流体急減圧と流体流動によるシリカ析出の比較および断層特性への影響
Contrasting silica precipitation via flash vaporization and fluid flow and possible effects on fault properties

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It is thought that precipitation of silica plays crucial roles on mechanical and hydrological properties of faults. The solubility of silica minerals varies significantly depending on temperature and water density (e.g., Manning, 1994). Okamoto *et al.* (2010) conducted the hydrothermal flow-through experiments at vapor-like supercritical condition (430 ℃, 31 MPa) and showed that silica precipitation predominantly occurred via quartz overgrowth and quartz nucleation (Okamoto *et al.*, 2010). In contrast, precipitation of silica is thought to be induced by decompression of fluids. Weatherley and Henley (2013) suggested that silica particles precipitate by flash vaporization at fault jog; however, the process of silica precipitation under such extreme condition has not been verified experimentally. The purpose of this study is to understand the mechanism of silica precipitation by hydrothermal experiments. In particular we focus on the difference in the mode of occurrences of silica precipitates between flashing and fluid flow system.
We conducted two types of experiments: (1) flash + batch experiments, and (2) flow-through experiments. Both experiments were carried out with using high-silica solutions (Si = 250-300 mg/kgH_2O, Na, Al, K = 4-6 mg/kgH_2O), that was prepared by dissolution of granite sand at 370 ℃ and 40 MPa. In the flashing experiments, after the input solution was enclosed into the autoclaves, elevated pressure and temperature, and flashed by opening the valve. Alumina filter (average pore size of 60 μm) was placed on the flow pathway to catch the silica particles. The flash P-T conditions were 261 ℃, 353 ℃, 400 ℃, and 450 ℃ at pressure of 35-38 MPa. In all conditions, silica precipitates did not include quartz, but spherical particles of amorphous silica with size of 0.1-10 μm were produced. Such amorphous silica was probably formed by nucleation and aggregation during the evaporation of water droplet. Then, we investigated the transformation of the flashing products (removed from the alumina filter and enclosed in Au tube) by the batch experiments at 261 ℃ and 351 ℃ at vapor saturated pressure, and at 400 ℃ and 450 ℃ under supercritical conditions. There was no change of silica after the batch experiments at 261℃ and 351℃ conditions within 5 days. In contrast, small quartz crystals (size of less than 10 μm) were produced in 5 days at 400 ℃ and in 3 days at 450 ℃. Albite was partly produced as the results of interaction with alumina-filter.
The silica precipitation was also investigated by the flow-through experiments at 390-430 ℃ and 25 MPa (supercritical condition) with constant flow-rate of 0.5 or 1 mL/min by using the granite-dissolved solution similar to the flash experiments. The silica was precipitated in alumina tube filled with alumina ball (diameter with 1 and 2mm). We found the silica precipitates clogged the pores within few days. Based on the XRD and SEM observation, the products of the flow-through experiments were mixture of amorphous silica and quartz. Some quartz crystals grew up to 100 micrometers and amorphous silica were precipitated on the alumina balls and the alumina pipe.
In both cases, amorphous silica was easily produced in response to the drop of water density at high temperatures. Such amorphous silica can move and clog effectively the pores. Also, our experiments revealed that such amorphous silica was changed to quartz, which depends on the temperature and fluid states (flow or batch). Such variation of silica by precipitation and transformation potentially would

provide a significant influence on the fault strength.

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