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The effect of secondary mineral formation for the migration behavior of iodine at hyperalkaline springs in Oman

Sohtaro ANRAKU^{1*}, Jun Hoshino¹, Kazuya Morimoto², Tsutomu Sato³, Tetsuro Yoneda³

¹Graduate School of Eng., Hokkaido Univ., ²Advanced Industrial Science & Technology, ³Faculty of Engineering, Hokkaido Univ.

In Japanese transuranic (TRU) waste disposal facilities, ¹²⁹I is the most important key nuclide for the long-term safety assessment. Thus, the distribution coefficients (K_d values) of I to natural minerals are important factor in the safety assessment. However, the degradation of cement materials in the repositories can produce high pH pore fluid which can affect the anion transport behaviour. Therefore, it should be necessary to understand the behaviour of anions such as I⁻ under the hyperalkaline conditions.

This study examined the naturally-occurring hyperalkaline conditions near the springs in Oman as natural analogue for the interaction between cement pore fluid and natural Mg-HCO₃⁻ river water. The generated natural hyperalkaline spring water (pH>11) from the partly serpentinized peridotite in the Oman ophiolite is characterized as hyperalkaline, reducing, low-Mg, Si and HCO₃⁻, and high-Ca while the river water where the alkaline spring, is moderately alkaline, oxidizing, high-Mg and HCO₃⁻. The mixing of these spring and river water resulted in the formation of secondary minerals, forming river terrace with height of more than 10 meters. The present aim of this paper is to examine the conditions of secondary mineral formation and the anion uptake capacity of these mineral phases generated. The long-term stability of this sorption behaviour in this system was also investigated.

Water and precipitate samples were collected at various distances from the spring vent to identify the effect of mixing ratios between spring and river water on mineral composition and water-mineral distribution coefficient of various anions. On-site synthesis was also carried out to support these data quantitatively. Furthermore, samples of deposits were collected from the river terrace at different height which corresponds approximately to the depositional age in order to find out the alteration of minerals and possible anion desorption.

The results of the mineralogical and chemical characterization of the collected samples confirmed that the formation of secondary mineral was dominated by aragonite at the mixing points of the spring and surface water, due to high Mg content of the latter. Hydrotalcite like compound (Mg-Al hydroxides) was also detected as accessory minerals since the hyperalkaline springs contain relatively rich in Al.

During the formation of the minerals at the mixing points, HCO₃⁻ in the river water was fixed as carbonate minerals in aragonite and calcite phases while H₃SiO₄⁻ in the river water was dominantly fixed into the interlayers and surfaces of HTlc. Iodine in spring and river water was mainly fixed in aragonite. XRD quantitative analysis by Rietveld method indicated K_d values of iodine increase proportionally to the aragonite content in the precipitate samples. Consequently, in terms of short-term assessment, particularly for I⁻, uptake by secondary minerals can be expected at hyperalkaline conditions as observed at Oman hyperalkaline springs.

Keywords: calcium carbonate, iodine, aragonite, calcite, hydrotalcite, natural analogue study