Environmental Geochemistry of Soil, Sediment and Meteoric Water at the Narim Mine Creek, Korea

Chan Hee Lee · Hyun Koo Lee · Jong Chang Lee*
(Department of Geology, Chungnam National University)
Yong-Kwon Koh (Korea Atomic Energy Research Institute)
e-mail :chanlee@hanbat.chungnam.ac.kr

The Narim gold mine is located approximately 200 km southeast of Seoul within the Muju mineralized district of the Sobaegsan gneiss complex, and it is previously one of the largest gold-silver mines in the Muju mineralized district, Korea. The mine had managed dressing plant, several cross adit, drift, shaft and some ore dump and tailing ponds. After closure, the mining company left out all facilities with the consequence that the secondary contaminants have dispersed into the nearby environments through the air as dust, along the stream with surface run-off and possibly through the groundwater carried by infiltration. Environmental geochemistry were undertaken for soil, sediment and various kinds of water (surface water, groundwater and mine water) collected of April, September and November in 1998 from the Narim mine creek.

Ratios of Al_2O_3/Na_2O and K_2O/Na_2O in soil and sediment are partly negative and positive correlation against SiO_2/Al_2O_3, respectively. Characteristics of some trace and rare earth elements (V/Ni, Ni/Co, Zr/Hf, La/Ce, Th/Yb, La/Th, La_N/Yb_N, Co/Th, La/Sc, Sc/Th) are revealed a narrow range and homogeneous compositions. These suggested that sediment source of host granitic gneiss could be due to rocks of high grade metamorphism originated by sedimentary rocks, and may be explained by simple source lithology. All samples are enriched Al_2O_3, MgO, TiO_2 and LOI, especially Fe_2O_3 (mean 7.36 wt.%) in sediments than the composition of host granitic gneiss.

Average enrichment indices of major and rare earth elements from the mining drainage are 2.05 and 2.91 of the sediments and are 2.02 and 2.60 of the soils, normalizing by composition of host granitic gneiss, respectively. Average composition (ppm) of minor and/or environmental toxic elements in sediments and soils are Ag = 14, 1, As = 199, 14, Cd = 22, 1, Cu = 215, 42, Pb = 1770, 65, Sb = 18, 3, Zn = 3333, 170, respectively, and extremely high concentrations are found in the subsurface sediments near the ore dump (Fig. 1).

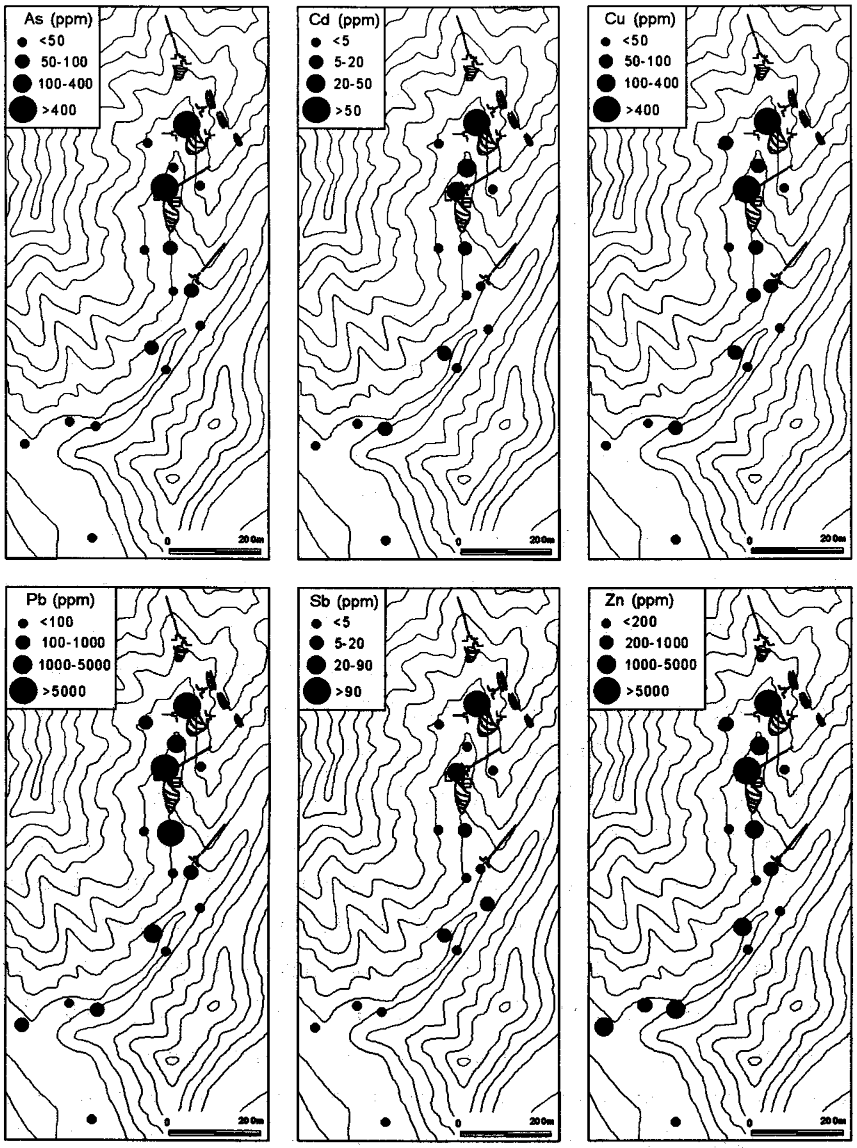

Fig. 1. Maps showing the concentration of environmental toxic elements in soil and sediment of the Narim mine area.

