Formation mechanism and elemental migration of redox front around the fracture in crystalline rock

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In the system of geological disposal of high-level radioactive waste (HLW), preservation of reductive geological environment is considered to be an important condition for the long-term safety. However, formation of a redox front in the near-field of a HLW disposal site is accompanied by oxidation of artificial barriers and basement rocks during the operation. In order to provide an analogue for secondary elemental migration associated with the formation of this redox front, we examined granite with a redox front formed along fractures through which groundwater flowed.

Geochemical analysis revealed that Fe concentration in the oxidation zone was higher than that of the parent rock, and Fe was secondarily added. This secondary Fe, which was round and reddish brown substances, concentrated at grain-boundaries and micro-pores. Secondary addition of Mn was also confirmed in the oxidation zone with about 5 times more than that of the parent rock. These results show that these elements were firstly carried by reduced groundwater, and then oxidized and precipitated after diffused into host rock matrix.

Also, it is found that heavy metals such as Pb, Ba and Rb are concentrated in the oxidation zone, and the concentrations of Pb and Ba are also increased about 2 times compared with that of the parent rock. The concentration of these heavy metals can be considered to occur due to adsorption on Mn precipitates, and this suggests that Mn precipitates are capable of retaining heavy metals within the oxidation zone. Additionally, it has also been revealed that REE has been accumulated to the part of redox front, and Fe precipitates are considered to adsorb this REE.

These results of an investigation on the redox front, show that secondary migration and accumulation of heavy metals including REE are accompanied by migration of redox front. A phenomenon like this may be considered as an analogue of near-field of a HLW disposal site.

Active participation of higher plants in weathering, inferred from their REE patterns.

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From the linear relationship between REE signature and Si concentration in seaweed, seaweed was reported to incorporate silicate minerals attached to the surface of its blade. This is one of our most successful applications of so-called “REE fingerprint” to the study of plant nutrients. Silicate minerals have unique REE signatures and we have conducted REE analysis of several plants and several fractions of soil in order to understand which part of soil is “digested” by plants.

After appropriate digestion of plants, REEs were preconcentrated by solvent-extraction and determined with ICP-MS. Chondrite normalized REE patterns of plants showed rather uniform REE signatures, which are most similar to those of silicate fraction of soil. The slope of pattern was steeper generally in the order of secondary roots, main root and leaf or trunk. Water soluble fractions showed varying REE patterns.

The partitioning of REEs by physiological processes of plants has been scarecely known. However, the consistent REE pattern of plants could be most easily understood assuming that plants absorbed REEs from silicate minerals rather selectively. REEs are not nutrient to plants. This indicates that plants incorporate inorganic nutrients from the silicate minerals. Silicate minerals contain some macro-nutrients such as K, Mg, Ca and Na and silicate minerals would be worthy to be absorbed by plants. The formation of phytoliths seems compatible with this indication: the remains after nutritious cations being extracted.

Active role of plants in weathering would be proved by physiological studies. The present authors have started two projects, one to understand the participation of root hairs to the mineral digestion and the other to discover digestion of potassium-rich minerals in a potassium deficient condition. The preliminary results will be shown.

References

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