Chemical and isotopic study of the impact on groundwater environment by an large underground facility

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This study aims to evaluate a geochemical method to estimate groundwater environment in and around a large underground facility. Water chemistry, isotopes (δD, $\delta^{18}O$, ^{3}H, $\delta^{13}C$, ^{14}C) and chlorofluorocarbons (CFCs) in groundwater down to a depth of 500 m were monitored in the Mizunami Underground Research Laboratory (MIU), Japan. In the MIU site, sedimentary rock formations with the thickness of about 170 m unconformably overlie basement granite. The granite is divided into a weathered zone at uppermost part, an upper highly fractured domain (UHFD) and a lower sparsely fractured domain (LSFD). Baseline of groundwater chemistry prior to the facility construction was characterized; Na-Ca-SO_4-HCO_3 type in shallow sedimentary rocks and Na-Ca-Cl type of water which salinity increases with depth in granite.

The groundwater level was lowered by long-term drainage of groundwater from the galleries. The monitoring of water chemistry for more than 10 years shows the increase of SO_4 and HCO_3 concentrations in UHFD at depths between 200 - 400 m. The shallow groundwater probably inflows into deeper depths with time. ^{3}H and CFCs as an index of surface water were detected in several monitoring points at these depths. Based on those concentration the mixing proportion of shallow groundwater was estimated up to about 50 %. On the other hand groundwater in LSFD at the depth of 500 m does not show increase of SO_4 and HCO_3 concentrations nor include ^{3}H, suggesting relatively isolated condition from the hydraulic disturbance by the facility construction. ^{14}C concentration in dissolved inorganic carbon was measured to understand residence time of the isolated groundwater. Then addition of ^{14}C-free carbon from carbonate minerals to groundwater was corrected by geochemical model using $\delta^{13}C$ value. Corrected ^{14}C value ranges from 5 to 11 pMC and it corresponds to the residence time of 18 - 25 ka.

The impact on the groundwater environment caused by a large underground facility was considerably different depending upon hydrogeological structure. The concomitant use of ^{3}H, $\delta^{13}C$, ^{14}C and CFCs is an effective method to identify the hydrochemical condition in the disturbed domain and undisturbed domain around the underground facility.