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Factors controlling dissolution rate of basalt for underground sequestration of carbon dioxide

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1. Introduction

Underground sequestration of CO_2 attracts attention these days as a measure which can expect an instantaneous effect on reducing anthropogenic CO_2 emission.

After injecting CO_2 into underground, CO_2 will react with rock and water, and will be finally fixed as carbonate (solubility trapping and mineral trapping). However, behavior of its chemical reaction is not revealed. When considering the above mentioned chemical reactions, dissolution rate of rock reacting with water is important as fundamental data, however dissolution rate of basalt changes greatly with different samples and/or experimental conditions. As factors controlling dissolution rate of basalt, Si:O ratio, crystal:glass ratio, structure of glass, experimental system (open system or closed system) and condition of agitation may be important.

Thus, we studied the influences of crystal:glass ratio and structure of glass on the dissolution rate of basalt (experiment 1). Moreover, we also studied the influence of experimental system (open system or closed system) and agitating on dissolution rate of basalt (experiment 2).

2. Sample preparation and experimental methods

In experiment 1, the basalt used was basaltic lava of younger stage Mt. Fuji and basaltic glass melted from its basalt lava and gradually cooled or rapidly cooled. This sample was put in a pressure tight vessel with solution, and CO_2 was injected into its vessel, and left in closed system. After reacted, the solid phase and liquid phase were separated. For the solid phase, before and after the reaction, analyzing the compositions of mineral and main element with XRD and XRF, and observing surface with SEM. The liquid phase was analyzed for cations(Ca^{2+} etc) and Si by ICP-MS.

In experiment 2, the basalt used was basalt lava. By changing the conditions of experimental system (open system or closed system) and agitation, the solution and solid phase were analyzed by the method same to experiment 1.

3. Results and discussion

In experiment 1, although the dissolution rate was about 1~2 times high and the increase order of dissolution rate was lava $<$ gradually cooled $<$ rapidly cooled, indicating much difference was not found. When it assumes injecting CO_2 in aquifer below 1000m depth, actual condition is in close to closed system. Therefore, under conditions of underground sequestration of CO_2, this result indicates that the difference in cooling rate from magma, the crystallinity do not affect dissolution rate significantly.

In experiment 2, the dissolution rate became higher for open system than closed system. Moreover, observing sample surface after the react with SEM, the surface did not change in open system, while the surface changed for closed system. This observation implies that in closed system, Si, Al, etc. precipitated when concentration of solution became high and covered the sample surface, forming alteration layer, and preventing dissolution. Assuming CO_2 is stored in aquifer below 1000m depth, the actual condition is in close to closed system. Until now, simulation assuming that dissolution rate of basalt is surface reaction controlled had been performed in Japan. But the simulation taking into account diffusion through alteration layer should be consideration.

Keywords: CCS, geochemical trapping, dissolution rate