CO_2 sequestration into geothermal fields: (1) The capacity and possibility

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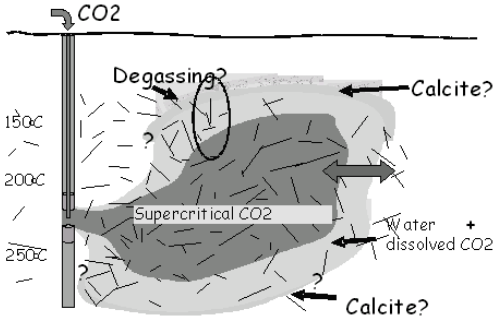
In most geothermal fields, carbonate-rich formations are commonly observed. CO_2 rich groundwaters are thought to have reacted with reservoir rocks to form a carbonate and kaolinite alteration assemblage by the reaction:

$$CaAl_2Si_2O_8 \text{ (plagioclase)} + H^+ + HCO_3^- + H_2O =$$
$$CaCO_3 \text{ (calcite)} + Al_2Si_2O_5(OH)_4 \text{ (kaolinite)} \quad (1)$$

This study has evaluated the capacity of geothermal fields in Japan to sequester CO_2 by storage of a free CO_2 phase and by fixation in carbonate minerals.



Capacity of CO_2 storage

The total volumes of rocks in high (>150°C) and middle (90 to 150°C) temperature fields are estimated 2100 and 2800 km^3 in Japan, respectively. The capacity of CO_2 storage is then calculated to be 19.7 billion tons CO_2 on the basis of estimated rock porosities (average 4%) and the density of supercritical CO_2 (100kg/m^3).

Capacity of carbonate fixation

During CO_2/rock/water interaction at geothermal temperatures, carbonate can be deposited as shown in reaction (1). To estimate the capacity for carbonate fixation, the Ca and Mg contents of rocks were calculated on the basis of estimated porosities and chemical compositions of rocks in Japan. The (Ca+Mg)/ CO_2 mole ratios of andesitic and granitic rocks exceed 45.6 and 15.3, respectively. These results strongly support the view that CO_2 sequestration into geothermal fields is technically feasible.

Structural change of REE coprecipitated with Fe-Mn oxyhydroxides

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To investigate the incorporation of seawater REE into deep-sea nodules and crusts, many researchers reported experimental studies. Ohta et al. (2000a, b) and Ohta and Kawabe (2001) have successfully reproduced the series variations of apparent REE distribution coefficient between Fe-Mn deposit and seawater by the simple experimental systems. Ohta and Kawabe (2001) pointed out that preferential adsorption of light REE onto δ-MnO_2 is obvious compared with their adsorption onto FeOOH. The similar trend is also found in the field system (ferromanganese nodules). The theoretical study suggested that the numbers of hydroxyl ions and coordinated waters ligating REE(III) scavenged by δ-MnO_2 are approximately the same as those onto FeOOH (Ohta and Kawabe, 2001). It is presumed that the structural change is identified by the change of number of coordinated water.

We measured REE-L_{III} XAFS spectra of La and Nd adsorbed on FeOOH and δ-MnO_2 in the fluorescence mode at the BL12C of KEK-PF under atmosphere and room temperature. XAFS spectra of La and Nd solutions with 1000 mg/l were also measured as standard materials. The imaginary parts of Fourier transformed spectra indicated that REE coprecipitated with FeOOH have similar local structure to $REE^{3+}_{(aq)}$, but have slight different structure to REE adsorbed on δ-MnO_2. Fourier transformed magnitudes of $REE^{3+}_{(aq)}$ spectra have only one large peak. The fitting results of the first shell (REE-O) suggested that the coordination numbers (CN) and interatomic distances (R) of $REE^{3+}_{(aq)}$ are consistent with the reported values (Rizkalla and Choppin, 1991). The CN and R of REE incorporated with δ-MnO_2 and FeOOH are almost the same as those of $REE^{3+}_{(aq)}$, although Fourier transformed magnitudes of REE adsorbed on δ-MnO_2 spectra show that a small peak with higher R overlaps with a main peak. The local structure of light REE adsorbed on δ-MnO_2 does not differ much from light REE coprecipitated with FeOOH.

References

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