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Spatial distribution of mineral veins at the exhumation stage of the Sanbagawa belt

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Mineral veins in high-pressure metamorphic belt provide a great opportunity for investigating the nature of the earlier fluid-filled cracks in the subduction zones. In this study, we investigated the spatial distributions, microstructures, carbon isotope compositions in mineral veins (composed of some combination of Qtz-Ab-Chl-Cal-Kfs) within the Sanbagawa metamorphic belt in Kanto Mountains and central Shikoku, Japan. The analyzed veins intersect the foliation and E-W streaching lineation of host rocks at high angle (60-90 degree), indicating they developed at the late stage of exhumation. The P-T conditions of these vein formation are 200-400 degreeC, 0.1-0.4 GPa. The spatial distribution of these veins is not homogeneous in the Sanabagawa belt. The volume fraction of the veins, measured as total vein width per 20 m scan line in each outcrop, is large within the lower structural parts (chlorite zone, 1-5 vol.%), but is very small in higher structural parts (garnet and biotite zones, less than 1 vol.%).

The relationship of mineral distribution between veins and host rocks suggest that thin veins (less than 5mm) with stretched crystal texture formed by mass transfer from adjacent host rocks, whereas thick veins (larger than 5mm) with blocky textures by influx of external fluids (Okamoto et al. 2008). The carbon isotopic signatures of calcite in veins and host rocks are also consistent with this result: the difference of delta13C value between vein and host rocks is small in thin vein, whereas it is large in thick veins (Morohashi et al. 2008). Some blocky veins shows significant texture that euhedral hexagonal (double-terminated) quartz with concentric growth zoning, indicating crystallization in crystal-fluid suspension subjected upward fluid flow. Applying crystal settling theory to crystal size distributions of quartz in such veins, we estimated the very high upward flow rate (0.01-0.1 m/s). Such a high flow rate is difficult to interpreted by fluid flow along the fracture network. On the other hand, the rate of propagation of fluid-filled cracks makes it possible to such upward flow rate.

Because the veins formed at the retrograde stage, the host rocks could not produce water by dehydration, but the hydration proceeded to produce actinolite and chlorite in basic schists (Okamoto and Toriumi, 2005). The fluids derived from dehydration of subducting slab and sediment underneath the exhuming Sanbagawa belt probably caused vein formation and hydration at the lower structural parts of the Sanbagawa belt. We present a conceptual model as follows: Fluid ascent by propagation of isolated fluid batch with fast ascend rate producing blocky veins, and they arrested at the shallower depth (chlorite zone) due to the leak of fluids and increase of crystal fraction. Input of external fluids increased fluid pressure of this region, leading to open cracks producing other types of veins (elongate-blocky, stretched crystal veins). Because the host rocks consumed the fluids by hydration reactions, the fluid pressure decreases, then vein-forming cracks did not develop at the higher structural parts (garnet, and biotite zones).

References

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