Hydrochemistry, Origin and Residence time of Deep Groundwater in the Yuseong area

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As a part of the radioactive waste disposal research program in Korea, the geological, hydrogeological and hydrogeochemical investigations have been carried out in the Yuseong area (KAERI). The 9 deep boreholes with depth of 200~500m were drilled in the KAERI, of which geology mainly consists of Jurassic two-mica granite (160 Ma). Fracture system (orientation, frequency and aperture size) in the boreholes was investigated by core logging and BHTV scanning, and hydraulic conductivities were estimated by hydraulic tests such as injection and pulse tests. The multi-packer system (Westbay Co., Canada) was installed in 3 boreholes and the borehole YS-01 with depth of 500m was isolated to 14 sections by packers according to fracture characteristics. The hydraulic and geochemical properties of groundwater including isotopes have been monitored since the installation of MP system on 2001.

The temperature of groundwater is measured up to 24℃ and thermal gradient is obtained to 0.26℃/100m. pH of groundwater at upper section shows about 7 and the pH of groundwater of 200m below surface reaches almost constant value as 9.9~10.3. The redox potential of groundwater varied with depth and more negative values were recognized in deep groundwater. The redox potential of deep groundwater, main factor of U solubility, was measured up to -150 mV. These high pH and reduced conditions indicates that the maximum U concentration in groundwater would be limited by the equilibrium solubility of U minerals. The chemistry of shallow groundwater shows Ca-HCO_3 or Ca-Na-HCO_3 type, whereas the deep groundwater belongs to typical Na-HCO_3 type. The chemistry of groundwater below 250m from the surface is constant with depth, indicating that the extent of water-rock reaction is almost unique, which is controlled by the residence time of groundwater.

The $\delta^{18}O$ and δD values are nearly plotted along the worldwide meteoric water line, which indicates that groundwater from the borehole was recharged from local meteoric waters under present climate conditions. It is noteworthy that isotopic compositions of deep groundwater are lighter than those of surface and shallow groundwater in the borehole of the Yuseong area. Considering the altitude effect (0.19/100m, $\delta^{18}O$) of isotope for precipitation in Korea, the recharge area of deep groundwater is estimated to higher elevations than the local land surface. Tritium contents close to zeroare observed in the deep groundwater, thus confirming a long residence time of deep groundwater. On the other hand, high tritium values characterized in the shallow groundwater are considered as recent waters with a very short circulating time. The carbon isotope data ($\delta^{13}C$) of groundwater show the contribution of carbon from either that microbial oxidation of organic matter or carbon dioxide from plant respiration. The measurement and interpretation of C-14 indicate that the residence time of borehole deep groundwater ranges from about 2,000 to 6,000 yr BP. The high $\delta^{34}S_{SO4}$ value of groundwater indicate that the sulfate reduction might be occurred in the deep environment.