Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.9545

Geochemical interactions of uranium deposits with groundwater at a natural analogue research site

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Deep underground disposal of high-level radioactive wastes should remain non-hazardous for a long time. To evaluate the long-term stability of a geological repository, it is important to analyze the water-rock interaction of uranium deposits under natural conditions. In this study, we evaluated the behavior of uranium associated with aqueous complexation and mineral dissolution-precipitation resulting from the interactions between uranium deposits and groundwater. The study area is located in Boeun-gun, Chungcheongbuk-do, Korea, a natural analogue research site, which belongs to the Okcheon metamorphic zone. Four groundwater wells at different depths were installed in the formation of coalyslate, containing an uranium ore. Based on the measurement of radioactivity, groundwaters were sampled at depths of 15 m, 25 m, 33 m, 55 m, and 80 m. Water quality analysis results showed that the average Eh-value is 105 mV, indicating an slightly oxidized state. Alkalinity increased as the depth increased. A previous study showed that precipitation of iron hydroxide occurs with increasing alkalinity [1]. Therefore, it is speculated that the Fe concentration decreases with depth in the study site.

The uranium concentrations were relatively high in the depths of 33 m and 80 m. It might be influenced by the dissolution of uranium minerals such as uraninite (UO_2). For the sections with relativley high concentrations of uranium, uranium existed in the form of $UO_2(CO_3)_2^{2-}$, and in the rest of the sections as $UO_2(CO_3)_3^{4-}$. The oxidized form of U(VI) was hydrolyzed to form $UO_2(OH)_2$ complex. Under these geochemical conditions, formation of iron hydroxides might also cause co-precipitation of uranium [1]. Thus, the transport of uranium in this slightly oxidized state can be governed by these geochemical reactions (i.e., complexation and co-precipitation). The geochemical interactions of uranium deposits with groundwater evaluated in this study can provide implications on the behavior of uranium under natural hydrogeologic conditions. This work was supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT, MSIT) (NRF-2021M2E1A1099413).

[1] del Villar *et al.* (2003), *Chem. Geol.* 190, 395-415.