

Metamorphic veins in serpentinite: kinetic control of mineral compositions during vein formation

Tadao Nishiyama[1]; Tsukasa Iwahori[2]

[1] Earth Sci., Kumamoto Univ.; [2] Earthsciences, Kumamoto Univ.

This paper describes occurrences and petrography of mineral veins in serpentinite which formed during regional metamorphism. Special emphasis will be placed on the compositions of vein minerals which show a systematic variation from the center to the margin in the case of chlorite monomineralic veins. The variation will be explained by the exchange equilibrium fractionation model (Cygan and Lasaga, 1982).

Various kinds of veins occur in a massive serpentinite body in Nomo Peninsula, a member of the Nagasaki Metamorphic Rocks, Kyushu, Japan, that is a Cretaceous subduction complex with nature of epidote blueschist facies metamorphism. In addition to the most abundant antigorite vein, commonly observed are monomineralic chlorite, tremolite and diopside veins, chlorite + tremolite and chlorite + diopside bimineralic veins, and so on. The serpentinite consists mostly of antigorite with small amounts of relic olivine and clinopyroxene, the latter of which is commonly replaced by carbonate (usually calcite). Original layering of peridotite is preserved in the serpentinite. Most veins originated from tensile fractures as suggested by no displacement of the layering through the veins. Each kind of veins has a characteristic feature as follows.

(a) Monomineralic chlorite veins occur ubiquitously in the serpentinite as thin platy veins. The composition of chlorite is close to antigorite at the margin and the most aluminous at the center of the vein. $MgO / (MgO + FeO)$ varies little. A remarkable relationship between the composition and the distance within a vein is observed such that a linear relationship between them shows the same gradient in all the veins studied. In other words, thicker veins have more aluminous centers. The same relationship is observed in chlorite from bimineralic chlorite + tremolite and chlorite + diopside veins.

(b) Monomineralic tremolite veins occur occasionally as platy veins with medium thickness. Tremolite crystals show strong preferred orientation in most veins, whereas aggregates of small acicular tremolite with random orientation occur in some veins. In both cases no compositional gradient is observed within the vein.

(c) Monomineralic diopside veins occur rarely. Diopside forming the vein is more aluminous and chromian than relict clinopyroxene in the serpentinite, which is diopside almost free from Al and Cr. Diopside crystal in bimineralic chlorite + diopside veins is occasionally cut by smaller chlorite vein.

These lines of evidence lead to the following interpretations for the formation of these veins.

(1) Chlorite precipitated from the fluid filling the tensile fracture. Precipitation started at the vein wall, keeping local equilibrium with the wall minerals. As a result, chlorite that first precipitated at the wall has a composition close to antigorite. Precipitation of silica-rich chlorite resulted in relative enrichment of aluminum in the fluid. Successive precipitation of chlorite follows the resultant change in the fluid, forming more aluminous chlorite towards the vein center. This process is similar to Rayleigh fractionation of trace components, but in terms of major components. Cygan and Lasaga (1982) formulated a model of such a process as an exchange equilibrium fractionation model which is an extension of Rayleigh fractionation model to major components. The model can be applied to our chlorite vein. As a prerequisite of the model, the fluid should be static, not flowing. Thus the compositional change in chlorite vein will give a view how the vein form from the fluid.

(2) Appreciable amounts of Al_2O_3 and Cr_2O_3 in the diopside newly formed in the vein imply the mobility of these components during vein formation, contrary to our common view of immobility of these components in metamorphic environments.

(3) The vein in vein cutting a single diopside crystal in the vein strongly suggests that hydrofracturing is prevailing during the vein formation.