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Nanoscale study of As and Fe redox transformations by bacteria in acid mine drainage

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Morin et al.[1] evidenced spatial and seasonal variations of the oxidation of Fe(II) and As(III) in the Carnoulès (Gard, France) Acid Mine Drainage (AMD) by using bulk XANES, EXAFS and XRD. Chemical and mineralogical data showed that indigenous bacteria living in the As-rich Carnoulès water ([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, while other bacterial species catalyze As(III) to As(V) oxidation leading to the formation of amorphous As(V) rich ferric oxy-hydroxides.

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[2]. Spectromicroscopy was performed at the C K-edge, Fe $L_{2,3}$-edge, and As $L_{2,3}$-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. 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 the environment.

1 Morin et al. (2003) Bacterial formation of tooeleite and mixed As(III)/(V)-Fe(III) gels in the Carnoulès acid mine drainage, France. A XANES, XRD and SEM study. *Environ. Sci. & Technol*. 37,1705-1712.

2 Benzerara K., Yoon T.-H., Menguy N., Tyliszczak T., and Brown G. (2005) Nanoscale Environments Associated with Bioweathering of a Meteoritic Mg-Fe-Pyroxene. *Proc. Natl. Acad. Sci. USA*, 102, 979-982.