Trace metal hosts in stream sediments impacted by mine waste

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Identifying trace metal hosts in mine waste is essential for remining waste and planning remediation efforts. Determining such phases can be challenging when host material is noncrystalline, nanoparticulate, or below the detection limit of readily available analytical techniques. Such challenges may be overcome with the recent emergence of automated mineralogy (AM) systems that interface with a scanning electron microscope (SEM) with energy dispersive spectroscopy (EDS) capability. These systems work to collect thousands of EDS spectra from a single thin section of epoxy-mounted sediment, compare the spectra to known spectra in a customized database, then map the mineralogy of the thin section and quantify solid phase abundance and grain size. This technology preserves important textural relationships within single grains.

In this study we compared the modal mineralogy obtained by quantitative bulk X-ray diffraction (XRD; using Rietveld refinements) to that obtained by AM on thin sections of sediments contaminated with metals at a historical mine site in Vermont, USA. The objective was to identify the solid phase hosts of copper, the trace metal present in highest concentration. The results were compared to copper speciation results from a previous study using synchroton-based X-ray spectrosopy (XAS) and X-ray fluorescence (XRF).

We analyzed seven contaminated stream sites and found that modal abundance based on XRD compared to that on AM was correlated best for muscovite (slope=0.5, r^2 = 0.85) and least for chalcopyrite (slope=0.4, r^2=0.06). XRD tended to give higher predictions than AM except for goethite, jarosite, chalcopyrite and garnet. Based on XRD results, 9-11 wt. % of the sediments were amorphous, which probably corresponds to Cu-, Mn-, and Fe-rich oxides detected with AM. Seventeen minerals were identified with AM that had not been recognized with XRD, including some that host copper and are consistent with XAS and XRF results. Our results highlight both the benefits and challenges in implementing AM techniques in studies of economic and toxic metals in mine waste.