

Verification of the processing method learnt to natural attenuation mechanism in AMD and characteristic of precipitation

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1.Introduction

Sulfide ores in abandoned mines react with dissolved oxygen in groundwater and atmosphere to generate acidic mine water that contains high concentration of dissolved metals such as arsenic, ferrous iron, and copper. Acid mine drainage (AMD) condition that result after the closure of the mines has become a problem in Japan and has the potential to pollute surrounding areas.

About 100 abandoned mines in Japan has experienced AMD conditions and are usually treated by neutralization. However, this remediation method is upset by two main problems: (1) an enormous expenditure which cannot be supported financially by the previous mine operator; and (2) not all the tailings can be contained in dams to neutralize the sludge.

As a case study, a novel remediation method has been applied for the Horobetsu mine in Hokkaido, Japan which contains high dissolved As concentrations. The poorly-crystalline schwertmannite which is generated by iron-oxidizing bacteria, was used to remove the high dissolved As content of acidic mine waters. Its efficacy in As uptake though sorption has been documented in the natural attenuation of acidic mine waters in Nishinomaki, Japan (Fukushi et al., 2003). This study which is handled jointly with the Metal Mining Agency of Japan demonstrates the advantages and feasibility of utilizing schwertmannite as a novel remediation method for removing high concentrations of dissolved As in AMD affected areas.

2.Experimental methods

An experimental facility was designed and constructed to treat AMD affected water from the abandoned Horobetsu mine. It has been known that schwertmannite is generated by acidic pH conditions and by the Fe-oxidizing effect of bacteria which was simulated in a flow-through system in the experimental facility.

Briefly, acidic mine water (pH 1.8, ORP 400mV) was continually pumped into a reaction tank that contains the Fe-oxidizing bacteria. The pH was adjusted (pH 3.5) with 5% Ca(OH)₂ suspension and oxidized to at least 500 mV (ORP). The reacted mine water was then transferred to a precipitating equipment where the solid and liquid components were separated. The solids which also contain the bacteria were incrementally re-circulated to the reaction tank.

The treated mine water was monitored for changes in pH, ORP and EC. Samples of the liquid were analyzed with ICP-MS and liquid chromatography. Some of the precipitates (solids) were sampled and a sequential extraction method was applied. The sequential extraction method involved deionized water (water-soluble salts), MgCl₂ (exchangeable salts), Morgan solution (carbonates), TAO (schwertmannite, poorly-crystalline and amorphous Fe-Al-Si minerals), CBD (crystalline oxides) and 6M HCl (clay minerals).

Schwertmannite sorption experiments were further conducted in situ (Horobetsu mine) and in the laboratory. In the in situ experiments, the pH and ORP was adjusted to oxidize arsenite species present in the mine water since schwertmannite is more selective with arsenate species. Arsenate and a simulated AMD-affected mine water was used in the laboratory sorption experiments.

3.Results and discussion

Results of water analyses indicate that dissolved Fe and As in the treated mine water was almost completely removed after the method described previously was applied. Sampled precipitates (solids) analyzed with the sequential extraction method comprises 24% gypsum and 67% schwertmannite. In situ sorption experiments show that dissolved As was not adsorbed by the schwertmannite, but were effectively adsorbed and removed in laboratory sorption experiments. These results show that dissolved As in AMD-affected water from the Horobetsu mine can be removed through in situ precipitation of schwertmannite in the experimental facility.