Environmental toxic elements were strongly enriched in all samples, especially As, Cd, Cu, Pb, Sb and Zn. The level of enrichment was very severe in mining drainage sediments, while it was not so great in the soils. Based on the EPA value, enrichment index of toxic elements is 8.63 of mining drainage sediments and 0.54 of soils on the mining drainage.

Hydrogeochemical compositions of water samples are characterized by the relatively significant enrichment of Na+K and alkali metals in groundwater, whereas the mine and surface waters are relatively enriched in Ca+Mg and heavy metals. Anion content of the groundwaters are typically enriched in HCO_3, NO_3, Cl and F, whereas the mine and surface waters are highly enriched in SO_4. Therefore, the groundwaters belong to the Na+Ca-HCO_3 type, whereas the peripheral water of the mining and ore dump area have the characteristics of the Ca+Mg-HCO_3+SO_4 type, respectively (Fig. 2).

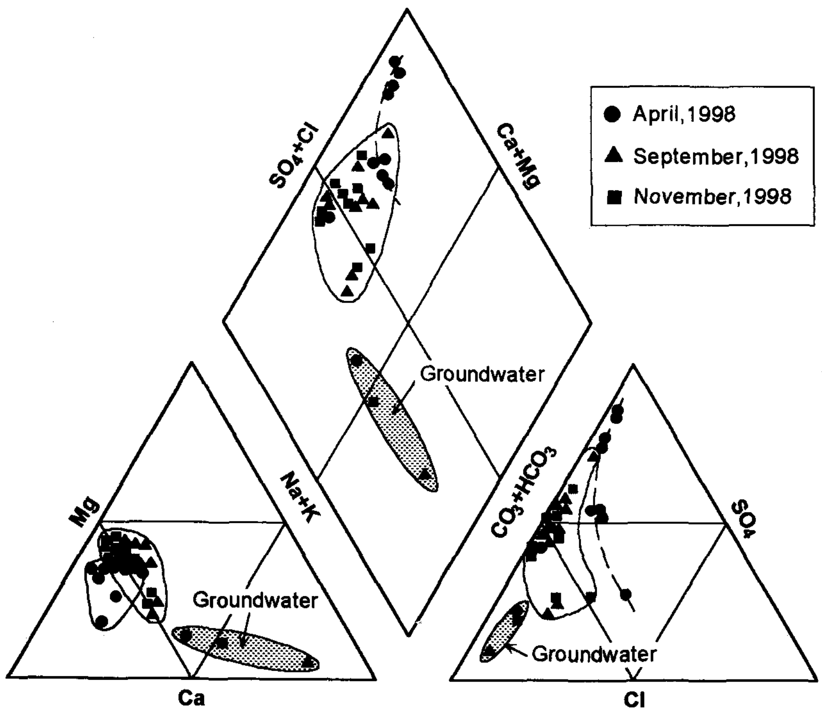

Fig. 2. Trilinear compositional diagram showing chemical compositions of various kinds of waters from the Narim mine area.

The pH and EC values of the non-mining creek surface waters range from 6.30 to 7.08 and 70 to 93 μS/cm, however, water of the mine and ore dump area are 7.02 to 8.30 and 208 to 1415 μS/cm, respectively. And these values of groundwaters are from 6.78 to 8.39 and 283 to 383 μS/cm. The d values ($\delta D-8\delta^{18}O$) of all kinds of water from the Narim mine creek are 5.8 to 13.1. The range of δD and $\delta^{18}O$ values (relative to SMOW) are shown in distinct two groups as follows: for the April waters of -64.8 to -67.8 ‰ and -9.6 to -10.0 ‰ (d value = 10.1 to 13.1), and for the November waters of -65.9 to -70.2 ‰ and -9.3 to -9.6 ‰ (d value = 5.8 to 7.9), respectively. This range variation indicates that two group water were composed of distinct waters with seasonal difference.

As a results from X-ray powder diffraction methos, mineral composition of soils and sediments near the mining area were partly variable being composed of quartz, mica, feldspar, amphibole, chlorite and clay minerals. With the gravity separated heavy minerals, soils and sediments of highly concentrated toxic elements included some pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, goethite and various kinds of hydroxide minerals on the polished sections.