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## Release of elements from basaltic rocks at high temperature and high pressure using a flow-type hydrothermal apparatus

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Hydrothermal fluids with a variety of chemical characteristics are generated in the sub-seafloor by reaction of various rocks with seawater under various physical conditions. Chemical diversity of the hydrothermal fluids leads to phylogenetical and physiological diversity of microbes thriving there (Nakamura and Takai, 2009). Experimental evaluation of water-rock reaction under the seafloor is needed to better understand deep-sea hydrothermal systems (Suzuki et al., 2009). To date, many experiments using batch system have been performed. However, there are few experiments using flow system simulating natural environments. Our goal is to develop a flow-type hydrothermal apparatus, to put it to practical use, and to understand marine hydrothermal system better.

We developed a flow-type hydrothermal apparatus that consists of HPLC pumps (flow rate: 6?600 ml/h), a preheating bath (SUS316, 100 ml), a water-rock reaction bath (hastelloy C276, 390 ml) and a cooling bath (SUS316, 5 l). The preheating and reaction baths are equipped with a heater (maximum temp. 300°C and 500°C, respectively). This apparatus can be operated at a pressure up to 50MPa. In the present experiments, the following settings were used: 6 ml/h of flow rate, 250°C for the preheating bath, 400°C for the reaction bath and 40MPa of pressure. Grains of a basaltic rock (300 g) that was collected in the Izu-Oshima Island were used for the water-rock reaction experiment. The surface area of the grains was 4.52 m<sup>2</sup>/g, determined by N<sub>2</sub>-BET method. We operated the apparatus for 1271 hours with rocks and ultra-pure water, for 1920 hours in that with ultra-pure water only, and for 864 hours with artificial seawater. Aliquots of reacted water were collected over time, and then pH and concentration of elements of these samples were determined by pH meter and ICP-AES.

Measured temperature in the reaction bath and pressure were stable at 340°C and 40.1MPa during operation. Although pH in the experiment with ultra-pure water only was stable between 7.0 and 7.3, pH in the experiment with rocks and ultra-pure water was stable between 8.7 and 9.0. Concentration of elements in the reacted water increased with time. Release rates of each element from the basaltic rocks were calculated: Si, 5.25.E-11; Na, 1.93.E-12; Al, 6.34.E-13; K, 2.17.E-13; Fe, 7.72.E-14; P, 3.05.E-14; Li, 1.70.E-14; As, 1.94.E-15; Hg, 6.16.E-16; Ni, 4.62.E-16; Zn, 1.86.E-16; Rb, 3.35.E-17 (mol/m<sup>2</sup>/s). In the experiment with the artificial seawater, Fe, Ni and Cr concentration increased.

This is the first report on the release rate of several elements (e.g., P) from basaltic rocks in a flow system under high temperature and high pressure. Our results provide insight into dissolution of basaltic rocks in natural environments under high temperature and high pressure, such as deep subsurface environments. However, some problems rise for the experiment with seawater. Further modification of the hydrothermal apparatus is required to simulate the seawater-rock reaction in laboratory.

Keywords: water-rock reaction, elemental dissolution, deep-sea hydrothermal system, flow-type hydrothermal apparatus, TAIGA project