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Morphological and chemical characterization of secondary carbonates in the Toki granite, central Japan, and the evolution of fluid chemistry

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Abstract

This study describes the: (1) morphological nature of the calcites in the Toki granite, central Japan; (2) the difference in chemical compositions in terms of morphological classification; and (3) the identification of the stages of calcite formation and the corresponding mass transfer between minerals and fluid owing to hydrothermal alterations and groundwater-rock interactions, which reveals the sequential variations in fluid chemistry during the sub-solidus stage. Calcites in the Toki granite were classified into four types: (1) lenticular calcite in the chloritized biotite; (2) granular calcite in the altered plagioclase; (3) intergranular calcite; and (4) fracture-filling calcite. The lenticular, granular, and intergranular calcites contain greater amounts of iron, manganese, and magnesium than fracture-filling calcites. The lenticular calcite in the chloritized biotite, granular calcite in the altered plagioclase, and intergranular calcite formed due to the precipitation of calcium, iron, manganese, and magnesium released from biotite and plagioclase owing to hydrothermal alterations. The fracture-filling calcites formed at a later stage than the lenticular, granular, and intergranular forms. In the hydrothermal fluid, the concentrations of aluminum, iron, manganese, and magnesium gradually decrease, and the concentration of calcium gradually increases as the alteration proceeds. The chemical characteristics of the fluid at the late stage of hydrothermal alteration and those of the subsequent groundwater are consistent with those of fracture-filling calcites, indicating that the fracture-filling calcites precipitated from the fluid at a late stage of hydrothermal alterations and then from the groundwater. Elements released from biotite and plagioclase owing to hydrothermal alterations were incorporated into and fastened to the calcite. Therefore, the calcites influenced the sequential variations in fluid chemistry during the sub-solidus stage.

Keywords: Carbonate mineral, calcite, hydrothermal alteration, precipitation, mass transfer, cathodoluminescence image