A behavior of arsenic in drainage from arsenic mine dump in Kiura mine

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Arsenic was produced from mining operation in Japan as well as other heavy metal. However, all of them already stopped the operation at the present. Many abandoned mine must conduct the treatment and management of the mine drainage containing arsenic. However, the cost of maintenance is large because the mine drainage is generated semi-permanently. In order to perform the effective management and remediation of mine drainage, it is important to understand the behavior of arsenic in the drainage. In this context, the objective of the study is to reveal the behavior of arsenic in the drainage from arsenic mine dump in Kiura.

In Kiura mine, the drainage comes out from the small ditch of the tailing dam at dumped area. The drainage is mixing with the stream water from the open channel, and then mixing with the large tributary in the area at downstream. pH, Eh and electric conductivity were measured at several site in the vicinity of the area. In addition, Fe(II) and total Fe contents were measured at each site using Pack Test kit. The water and precipitates were corrected from the several sites. The water samples were filtrated in the site and serve for the solution analyses by alkalinity titration, ICP-MS and ion chromatograph in laboratory. The precipitates serve for X-ray diffraction, infrared spectroscopy, SEM observation, and selective extraction analysis. Moreover, the geochemical modeling of the drainage was performed by using The Geochemist Workbench (GWB).

The drainage from the ditch is characterized to neutral pH and low Eh and contains much amount of sulfate, iron and arsenic. From the dissolved species, it can be determined that the contaminated water has been generated within the mine dump by the process of oxidative dissolution of arsenopyrite and pyrite. The solution yielded by the oxidative dissolution of sulfide is known to exhibit acidic pH. However, the reaction modeling of GWB indicates that the neutral pH of the drainage is achieved by (1) reduction of Fe(III) to Fe(II) under the reductive condition and (2) mixing with the underground water containing bicarbonate ion.

Arsenic content in the drainage drastically decreases after mixing with the stream water from the open channel. The dilution ratio estimated from the change in sulfate concentrations indicates that the concentration of arsenic was lower than the expected from the simple dilution. On the other hand, the arsenic was rich in the precipitates at the level in 40mg/g. The enrichment indicates that the precipitates scavenge much arsenic from the drainage. These precipitates are mainly composed of schwertmannite and ferrihydrite. On the contrary, the speciation-saturation analysis shows that these minerals do not thermodynamically form at this drainage condition with insufficient inorganic oxidants. In the precipitates, however, the substances implying the existence of iron bacteria were frequently observed by SEM. If activity of the bacteria is great, Fe(II) is oxidized to Fe(III) via metabolism of iron bacteria and Fe(III) is quickly distributed to solid phase due to their low solubility. Especially in the case of quick oxidation, pH is drastically lowered because of the hydrolysis of Fe(III). It would make the formation of schwertmannite possible. The reaction presumably occurs at the local region in the vicinity of bacteria. Although arsenic in the drainage is expected to exist as As(III) from the speciation modeling, that in the precipitate is observed as As(V) from the infrared spectra. If the precipitates formation were mediated by iron bacteria, the increase of Fe(III)/Fe(II) ratio make the redox potential high value around the bacterial surface. Thus, arsenic is also oxidized to As(V) and then sorbed to the precipitates. Consequently, the precipitation of iron minerals with bacterial activity and the sorption of arsenic to the minerals play a significant role on the attenuation of arsenic even in neutral pH and low Eh condition.