Statistical Approach of the Geochemical Mobility and Behavior of Natural Uranium in KURT Groundwater

JiHye Jeong*, Jang-Soon Kwon, Yong-Kwon Koh, and Jae-Kwang Lee

Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea

*yz0201@kaeri.re.kr

1. Introduction

For the high level radioactive waste disposal facilities it is important to evaluate the mobility of radionuclides in groundwater and the geochemical factors that control its behavior in case of unplanned leakage of radionuclides to groundwater. So far, a number of studies have been conducted to investigate hydrochemical and biogeochemical properties of the groundwater in the KAERI Underground Research Tunnel (KURT) [1]–[4], but statistical approach of mobility and transport of natural nuclides in the groundwater have not been carried out. The purpose of this study is to statistically identify factors that affect uranium mobility in the KURT groundwater and to understand how the transport of natural uranium changes under the geochemical controls.

2. Results and discussions

2.1 Geochemical mobility of uranium using statistical methods

The main factors affecting uranium mobility in groundwater are pH, DO (ORP) and partial pressure of carbon dioxide (PCO_2). Uranium mobility shows the increases in the groundwater with higher oxic-alkaline condition and PCO_2. The uranium concentration in the KURT groundwater is the highest in the i3 section (mean value: 720.34 μg/L) and lowest in the i5 section (mean value: 0.85 μg/L). The uranium concentration in each section showed a statistical difference through the analyses of Variance (ANOVA) test was performed ($p < 0.05$). Then the influences of the aforementioned factors on the uranium concentration in each section (depth) were statistically expressed (Fig. 1). The result confirmed that uranium mobility is higher under the pH 8.0 - 9.5, DO>0.5 and high PCO_2 conditions. Furthermore, the Eh-pH diagram for uranium species in the groundwater showed that uranium existed as $UO_2(CO_3)_3^{4-}$, which has the highest mobility.

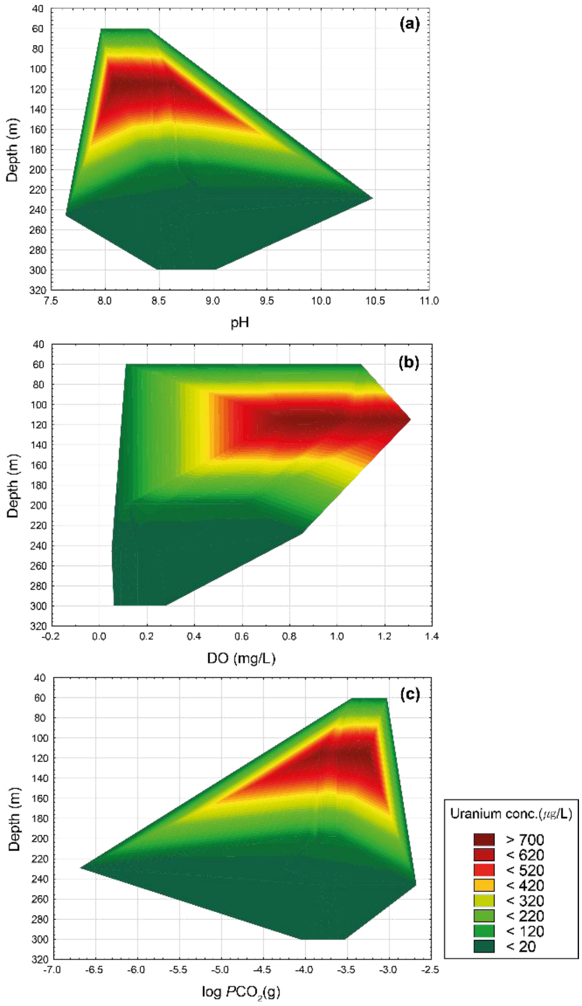

Fig. 1. Wafer plots of U concentration within pH (a), DO (b) and PCO_2 (c) in KURT groundwaters using Statistica program.

2.2 Geochemical behavior of Uranium in groundwater

According to a report published by KAERI in 2012, there is information on the mineral adsorption of uranium in KURT groundwater [5]. However, there is a limit to the accuracy of the results because the analysis is performed on the cores of other wells, not the cores of the corresponding groundwater. Therefore, this study analyzed the saturation index (SI) of the mineral by depth in the DB-1 groundwater through PHREEQC program. Assuming there is a possibility that the mobility was lowered by the adsorption of uranium, this is probably due to the influence of chlorite in KURT granite minerals. The SI value of chlorite is supersaturated only in the i5 section where uranium concentration is lowest (Fig. 2).

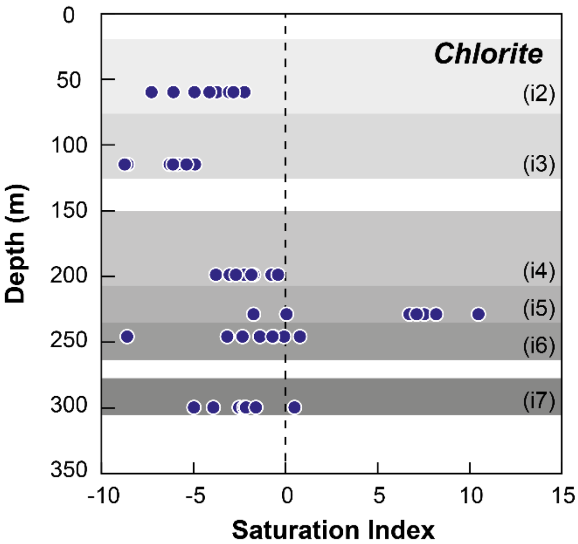

Fig. 2. Saturation index for Chlorite in KURT groundwater using PHREEQC program.

3. Conclusion

Natural Uranium in the KURT groundwater within granite bedrock had different mobility in each section (depth). Uranium mobility in groundwater is controlled by pH, DO, and PCO_2 its mobility in the KURT groundwater is the highest when the groundwater is under oxic-alkaline and high PCO_2 conditions. In addition, it is reported that uranium is well adsorbed to iron and manganese oxides and on chlorite; Assuming that the decrease in uranium concentration affects the adsorption of minerals, uranium in KURT groundwater might be predicted to adsorbed on chlorite.

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