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Hydrochemical and Isotopic Assessment of Deep Groundwater: Residence Time, Circulation and Inter-Aquifer Mixing in South Korea

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Hydrogeochemical and isotopic properties of deep groundwater play a crucial role in the assessment of secure geological radioactive waste disposal. A previous study by Kim et al. (2020) classified South Korean deep groundwater (average well depth of 624 ± 262 m) into five major geochemical groups (G) and four mixing groups (M): G1 (saline), G2 (CO_2-rich), G3 (high-pH alkaline), G4 (sulfate-rich), G5 (freshwater), and mixing groups (M1 to M4). As a follow-up study, this study aims to investigate the residence time, recharge mechanism, and origin of deep groundwater using environmental tracers, including $\delta^{18}O$, δD, $\delta^{34}S$-SO_4, $\delta^{18}O$-SO_4, $\delta^{13}C$-DIC, and ^{14}C, in conjunction with hydrochemical variables. Data of isotopic compositions and hydrochemistry indicate that each group evolved through distinct water-rock interactions and mixing between each group. The $\delta^{18}O$ and δD values of deep groundwater tend to be lower in the groups G2, G3, and G4, while the groups G1 and G5 are higher due to seawater mixing and shallow groundwater mixing, respectively. The potential recharge zone of deep groundwater is evaluated based on the hydraulic conductivity and residence time (i.e. ^{14}C age), and shows that the $\delta^{18}O$ and δD values decrease with increasing altitude of the estimated potential recharge zone. We suggest that a large amount of paleo-recharge from Mountain Block Recharge (MBR) constitutes deep groundwater through slow regional flow. This study shows that a comprehensive hydrochemical and isotopic characterization of deep groundwater provides crucial information concerning the safe geological nuclear waste disposal, such as the processes of recharging, regional groundwater flow, and hydrologic mixing.

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[1] Kim, K. H., Yun, S. T., Yu, S., Choi, B. Y., Kim, M. J., & Lee, K. J. (2020), *Journal of Hydrology*, *589*, 125202.