Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18048

Co-contamination of dissolved antimony, arsenic, and fluoride in mining-influenced aquifers from the Xikuangshan antimony mine, China

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The mining of antimony ores may release many kinds of pollutants, including antimony and arsenic. Both antimony and arsenic have been listed as priority pollutants of interest in many countries because of their highly toxicity and relatively high mobility. Therefore, the WHO has recommended a guideline of antimony and arsenic concentration with 5 and 10 μg/L in drinking water, respectively. Chronic ingestion of high fluoride groundwater (>1.5 mg/L) may also cause inverse health consequences. The cooccurrence of high groundwater antimony, arsenic, and fluoride concentrations in a mining-affected aquifer was previously documented, while geochemical processes controlling their fates remain poorly understood. Along these lines, the Xikuangshan antimony mining area of China, the world's largest antimony mine, was selected as the study area. In the area, 75 groundwater samples were collected and analyzed for antimony, arsenic, and fluoride concentrations.

Results show that dissolved antimony, arsenic, and fluoride concentrations had a wide range of 0.0001–22.1, 0.0009–28.8, and 0.075–11.9 mg/L. Concentrations of the three elements were significantly positively correlated between each other ($r > 0.7$; $p < 0.001$), which possibly indicating that their fates were controlled by similar geochemical processes. The significant positive correlation between groundwater SO_4^{2-} and antimony, arsenic, and fluoride concentrations ($r > 0.6$; $p < 0.001$) may indicate that the oxidation of stibnite and/or arsenopyrite during the mining activity were responsible for the elevated antimony and arsenic concentrations. During the process, the produced H^+ may also facilitate fluorosilicate weathering to cause high fluoride groundwater. On the other hand, groundwater Ca^{2+} were significantly negatively correlated with antimony, arsenic, and fluoride concentrations ($r < -0.6$; $p < 0.001$), indicating that higher Ca^{2+} concentrations were responsible for the lower antimony, arsenic, and fluoride concentrations. This may be due to the precipitation of calcium antimonate, pharmacolite, and fluorite favored by high Ca^{2+} concentrations, as evidenced by the geochemical solubility calculations. The study suggests that higher antimony, arsenic, and fluoride groundwaters are tended to occur in silicate weathering-dominated aquifers with lower Ca^{2+} concentrations.

Acknowledgements:

The study was financially supported by the National Natural Science Foundation of China (grant No. 42201044).