Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.13128

Automated mineralogy to characterize residence of lead in fine grained sediment along a river impacted by historic lead mining in southeast Missouri, USA

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The Big River drains historical lead (Pb), zinc, and barite mining districts in Southeast Missouri, including the Old Lead Belt (OLB). Underground mining (1864-1972) resulted in chat piles and tailings impoundments that released Pb-bearing material to the watershed. These sources have been stabilized, but huge volumes of sediment continue to store and release concerning amounts of Pb. We are exploring sediment collection and analytical methods to characterize major host phases of Pb and understand their release and transport under different hydrological regimes, from base flow to extreme flood. Here we emphasize results from scanning electron microscopy automated mineralogy analysis for quantification of rare Pb-bearing grains that result in bulk Pb concentrations of environmental concern.

Bed sediments, suspended sediments, and recent flood deposits were collected along 200 km of the Big River from above the OLB to near its mouth at the Meramec River. Fine-grained (<63 mm) material comprised <1 wt % of riverbed sediments but dominated suspended sediments and flood deposits. Lead concentrations were consistently highest in flood deposits and lowest in bulk (<2 mm) bed sediments. Concentrations were intermediate in fine-grained bed and suspended sediments. Fine-grained sediments collected within the OLB had Pb concentrations of 800-4,500 mg kg^{-1} while those collected near the mouth of the river were lower but still of environmental concern (600-1,200 mg kg^{-1}).

Up to 280,000 grains per sample were analyzed by automated mineralogy. At least 85 wt % of grains in all samples were quartz, feldspar, and carbonates (dolomite, ankerite, calcite) and major mineral abundances correlated well with bulk chemistry. Carbonate minerals reflect the gangue that dominates tailings and their high abundance (up to 20 wt %) in some fine-grained sediments demonstrates the large extent of contamination. In contrast, only up to 20 grains of galena (dominant Pb ore mineral) and 74 grains of cerussite (secondary ore mineral and/or galena weathering product) were detected in each sample. These rare grains account for much of the Pb in some samples. A Pb-bearing iron oxide phase was also prevalent and became a more dominant host of Pb downstream of the OLB, suggesting weathering accompanies transport.