Arsenic speciation in waters draining historical Alaskan mine sites

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Alaska has approximately 6,800 abandoned hardrock mines. It continues to be an active exploration target of mining companies, with several large mine projects in the permitting stage. The environmental impact of these projects is hotly debated, in part because of the legacy of contaminated mining lands in the state. Arsenopyrite is a ubiquitous accessory mineral in many Alaskan ore deposits and consequently, water draining abandoned mine sites is frequently elevated in arsenic. The mobility of arsenic in such water systems is largely controlled by the valence state of the arsenic species present and speciation is therefore an important tool in predicting the environmental impact of mine drainage.

To investigate arsenic speciation, water samples were collected at four historical mining sites in Alaska; Lucky Shot mine, Red Devil Mine, Golden Zone and the Hi-Yu mine, from streams and adits draining mine workings and tailings piles. Sites were selected based on their sulphide mineralogy and the presence of other potentially toxic metals, such as Sb and Hg in the system. Arsenic species were separated in the field using anion-exchange chromatography, for later analysis by ICP-MS and hydride generation atomic fluorescence spectrometry.

At all of the study sites, the dominant inorganic arsenic species was arsenite, (As(III)), even though the arsenate (As(V)) species should be stable at the measured pH and Eh, which were generally circum-neutral and oxidising. One possibility is that arsenate species are more readily absorbed on mineral surfaces and consequently less mobile. The presence of other metal species, such as Sb(III) may also impact arsenic speciation at some sites. Stable isotope analysis of water samples indicates that the water these sites has a short residence time, limiting the time for thermodynamic equilibrium to be attained and further favouring the predominance of arsenite species at the expense of arsenate. Suggestions for possible remediation options are provided for the site that limits the mobility of all potentially toxic metals.

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