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地殻におけるシリカ析出の反応速度
Kinetics of overall silica precipitation within the Earth's crust

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The kinetics of dissolution and precipitation of silica minerals is important to reveal the geochemical reaction and to estimate how long silica deposits forms in the Earth's crust. The present kinetic equation for silica-water reactions was determined at 0-300 C and in the low Si saturated solution, where quartz growth on quartz surfaces occurs than that of nucleation of silica polymorphs [1]. However, the precipitation experiments of the high Si supersaturated solution showed that the co-precipitation of silica polymorphs via nucleation could occur [2], and the euhedral quartz crystals precipitates without precursor of silica polymorphs from the solution with minor components (Al and Na) [3].

In this study, the overall precipitation rate of silica minerals, which includes surface reaction of quartz (first term) and nucleation of silica polymorphs (second term), is derived empirically to estimate the total amount of silica precipitation within the Earth's crust. The previous kinetic equation of surface reaction [1] is applied as the first term. Based on the precipitation experiments of flow rate, the nucleation-controlled precipitation of silica minerals is expressed in a first order rate equation in the second term. The applicability of the nucleation term determined as the nucleation parameter is only in the conditions that precipitation occurs: in the solution supersaturated with respect to quartz, and in the supercritical conditions of water. The rate constant of nucleation is derived as a function of Al concentration in the solution based on the experiments of silica precipitation [3].

By using the new kinetic equation, silica-water interaction was simulated at the wel WD-1a of the Kakkonda geothermal field, Japan, which penetrated the boundary of the hydrothermal convection and heat conduction zones [4]. Amount of dissolution and precipitation of silica minerals increases with decreasing of the fracture permeability. The largest amount of silica precipitation occurs in the downflow fluid at the permeable-impermeable boundary regardless of the fracture permeability.

The equilibrium consideration [5] and the kinetic results indicate that, if open fractures forms at the depth of the permeable-impermeable boundary, the impermeable zone could be reproduced by precipitation of silica minerals, which cause the sustainable division between the permeable zone and the impermeable zone in the Earth's crust.

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