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石英脈形成における微細組織発達

Microstructural evolution of quartz aggregate during vein formation

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Fractures (and faults) play dominant fluid pathways at shallower levels of crusts. Ubiquitous occurrences of quartz veins indicate that precipitation of silica minerals is of special importance for spatial and temporal variations of rock permeability and rock strength at the depths around and below brittle/ductile transition. However, the physico-chemical conditions during quartz vein formation (fluid compositions, flow rate, fracture geometry etc.) has been poorly constrained, probably due to their simple chemical compositions. On the other hand, it is known that veins produce a variety of textures including fibrous, elongate blocky and blocky textures. These textures are defined by grain shape, grain size and the relation to the wall rock, which records a significant information during crack sealing. However, the interpretation of these textures is rather arbitrary, and thus the microstructural evolutions of quartz veins are still unclear. One of the important phenomena during polycrystalline growth is growth competition, that crystals with favorable orientation and position survive.
In this study, we developed a method of quantitative analyses of shape and c-axis fabric of quartz aggregates, and applied it to textures in the synthetic quartz aggregates grown from the Si-saturate aqueous solutions. Then, we compare them to natural quartz veins from the Shimanto accretionary complex, and the Sanbagawa metamorphic belt. For the textural analyses of quartz aggregates in thin sections, we used the orientation imaging microscopy. This system provides the two-dimensional data of retardation and the orientation of maximal retardation with respect to the reference lines (0-180 degree). Because the orientation of the optical slow axis of quartz is consistent with its c-axis, we can calculate plunge and azimuth of c-axis with respect to a thin section plane, when thickness of thin section is given. Based on two types of two-dimensional data, we develop the algorism to detect the grain boundaries, and the orientation of c-axis of individual quartz grains with respect to a vein wall plane.
The polycrystalline quartz aggregates grown from the aqueous solutions were created by hydrothermal flow-through experiments at 430 degreeC and 30-32 MPa with the flow rate of 1 g/min. We used Si-saturated solutions created by dissolution of granite sand at 360 degreeC, that contains Si = 300-400 ppm (the degree of supersaturation is 3-4) with minor Al, Na and K with several ppm. The minor cations are important for growth of quartz, because our previous experiments revealed that metastable silica polymorphs (opal-A and opal-C) are predominantly nucleated in pure Si solutions. We used fine-grained metachert (0.02-0.05 mm) with random fabric as the rock substrates. After one week experiments, euhedral quartz grains grew from the substrate wall. In spite of random c-axis fabric in the substrate metachert, the quartz grains, which c-axis orientation is nearly normal to the vein wall, selectively grew into the open cavity. Also, the long axis of the growing crystals is parallel to the c-axis. This suggests that growth competition operated during the growth of quartz due to the strong anisotropic growth rate; the growth rate

along c-axis is much faster than other orientations. Such a microstructural features are well consistent with the natural quartz veins with elongate blocky textures. On the other hand, in the cases of natural veins with fibrous or stretched crystal veins, c-axis fabric of the vein quartz is not concentrated, and it reflects the fabric of the host rocks. We will show the differences of these vein textures in terms of the degree of c-axis fabric concentration and shape parameters (aspect ratio, width). Also, the controlling factors to produce fibrous textures will be discussed, especially focusing on crack apertures during vein formation.

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