Formation of mineralized quartz veins induced by flash evaporation from liquid to vapor under sub and supercritical conditions

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Fluid flow through faults and fractures in Earth's crust controls transport of elements, energy and heat, and it is associated with formation of many types of ore deposits. Since the solubility of silica in water drastically changes with temperature and pressure conditions, fluid flow and phase transition of aqueous fluids produce silica scales in pipelines of geothermal power plants and also mineralized quartz veins. A drop of fluid pressure and involving boiling could be a cause of precipitation of silica and metal species. Weatherley and Henley (2013) proposed a hypothesis of gold mineralization by "flash vaporization", which is an instantaneous vaporization at fault jog induced by fault displacement. They suggested a possibility of the formation of gold-quartz veins at the time of earthquake. Since there are many similarities between conditions of superctical geothermal reservoir and hydrothermal ore deposits, the exploitation of supercritical geothermal reservoirs would provide us good opportunities for further understanding mechanism of hydrothermal ore deposits. However, to our knowledge, there have been no studies on precipitation of silica under such extremely high-supersaturated conditions, and its relation to ore formation. The aim of this study is to understand the mechanism of silica precipitation by flash vaporization and its relation to hydrothermal ore deposits. The reaction vessel (50 or 110 ml) has inner wall made of Ti, and P-T conditions were up to 450 and 50 MPa, respectively. Initially, we enclosed the fluids into the vessel, elevated pressure and temperature, and then, flashed fluids by opening the valve. Alumina filter with pore size of 10-30 micron was placed on the flow path to catch precipitates during vaporization.

In the experiments of silica precipitation by flashing, the input solution (Si = 370 ppm) was prepared by dissolution of composites of quartz and granite sand. The rapid decompression experiment was carried out by flashing from 30 MPa under liquid (200, 250, 300, 350°C) and supercritical conditions (400, 450°C).The pressure of the input solution was instantaneously decrease to the vapor conditions within a few seconds. In contrast to our previous studies of silica precipitation by flow-through apparatus (Okamoto et al. 2010), where phase transition of water occurred by increasing temperature, silica precipitates did not include quartz but occurred as spherical particles of amorphous silica with size of 1-3 micron, probably due to a lack of duration of transformation into more stable phases. The Si concentration of the output solution ranged from 10 to 60 ppm, which is lower than the solubility of silica on the saturated vapor pressure curve along the P-T path. These occurrences of silica indicate that metastable amorphous silica particles were formed by rapid decompression and transported from sub- to supercritical fluids, which leads to the formation of silica scales and clogs of fractures.

Next, we prepared the initial fluids (pH = 2, HCl added) with metal components, Cu (170 ppm) and Mo (30ppm), as well as silica (Si = 400 ppm). The input solution was kept four hours at 350°C, 30 MPa, then was decompressed in two ways; first one is slow decompression by natural cooling, and the other was near adiabatic decompression by flash vaporization. As the result of slow decompression, the composition of the solution after the experiment does not change significantly (Si = 360 ppm, Cu = 130 ppm, Mo = 12 ppm). In contrast, in the rapid decompression experiment, each concentration decreased drastically to Si = 13 ppm, Cu = 4 ppm, Mo = 0.2 ppm, respectively. Our results indicate that mechanism and rate of the formation of mineralized quartz veins was highly depends of P-T-t path of the fluids, and that flashing from sub to supercritical conditions (phase transition of water) potentially plays roles of mineralizeation.

References

1. Weatherley, D.K., Henley R.W., (2013). Flash vaporization during earthquakes evidenced by gold deposits. *Nature Geoscience*, 6, 294-298.
2. Okamoto, A., Saishu, H.,Hirano, N., Tsuchiya, N. (2010). Mineralogical and textural variation of silica minerals in hudrothermal flow-through experiments: Implications for quartz vein formation., *Geochimica et Cosmochimica Acta*, 74, 3692-3706.

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