

玄武岩-水系における熱水変成作用によるザクロ石の合成

Synthesis of garnet by hydrothermal metamorphism in basalt-water system

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The Island Deep Drilling Project (IDDP-2) reached 427 °C and 34 MPa, which exceeds the critical point of seawater. The cores revealed that intense water-rock interaction with mineral assemblage of greenschist to amphibolite facies metamorphism. Although such deep drilling provides us direct information of active metamorphic processes; however, it is still unclear that conventional petrological analyses could apply to reaction processes in open systems at high temperature hydrothermal alteration at seafloor. There have been few experiment studies on the water-rock interaction under supercritical conditions with some exceptions (Yardley et al. 2014).

In this study, we conducted hydrothermal flow-through experiments on basalt-H₂O system at 410 °C and 35 MPa for 810 h. We used a powder of MORB (Island, 250-500 μm), which is composed of plagioclase (Pl), olivine (Ol) phenocrysts and clinopyroxene (Cpx), Pl groundmass, were enclosed in a Ti inner tube (L=275 mm, I.D.= 4.35 mm). During the run, distilled water was continuously pumped into the reaction vessel at a constant flow rate of 14.4 ml/day, and the output solution was collected every day. The concentration of Si, Al, Ti, Fe, Mg, Ca, Na, and K in the output solution was analyzed by ICP-AES and AA. For comparison, we also conducted experiments on the gabbro-H₂O system. The speciation of aqueous species and saturation index were calculated by using SOLVEQ-XPT (Reed, 1982).

In the basalt-H₂O experiment, notable spatial variations of products mineral were observed in basalt. At the inlet of the inner tube, grossular was formed preferentially in the groundmass, chlorite was formed around olivine grains, and porous anorthite (X_{Ca} = 0.98) grain was formed. At the middle and outlet part of the inner tube, amphibole and chlorite were formed as replacing groundmass. In the gabbro-H₂O experiment, the extent of reaction was very low, with producing a subtle amount of biotite.

The pH of the output solution (25 °C) in basalt-H₂O experiment increased from 6.5 at ~190 h to 7.5 at ~357 h. Concentration of Na and Al increased with time from 1.0 mg/kg H₂O at ~190 h to 9.0 mg/kg H₂O at ~334 h and from 0.1 mg/kg H₂O at ~190 h to 5 mg/kg H₂O at ~310 h, respectively. The concentrations of the other elements were less than 1 mg/kg H₂O. We performed the principal component analysis on the solution chemistry, and revealed that the PC1 represents pH, Al, and Na, PC2 represents Mg and Ca, and PC3 represents silica. The temporal variation of PC1 is consistent with that of saturation index of albite as well as linked to anorthite and grossular, indicating that (1) leaching of albite component from plagioclase predominantly controls the reactions and causes an increase of pH in the solution was increased, and (2) anorthite and grossular was formed as a residue of the leaching. Similarity between PC2 and the saturation index of Mg-bearing minerals (such as diopside, amphibole, and chlorite) suggests that PC2 represent the precipitation of these minerals under elevated pH. Our results suggest that preferential dissolution of specific minerals controls the progress and pathway of the reactions, and the

principal component analyses of solution would be useful for extracting information of main reaction system under the hydrothermal conditions.

Reference

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