

Micro-PIXE study of toxic elements in iron sulfates precipitated from acid mine waters

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Iron Mountain in California, USA, is a site of spectacular acid drainage where mine waters have pH values as low as –3.4, temperatures as high as 47°C, and extremely high concentrations of metals, notably Cu, Zn and Cd. Within the underground workings, located high on a mountain, iron sulfates precipitate during dry summers and dissolve during rainy winters.

In order to understand how the formation and dissolution of these secondary minerals control the attenuation and release of potentially toxic elements to the mountain streams, the major and trace element composition of iron sulfates collected underground was determined using electron microprobe and micro-PIXE analysis.

True elemental x-ray imaging of mineral grains was performed using the nuclear microprobe at Materials Research Group, iThemba LABS. Mapping was initially conducted using GeoPIXE-I with pre-selected set of elements, and next using GeoPIXE-II with list-mode data storage and off-line processing. Three analysed hydrated ferrous sulfates – romerite, coquimbite and szomolnokite – showed very inhomogeneous distribution of Fe, Cu, Zn, As and Pb. Surprisingly, such inhomogeneity was not found in voltaite, a K-bearing, hydrated, mixed ferrous-ferric sulfate. Other elements - Cr, Mn, Ni, Ge, Se, Rb, Sr, Y, Nb, Mo, Rh, Pd, Cd, In, Sb, Tl, Bi – were found at concentrations too low to show distribution details in elemental maps. For selected areas within mineral grains the agreement between concentrations obtained using Dynamic Analysis and from fully deconvoluted spectra was very good, with differences not exceeding estimated analytical errors.

These results can be combined with water analyses to refine geochemical modeling, predict metal release and improve remediation strategies at Iron Mountain.