A process of natural attenuation in drainage from an abandoned arsenic mine. K. Fukushi¹, M. Sasaki¹, T. Sato¹, N. Yanase¹ and H. Amano², ¹Division of Global Environmental Science and Engineering, Graduate School of Natural Science and Technology, Kanazawa University, Kakuma, Kanazawa, Ishikawa 920-1192 Japan, e-mail: fukushi@earth.s.kanazawa-u.ac.jp, ²Department of Environmental Sciences, Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, 319-1195 Ibaraki, Japan

Introduction: Sulfide minerals brought to the surface by mining operation are dissolved at oxidative condition and make the surface water to acid mine drainage (AMD). AMD is rich in contaminants and seriously affects to the biota at the mine district. Therefore effective management and remediation of AMD are necessary before AMD flow to the human life environment. The water quality of AMD is controlled by several factors such as hydrology, geology and geochemistry of the mine districts. In order to perform the effective management and remediation of AMD, it is important to understand the relation of the AMD quality to the above factors. At the Nishinomaki abandoned arsenic mine in Gunma prefecture, Japan, the water quality of the stream where waste rocks were dumped is acidic and rich in arsenic. In this area, the management of the AMD has not been performed at all. In spite of no management, the arsenic concentration in the stream water is naturally attenuated and remarkably lowered at downstream. Water and sediments were investigated to understand the process and mechanism of natural attenuation of arsenic that is anionic form contaminants.

Samples and methods: At the mining district, ground water continuously drains from the old adit sealed by concrete. The stream infiltrates through the piled waste rocks or flows on the waste rocks and then mixes with larger tributary at the downstream. The two tailing dams are established between the old adit and downstream. In upward of second tailing dam, the waste rocks are piled up as filling V-shape gully. On the other hand, the voluminous secondary ochreous precipitates are formed in downward of the dam.

pH, Eh and electric conductivity were measured at each site located from upstream to downstream of the mine district. The water, waste rocks and precipitates are also collected at the each site. The water samples were filtrated in situ using a 0.20 μm membrane filter, and served for ICP-MS analyses and ion chromatograph in the laboratory. Waste rocks and ochreous precipitates were served for X-ray diffraction, infrared spectral analysis, SEM observation and EPMA element map analysis. Selective extraction technique was applied for the ochreous precipitate and the chemical form of arsenic in the precipitates are estimated from the distribution of arsenic in the speciation and the saturation index of the stream waters and stability fields of some minerals phase extracted using the ICP-MS and ion chromatograph analyses. The observed in this study were calculated by using the computer code The Geochemist’s Workbench® [1].

Results and Discussion: From the mineralogical and chemical characterization of collected samples with calculations of geochemical code, the controls of chemical evolution of arsenic in abandoned mining area are better understood. Pyrite and realgar contained in the piled waste rock are oxidized at the surface and release heavy metal, sulfate, arsenate and proton at the upstream. While concentrations of several dissolved components and proton keep on constant high value until mixing point with larger tributary, these of iron and arsenic are significantly lowered by some chemical processes. Although the dissolved iron released mainly exists as ferrous form in bulk solution, it transforms to ferric form by locally occurred bacterial oxidation. Additionally in the water condition containing high amount of sulfate and proton, schwertmannite rapidly forms and deposits.

The iron precipitates contained much amount of arsenic (up to 7 wt%). At an acidic condition, iron functional group of iron hydroxide exhibit the high sorption affinity to arsenate. Moreover schwertmannite is excellent scavenger of arsenate because it can exchange the structural sulfate with arsenate. Thus, the ochreous precipitates containing schwertmannite effectively remove arsenic from the contaminated water. Then the arsenic was attenuated naturally before mixing with larger tributary.