Melt inclusions in clinopyroxenes of the Tobe hornfels, western Shikoku, Japan

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It is commonly accepted that low-K granitic magmas including tonalite and trondhjemite form by partial melting of basaltic rocks. However, it is a few examples of investigating partail melting of basaltic rocks in the lower crusts.

Here we have found melt inclusions from the Middle Miocene Tobe hornfels originated from the Sanbagawa basic schists in the Tobe Town, western Shikoku, Japan. In this study, we present results of mineralogical and petrographical study of the Tobe hornfels including the melt inclusions and discuss partial melting of the hornfels, and migration and crystallizaiton of melt.

The Tobe hornfels occurs as a tabular body, about 200m in thickness, in the Sanbagawa basic schists. It has banded structures originated from the Sanbagawa schistosity. On the basis of mineral assemblages, the Tobe hornfels can be devided into three mineral zones; plagioclase, hornblende and orthopyroxene (Sakakibara and Isono, 1996).

The melt inclusions are found from clinopyroxenes of clinopyroxene-plagioclase veins in the hornblende and orthopyroxene zones. The basic hornfels being contact with the veins is made up mainly of fine-grained clinopyroxene and fluid inclusion-bearing and Ca-rich plagioclase (An38-76) and is characterized by abundance of bioitite and opaque minerals, and disapperance of hornblende.

The melt inclusions range from 7 to 30 microns and is colorless under microscope. They show negative inclusion form and frequently include bubbles and calcic amphibole as a daughter mineral. The inclusions have a chemical composition (in wt %), of 75-79 SiO_2, 9.8-11.1 Al_2O_3, 1.2-1.7 FeO, 0-0.3 MgO, 0-1.1 MnO, 0.4-0.7 CaO, 3.2-3.5 Na_2O, and 0.9-2.6 K_2O. During heating, melting occurred at about 850 degree C in some of the inclusions. The calcic amphiboles in the inclusions are prismatic and pale greenish in color. They are ferro-edenite and richer in Fe than those in matrix of the hornfels. Clinopyroxenes including the melt inclusions have a compositional zoning.

Clinopyroxene in the clinopyroxene-plagioclase vein is generally richer in Fe than that in the matrix. It occasionally has a Fe-rich rim. Plagioclase commonly shows a compositional zoning that its core is An36-41 and rim is An16-21.

During a thermal peak stage of the metamorphism, the Tobe hornfels partially melted along the cracks and layers. The H_2O contents of the glass and existence of bubbles in the inclusions suggest that the Tobe hornfels partially melted in the domain characterized by the disappearance of calcic amphibole and fluid inclusion-rich plagioclase under a H_2O-saturated condition, and the primary melt contained much H_2O. The residual phases in the domains are clinopyroxene + plagioclase + opaque minerals.

During the early cooling stage, the melt crystallized Mg-rich clinopyroxene and Ca-rich plagioclase, and then Fe-rich clinopyroxene and Na-rich plagiocalse.

It seems that H_2O in the melt infiltrated into the wall rocks and trapped in plagioclase as fluid inclusions. Quartz filled into the minerals at the latest stage. During rapid cooling, epitaxial Fe-rich clinopyroxene crystallized, and then calcic amphibole grew prior to cooling to the glass transition.