Silica precipitation and formation of mineralized vein induced by flash vaporization of sub- to supercritical fluids

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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 ore deposits. Since the solubility of silica in water drastically changes with temperature and pressure, fluid flow of aqueous fluids produced mineralized quartz veins. A drop of fluid pressure and involving boiling has been known as possible cause of precipitation of silica and metal species. Weatherley and Henly (2013) proposes a more drastic model that a gold- quartz veins are instantaneously formed by decompression of crustal fluid to near atmospheric pressure due to fault formation ("flash vaporization"). However, to our knowledge, there have been no studies on precipitation of silica under such extremely high-supersaturated conditions like flashing, and its relation to ore veins formation. The aim of this study is to understand the mechanism of silica precipitation by flashing and its relation to hydrothermal ore veins.

We developed a new experiment apparatus which is consist of autoclave (110 ml, inner wall made of Ti alloy) for the flashing of fluid from sub- to supercritical condition. Initially, the fluids into the vessel were enclosed, elevated pressure and temperature, and then, flashed fluids by opening the valve. Alumina filter (average pore size of 60 μm) was placed on the flow pathway to catch silica particles.

In the experiments of silica precipitation by flashing of crustal fluid, the input solution was prepared by dissolution of quartz and granite sands by the flow through experiments (Si: 258 mg/kg H_2O, Na, Al, K: 4-6 mg/kg H_2O). The flashing experiment was carried out from 36 MPa under liquid (250, 350 ˚C) and supercritical conditions (400, 450 ˚C). The pressure of the input solution was instantaneously decrease to the vapor conditions within 1-2 seconds. In contrast to our previous studies of silica precipitation by flow-through experiments (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 0.1-10 μm, probably due to a lack of duration of transformation into more stable phases.

The flashing experiments of mixed fluid containing silica, Cu and Mo solution was conducted to clarify the formation process of the mineralized veins. The mixed hydrochloric acid aqueous (pH 5.01) containing Si (500 mg/kg H_2O), Cu (100 mg/kg H_2O) and Mo (50 mg/kg H_2O) were prepared. Flashing processes were repeated in four times from 36 MPa and 400 ˚C. After the first flashing, spherical silica particles (1-10 μm), copper as dendrite shapes (20-50 μm of length) and molybdenum as rhombic shape particles (5-10 μm) were formed separately. By the repeated flashing, layering deposits were formed. Elemental map observation, each mineral particles deposits as; Mo →Cu →silica.

It seems that the effects of particle shapes of minerals make up these layers. Fine mineral particles are hardly susceptible to air resistance during fast fluid flow such as shock wave at flashing, and deposit early. Since dendrite shapes copper is considered to have a large surface area and large resistance, it deposits from mid to late stage. Even in the formation of natural ore veins, it is considered that spherical silica particles were formed by flashing and separate layers of minerals are separated by mechanical sorting in fast fluid flow.

References

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