# The influence of colloidal phases on Hg-transport from mercury mine waste tailings: A laboratory case study of the New Idria and Sulphur Bank Mines, California, USA

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Waste tailings from historic mercury mining sites release a significant amount of mercury to the environment posing contamination threats to local drinking-water sources and fish populations. Natural colloidal phases are thought to play an important role in the release and transport mechanisms of mercury from mine sites. This study uses laboratory column experiments to understand the potential influence of colloidal release/precipitation on the transport of mercury from mine waste tailings and the potential implications this may have for remediation of these sites. Column experiments were performed using mine tailings (calcines) from the New Idria (NI) and Sulfur Bank (SB) Hg mines in CA. Calcines were dry sieved (8 size fractions spanning 2.8mm to <0.045mm), and each fraction was characterized using XRD, BET, laser scattering, TEM/EDAX, and cold vapor atomic fluorescence spectroscopy (CVAFS). For the NI calcines, BET surface areas and Hg concentrations increase with decreasing particle size, ranging from 10 $m^2/g$ and 350 ppm Hg ($2mm>d_p>0.5mm$) to 19 $m^2/g$ and 770 ppm Hg ($d_p<0.045mm$). For the SB calcines, BET surface areas are higher than for NI, the maximum occurring in the size range $0.5mm>d_p>0.25mm$ (84 $m^2/g$) and decreasing both below that range (61 $m^2/g$, $d_p<0.045mm$) and above that range (66.5 $m^2/g$, $2.7mm>d_p>2mm$). XRD indicates that the NI calcines consist of quartz, alunite-jarosite, and hematite, with the fraction of quartz decreasing with decreasing particle size. TEM analysis of the NI $d_p<0.045mm$ size fraction also indicates an additional poorly-ordered Si-Al-containing phase. XRD and TEM indicate that SB calcines consist of quartz, hematite, plagioclase feldspars, and montmorillonite.

Chromatographic columns filled with NI or SB calcines ($2.0mm<d_p<0.5mm$) were preconditioned by leaching with approximately 100 pore volumes of 0.1M NaCl. Colloid generation was then initiated by leaching with 5mM NaCl. A pH buffer (15mM malonic acid/25mM NaOH, pH=5.8) and biocide (1mM sodium azide) were present in all steps.

The NI calcines released significant quantities of Hg-bearing colloids in the 50nm to 400nm size range. TEM/EDAX analyses indicate that colloids (Figure 1) consist of crystalline alunite-jarosite, iron oxide, and a poorly ordered Si-Al gel phase; thus the colloids are similar in composition to the bulk material. Total Hg concentration in the column effluent is less than 75 μg/L (ppb) during preconditioning, but up to 2000 μg/L (ppb) when containing colloidal particles, indicating that mercury associated with colloids may be a significant transport mechanism for the NI tailings. The SB column effluent contained no observable colloids until the pH was increased to 8.0 resulting in the precipitation of colloidal material. TEM/EDAX indicates this is a poorly ordered Al-Si-Fe rich gel similar to that observed at the waste pile dam/lake interface next to the Sulphur Bank Mine (Clear Lake, CA). EXAFS analysis of this synthetic flock indicates that mercury can be associated with this colloidal material.

This study demonstrates the importance of colloidal phases in the transport of mercury from mine sites. Colloid generation can occur via two mechanisms; a detachment/breakup of the bulk matrix as observed for the New Idria mine waste, or dissolution/reprecipitation as observed for the Sulphur Bank site. The association of mercury with these colloidal phases indicates that mercury transport may be strongly linked to colloid movement, and that transport of mercury as a dissolved phase may be relatively minor.

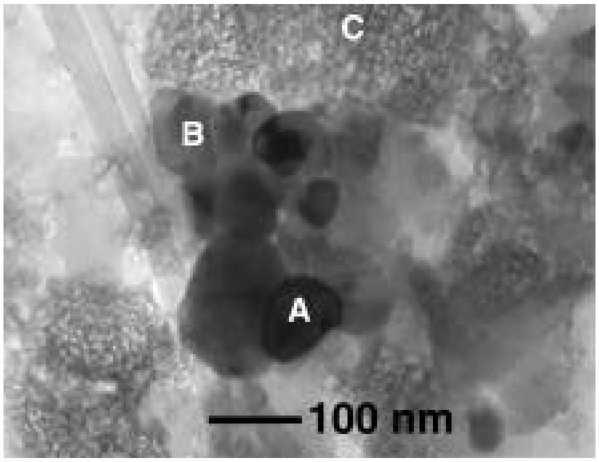

**Figure 1.** TEM micrograph of colloids generated from the New Idria mine waste. A = hematite ($Fe_2O_3$) B = alunite-jarosite ($K(FeAl)_3(SO_4)_2(OH)_6$) and C = poorly-ordered Al-Si gel. Note that the primary particle grain size of all the phases is less than 0.1μm.