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Formation of bi-pyramidal quartz within hydrothermal vents: insights from Kuroko deposits and hydrothermal experiments

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Mineral precipitation in hydrothermal vents has been thought to occur in response to quenching of hydrothermal fluids by mixing with seawater, but the mechanism of mineral precipitation is still unclear. Characteristic bi-pyramidal quartz grains have been reported in the concentric structures of Kuroko-type ore, which represent the chimneys in submarine hydrothermal deposits, and are thought to be the key to understanding the physico-chemical conditions of mineralization[1].

We analyzed two Kuroko ore specimens containing quartz grains collected from the Hanaoka mine in the Hokuroku district, NE Japan. The quartz grains show euhedral bi-pyramidal shape with a long axial length of 0.07–0.45 mm and aspect ratio of 3-5, and contained fluid inclusions. We investigate the homogenization temperature, and they suggest that quartz crystals were formed from high temperature fluids of 277–309°C. From Stokes' equation, the fluid ascending velocity within the chimney was estimated to be 0.04-1.6 m/s, which is consistent with that measured at the active hydrothermal vents[2].

The hydrothermal experiments were conducted using a flow-through apparatus with vertical flow-path with using high-silica aqueous solution (~300 mg/kg(H_2O)). We conducted two runs at supercritical condition of 25 MPa and 430 °C and vapor condition of 8.6 MPa and 300 °C. For the experiments under supercritical conditions, systematic changes of silica minerals were observed along the path. The quartz grains show euhedral bi-pyramidal shape with size of 6-103 micrometers. Some of quartz grains were embedded within the cristobalite particles. For the experiments under saturated vapor pressure conditions, very fine particles of amorphous silica were observed. These results suggest that the formation of bi-pyramidal quartz could be formed via amorphous silica, and the changes to quartz crystals occurs by dissolution and precipitation via the continuous supply in liquid or supercritical fluids. Stokes' equation predict that the silica particles smaller than ~14 micrometers can move upward in the experiments, which is consistent with the particle size observed, suggesting that the bipyramidal quartz formation occurred in suspension.

References

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