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Coupled mass transport and serpentinization at crust/mantle boundary: Insights from hydrothermal experiments

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Serpentinization commonly proceeds by a supply of water passing through crust, and thus a large mass transport could occur during serpentinization reactions. Especially, silica activity is known as a control of the reaction paths and rate during the hydrothermal alternation of peridotites [1, 2]. However, it is still unclear the role of mass transport on reaction paths, overall hydration rate and volume change during serpentinization. In this study, we conducted two types of hydrothermal experiments on serpentinization. First one is the metasomatic-reaction experiments between olivine (Ol) ? quartz (Qtz) zones as analogue of boundary of mantle and crustal rocks. Second one is the hydrothermal experiments with sintered olivine (analogue of low porosity rock). Both types of experiments were carried out at 250 ?C and vapor-saturated pressure (= 3.98 MPa) in alkaline aqueous solution.

In the Ol-Qtz metasomatic experiments (up to 46 days.), composite powders, which was composed of Qtz zone and Ol zone was set in inner tubes and then loaded into autoclave. After the experiments, the mineralogy and H2O content of the products were evaluated as a function of the distance from Ol/Qtz boundary. The reaction products after olivine are serpentine (Srp), brucite (Brc), magnetite (Mgt) and smectite (Smc) (instead of talc). The products systematically change from the Smc+Srp to Srp+Brc+Mgt with increasing the distance from the Ol/Qtz boundary. The H2O content of the products is low at the Ol/Qtz boundary (i.e., 3.9 wt.% after 46 days), and increases toward the margin of the tube (12 wt.% at ˜30 mm from the Ol/Qtz boundary).

The detailed mass balance calculation between 25 to 46 days reveals the characteristic nature of the metasomatic reactions and porosity change as follows. Near Ol/Qtz boundary (Smc+Srp zone), smectite was formed by supply of silica in two ways; hydration of olivine and dehydration of serpentine. In contrast, at the zone far from the boundary (Srp+Brc zone; >20 mm from O/Qtz), the production rate of serpentine and brucite are constant without any silica supply. At the transition zone between Smc+Srp and Srp+Brc zones, a large amount of serpentine is formed by consumption of both brucite and olivine, which results in a largest porosity reduction (˜30 %). In the Smc+Srp zone, dehydration and porosity reduction occurs simultaneously, implying a possible raise of fluid pressure. Silica metasomatic reactions causes a significant variation not only in mineral assemblage but also in porosity and fluid pressure, which will characterize the dynamic change of mechanical properties at crust/mantle boundary.

In the hydrothermal experiments of the sintered olivine, the starting olivine aggregate (initial porosity <˜10 %, covered by Pt jacket), which was made by hot press at 1200 degreeC, 1 GPa and 4 days, was emplaced in the alkaline water. After 3 days, we recognized the progress of serpentinization reaction to produce serpentine and brucite. An interesting finding of this experiment is that brucite did not formed in pores of the core sample, but it was formed only at the top of the cylindrcial core of the sample. This result is quite different from with our previous experiments with using olivine powder (initial porosity is ˜50 %) [3], in which brucite and serpentine was formed uniformly. The result of our present study of the sintered olivine suggests that, when the rock porosity is low and volume expansion is difficult, brucite is segregated into open space (c.a. open fracture) during serpentinization; which may also affects on the formation of the local weak zone within the mantle peridotite.

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