Biogenic and abiogenic nucleation of uranium in anaerobic environments

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Biogenic uranium transformation

Biogenic UO_2 (uraninite) nanocrystals may be formed as a product of a microbial reduction process in urnaium-enriched environments near the Earth's surface [1]. We investigated the size, nanometer-scale structure, and aggregation state of UO_2 formed by iron-reducing bacterium, *Shewanella putrefaciens*, from a uranium-rich solution. The UO_2 nanoparticles were highly aggregated by extracellular polymeric substances (EPS) (Figure 1), which limited a dispersal of the nanoparticulate uranium phase. Nearly all of the nanocrystals were networked in more or less 100 nm diameter spherical aggregates that displayed some concentric UO_2 accumulation with heterogeneity.

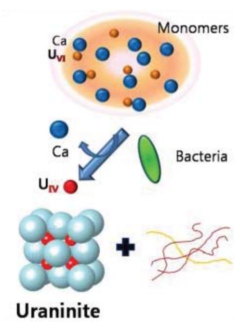

Figure 1: The microbial UO_2 formation and aggregation by EPS

Abiogenic U(IV) phase catalyzed by a biogenic sulphide mineral

Sulphate-reducing bacteria (SRB) and their by-products, such as iron sulfides, are widely distributed in subsurface environments, and can affect subsurface chemisty. There was a catalytic reduction and nucleation of uranium by fast-growing biogenic mackinawite (FeS), which is a common iron monosulphide observed in the anaerobic subsurface. The formed uranium phase was a nanoparticulate U(IV) phase. However, the U(IV) nanoparticles were easily released and dispersed without aggregation. It shows that a mobility of the reduced uranium phase might exist and be influenced by the ways that it was reduced in a heterogeneous microbial system.

[1] Suzuki *et al*. (2002) *Nature* **419**, 134.

Strontium, Carbon, Hydrogen and Oxygen Isotope Geochemistry from two hot spring waters in Busan area, Korea

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Introduction

Dongrae and Haeundae hot springs are one of the representative hot springs with water temperatures more than 58°C in South Korea. Both hot springs occur in Mesozoic granite area which is located in the Busan city at the margin of southeastern coastal side of the Korean peninsula, and have been used for spa for the past 1,000 years. Here we report ^{14}C, ^{3}H, $\delta^{18}O$, $\delta^{2}H$ and $^{87}Sr/^{86}Sr$ isotopic data for the Haeundae and Dongrae hot spring waters, which were collected for 2004-2011. Based on the geochemical data mentioned above, the groundwater cycle between hot spring waters and shallow graoundwaters, and heat source of the hot springs in Busan area will be discussed.

Results and Discussion

Geochemically, both of the hot spring waters are of Na-Cl type. The result of stable isotope compositions of O and H suggested that both of the hot spring waters should be derived from meteoric water. Furthermore, the chemical components of the hot spring waters indicate that they all were derived from hot spring water-rock interaction rather than through anthropogenic input. The $^{87}Sr/^{86}Sr$ ratio in Dongrae hot spring waters during the past 8 years ranges from 0.705632 ± 0.000012 to 0.705694 ± 0.000010. And the $^{87}Sr/^{86}Sr$ ratio in Haeundae hot spring waters ranges from 0.706023 ± 0.000011 to 0.706082 ± 0.000011. The ^{14}C ages in Dongrae hot spring waters ranged from 1,271 to 2852 years(BP) whereas those from the Haeundae from 2037 to 6687 years(BP). Such age difference corresponds well with aquifer depth of hot spring waters.

Conclusion

In this study, we could observe that there was no variation in the $^{87}Sr/^{86}Sr$ ratio from both hot spring waters during last 8 years. The chemical component also does not show significant variaton in their compostion. These all indicate that the hot spring waters in Busan area might be a product of long-term water-rock interaction rather than short-term water-rock interaction due to the input of recent meteoric water. In this research, we could confirm that $^{87}Sr/^{86}Sr$ ratio in the groundwater can be used as a tracer for monitoring the groundwater mixing history among several different aquifers such as shallow and deep groundwaters.