

Biotransformation Rare Earth Elements

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Geochemical behaviors of rare earth elements (REEs of La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) are important to understand the migration of trivalent actinides fission genic REEs from nuclear power plants and high level radioactive waste. When REEs migrates in environments, their chemical states may change by the interaction with inorganic and organic materials. Many researchers have studied the interaction of REEs with inorganic materials. However, the biotransformation of REEs have not fully understood. We have conducted the research on the effects of microorganisms on chemical states change of REEs.

The REEs patterns of the distribution coefficients (K_d) for hyphae of *Acremonium* sp. showed no Ce anomaly. On the contrary, the REEs pattern of K_d for biogenic Mn oxides with *Acremonium* sp. showed positive Ce anomaly at pH 3.7 by oxidization of Ce (III) to Ce (IV) by Mn oxides. With increase of pH in solution positive Ce anomaly became smaller, and the polarity of Ce anomaly shifted from positive to negative around pH 6.5. This anomaly shift is probably caused by organic molecules released from the hyphae.

Presence of desferrioxamine B (DFO) showed negative anomaly of Ce in the REEs patterns of K_d for *Pseudomonas fluorescens*. Negative Ce anomaly came smaller with increasing contact time, caused by oxidation states change of Ce (IV) in the Ce-DFO complex to Ce (III).

We found that Ce (III) phosphate nano minerals were formed on the cells surface of yeast *Saccharomyces cerevisiae* after exposure of Ce (III) solution with the resting cells, even though no phosphate is added. Ce (III) ions were first adsorbed by the functional groups of cells surface, followed by the chemical states change by the reaction with phosphate ions released from inside the yeast cells.

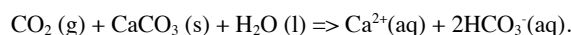
These findings indicate that microorganisms affect geochemical behavior of REEs.

Carbonate dissolution at oceanic atolls: A CO₂ sequestration option

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Carbon dioxide storage in the ocean will eventually bring about the dissolution of carbonate in the ocean floor. Ohsumi [1] suggested the purposeful *in situ* reaction of CO₂ with the ocean-floor carbonate as a storage option of captured CO₂. However, the carbonate dissolution method [2, 3] proposed and discussed technically and geochemically so far has put the focus on siting the reactor vessel on land near emission sources of CO₂. The ocean bottom covered with carbonate sediments may not be suitable in applying the carbonate-dissolution method, because of high implementation cost as revealed by the research and development effort of the deep-sea Mn nodule mining and also of the associated environmental impacts on the open ocean. If the partial pressure of CO₂ is raised up more above one atmosphere by selecting the site of the dissolution underground, the volume of water required for the reaction to proceed could be saved, the reaction being:



Large scale coral atolls found typically in the Pacific ocean give an appropriate example of the installation site of the reaction system. When several hundreds tonnes H₂O coexisting with one tonne CO₂ are to be reacted with the ambient carbonate rocks at depths of a few hundred meters inside the atoll, ca. 20% of the injected CO₂ would be transformed into bicarbonate, reaching to the equilibrium where the pH value is above 6 and the CO₂ partial pressure is below one atmosphere. The drainage waste water containing the residual CO₂ (aq) and the reaction products, *i.e.* calcium bicarbonate solution would be discharged directly to the deep ocean for further dilution of CO₂ (aq). The discharge operation offers an opportunity for the measurement of CO₂ inventory, and more importantly contributes avoidance of the long term possible erosion of the atoll and its consequent impacts to the island surface.

The presented storage concept of captured CO₂ is essentially the ocean storage by dissolution of carbonate minerals, but eliminates the large-scale surface reaction plant.

- [1] Ohsumi (1993) *Energy Convers. Mgmt.* **34**, 1059–1064.
[2] Rau & Caldeira (1999) *Energy Convers. Mgmt.* **40**, 1803–1813. [3] Caldeira & Rau (2000) *Geophys. Res. Lett.* **27**, 225–228.