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Application of automated mineralogy to characterize and quantify trace metal residence in fluvial sediments impacted by legacy mining

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Automated mineralogy (AM), a scanning electron microscopy (SEM)-based technique developed for mining applications that is increasingly being used in broader geochemical investigations, uses backscattered imaging and multiple energy dispersive X-ray spectroscopy detectors to rapidly classify and quantify minerals in samples consisting of tens to hundreds of thousands of particles. Software allows multiple approaches to sort and view target minerals (e.g., by size) and facilitates further detailed analyses (e.g., electron microprobe).

The Big River drains historical lead mining districts in southeastern Missouri, including the Old Lead Belt (OLB). Chat piles and tailings impoundments from extensive underground mining (1864-1972) have released large volumes of lead, zinc and cadmium-bearing material into the watershed resulting in widespread environmental issues. Riverbed sediments, suspended sediments, and recent flood deposit samples were analyzed by AM, focusing on <63µm size fractions. Up to 280,000 grains were analyzed per sample with at least 80 weight percent of grains in all samples classified as quartz and feldspar (natural source) or carbonates (dolomite, ankerite, and calcite which dominate OLB mine waste). These mineral abundances correlated strongly with whole sample total silicon, calcium, magnesium, and inorganic carbon. Carbonates in some samples reached upwards of 30 weight percent, demonstrating the large extent of sediment contamination by mine waste and explaining sediment lead concentrations as high as 5,000 mg/kg.

Three dominant lead-bearing phases were identified: galena, cerussite, and lead-bearing iron oxide. Combined, these phases typically comprised much less than one weight percent of each sample making manual identification and quantification by traditional SEM onerous. Relative abundance progressed from galena and cerussite near mined areas to lead-bearing iron oxides further downstream and into the Meramec River into which the Big River drains. This is consistent with a published X-ray absorption spectroscopy study and suggests weathering of tailings with downstream transport. Sparse sphalerite particles were also identified and, when compared with cadmium concentrations, indicate weathering of cadmium from sulfide to more labile phases with transport, consistent with sequential extraction studies. Overall, AM proved promising for assessing trace metal residence in Big River sediments and we are currently applying it in another mining impacted watershed in Colorado.