Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34654

Long-term geochemical stability of vitrified-arsenical glass in contact with underground-mine water

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Historical roasting of arsenopyrite (FeAsS) ore at the Giant Mine (Yellowknife, NT) generated 237,000 tonnes of arsenic trioxide roaster waste (As dust), currently stored in underground chambers and mined-out stopes, posing significant risks to the surrounding environment. Vitrification of the As dust has been proposed as a potential stabilization approach to limit the release of As. Previous selective extractions on the arsenical glass demonstrated vitrification of the As dust substantially decreased concentrations of As in environmentally relevant solutions. This study evaluated the stability of arsenical glass in contact with continuously flowing underground-mine water. Three arsenical glasses, each prepared with different amounts of the As dust from the Giant Mine by Dundee Sustainable Technologies, with particle sizes between 5 and 15 mm, were packed into acrylic columns. An influent solution, with a composition similar to the underground-mine water at Giant Mine, was continuously pumped upwards through each column at an average flow rate of 1 mL h^{-1} over three years. The experiments were conducted in an anaerobic chamber to mimic the reducing environment present under flooded-mine conditions. Aqueous samples from column effluents were analyzed to monitor changes in composition, and solid samples from each column were collected over the experimental duration to examine temporal alteration of the glass. Less than 0.1% of total As in the glass was released during the 3-year experimental period. The rate of As release increased at early time and then decreased at later time. Reductive dissolution of Fe and Mn impurities in the glass may be associated with the increase in As release. The decrease in As release at later time may be related to generation of dissolved sulfide and formation of secondary sulfide phases. Results of this study indicate that arsenical glass is generally stable when in contact with flowing groundwater in a reducing environment. Potential application of the vitrification technology to stabilize As dust necessitates a strong understanding of geochemical storage conditions before applying this approach at a large scale.