Arsenic and Mercury Contamination from Historical Gold Mine Tailings in Nova Scotia

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Historical stamp milling and Hg amalgamation activities at lode-gold mines in southern Nova Scotia have generated more than 3 million tonnes of tailings. From 1861 to the mid-1940s, gold was mined in 64 districts throughout the Meguma Terrane, resulting in a total production of 1.2 million oz. (37 tonnes) of gold. Most of this gold was recovered using Hg amalgamation, and an estimated 10-25% of the Hg used was lost to the tailings and to the atmosphere. In addition to Hg added during the milling process, toxic metal(oid)s (primarily As) also occur naturally in the ore, and are present at high concentrations in the mine wastes. Tailings from these early operations were generally slurried into local rivers, swamps, lakes, and the ocean with little or no consideration of their impacts on receiving environments.

This study is a multi-disciplinary, multi-partner investigation of the dispersion, transformation, and fate of metals and metalloids in freshwater and marine environments surrounding abandoned gold mines in Nova Scotia. From 2003 to 2005, samples of tailings, soil, till, rock, sediment, water, and/or vegetation were collected at 15 past-producing gold mines. Field studies reveal that most mine sites contain large volumes of unconfined tailings, which are generally located in low-lying areas downslope of stamp mill sites. In some districts (e.g. Goldenville, Upper/Lower Seal Harbour) the tailings have been transported significant distances (>2 km) offsite by local streams and rivers. At most mines, the tailings are overgrown and often difficult to recognize; however, some tailings deposits have recently been disturbed by human activities (e.g. gold panning, fill excavation, off-road vehicle usage).

Whole-rock chemical analysis of unmineralized Meguma Group bedrock away from lode-gold deposits suggests background levels for Hg and As to be ~3 ppb and <5 ppm, respectively. Within gold districts, however, concentrations for Hg and As in the ore zones average ~50 ppb and ~1 000 ppm, respectively. Chemical analyses of 433 tailings and downstream sediment samples show high concentrations of Hg (<5 ppb to 350 ppm; mean 7 ppm) and As (9 ppm to 31 wt.%; mean 1 wt.%). The highest Hg levels are found near mill structures, reflecting Hg loss during amalgamation and retorting. Droplets of elemental Hg and particles of amalgam (Au_xHg_x) have been observed in the tailings at several locations; however, Hg may also exist in secondary phases (e.g. metacinnabar, HgS), or may be sorbed to mineral surfaces and/or organic material. Arsenic concentrations >1 wt.% (measured in ~22% of all tailings/sediment samples) are generally restricted to areas where arsenopyrite (FeAsS) concentrates are present, or where weathering of the tailings has concentrated As in secondary phases such as scorodite ($Fe^{III}AsO_4 \cdot 2H_2O$). Water chemistry data indicate that dissolved As concentrations are very high at some locations (0.2 to 6600 ppb; mean 390 ppb; n = 122), as compared to background levels of generally <25 ppb. Dissolved Hg levels range from 1 to 60 ppt (mean 13 ppt; n = 122), and show a significant positive correlation with dissolved organic carbon at most sites. In general, the dissolved Hg concentrations in surface waters are relatively low (i.e. <20 ppt) even close to tailings with high (i.e. >1000 ppm) levels of Hg, suggesting that most of the Hg is present in relatively insoluble forms.

Ongoing studies by the authors and other project partners are characterizing the background levels, seasonal variability, speciation, mobility, and bioaccumulation of metal(loid)s in both freshwater and marine systems. Results from this study have recently led to the formation of a provincial-federal Historic Gold Mines Advisory Committee (http://gov.ns.ca/enla/contaminatedsites/goldmines.asp). This committee is evaluating the potential ecological and human health risks associated with gold mines throughout Nova Scotia, and developing recommendations for management of these tailings sites.

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