resolution and to perform high resolution imaging at the submicrometer scale, following procedures described previously (Benzerara et al., 2006). Spectromicroscopy was performed at the C K-edge, Fe L2,3-edge, and As L2,3-edge offering the possibility to locate living and/or mineralized bacterial cells and to characterize Fe and As oxidation states in the vicinity of those cells. Many precipitates were found associated with extracellular organic polymers. Moreover, some As-Fe precipitate show a vesicular appearance that we interpret as microbial cell’s products. TEM was used to image the same areas, providing higher resolution images and complementary crystallographic and chemical information through electron diffraction and EDX analysis. This approach offers a unique opportunity to assess at the submicrometer scale the various and heterogeneous geochemical activities of complex microbial communities in acidic environments.

References