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# Investigating hydrogeochemical behavior of uranium in fractured-rock groundwater flow system

**DONG-HEE KIM**[1], YE JI KIM[1], SANGHOON LEE[2], JAEYEON KIM[1] AND KANG-KUN LEE[1]

[1]Seoul National University
[2]Korea Atomic Energy Research Institute

Ensuring the long-term safety of deep geological disposal systems depends on understanding uranium mobility in groundwater. In crystalline host rocks, fractured zones may act as preferential pathways for groundwater flow and uranium transport, yet uranium behavior in such zones remains poorly constrained. This study investigates uranium hydrogeochemistry in groundwater systems controlled by fractured zones. The study site is located within the KAERI Underground Research Tunnel (KURT), a subsurface research facility at the Korea Atomic Energy Research Institute (KAERI). The rock mass at KURT includes a highly fractured zone that forms a major groundwater flow pathway. Tritium-based groundwater age dating indicates that this zone rapidly transmits recently recharged groundwater, producing younger and more oxidizing waters than those in the surrounding bedrock. These conditions are associated with anomalously high uranium concentrations within the fractured zone. Uranium concentrations, however, decrease progressively from upgradient to downgradient areas along the fractured zone. PHREEQC inverse modeling and saturation index indicate that the precipitation of secondary uranium minerals is the primary mechanism controlling uranium concentrations along this flow path. Overall, these findings suggest that uranium hydrogeochemical behavior evolves within fractured zones, highlighting the coupled influences of uranium mobility and fracture-controlled groundwater flow in the safety assessments of deep geological disposal systems.

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