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Aqueous fluid activity in the MCT zone and its role in High Himalayan leucogranite formation, Dhankuta, Eastern Nepal

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Significant aqueous fluid activity during the prograde to retrograde metamorphism in the footwall side of the Main Central Thrust (MCT) is observed in the MCT zone around Dhankuta, Eastern Nepal. A term 'MCT zone' in this study is used to represent the garnet to the kyanite zones developed in the footwall side of the MCT, where inverted metamorphism is observed. In the MCT zone, several evidences of continuous fluid activities during metamorphism and their movement cutting the schistosity can be observed.

The first and most important is the abundant quartz veins. They are found as sheared lenses in the MCT zone, and asymmetric textures show top-to-the-S sense of shear indicating the deformation during the MCT movement. In the kyanite zone, quartz veins contain mm- to cm-sized crystals of kyanite and minor plagioclase. Garnet and kyanite are coarse-grained only at the vicinity of the quartz veins, and in the staurolite and garnet zones as well, garnet tends to be coarser-grained around the quartz veins. These observations suggest that the aqueous fluid infiltration that formed the quartz veins took place at the prograde to peak stage of the metamorphism in the MCT zone.

Meta-dolostone in the kyanite zone is also a good indicator of H_2O movement. It is commonly almost completely metamorphosed to tremolite schist. In such rocks, radiated aggregates of tremolite form a flat, oval-shaped aggregate are arranged parallel to define the schistosity. Locally, such a tremolite arrangement discordantly cut the schistosity like a vein. In some meta-dolostones, dolomites are still preserved, and veins of tremolite discordantly cut the schistosity as well as stem out parallel to the schistosity. These observations indicate that SiO_2-bearing aqueous fluid infiltrated into the dolostone and reacted with dolomite to form tremolite, calcite and CO_2 along the vein and schistosity.

Tourmaline (Tur) is an important sink mineral of incompatible element B, and thus is often abundant in the environment where water-rock interaction took place. Unusually abundant Tur is locally found in metapelites of the MCT zone. It is localized in aluminous, muscovite-rich layers and can be formed through the input of external B into the appropriate whole-rock composition for Tur growth. Such a B-bearing fluid infiltration continued from the prograde stage because garnet with prograde chemical zoning includes abundant Tur crystals. B-bearing aqueous fluid infiltration continued in the post-peak stage as suggested by the presence of Tur-rich vein cross-cutting the schistosity. In the kyanite zone, Tur veins are found cutting the schistosity and/or stem out parallel to the schistosity. In such samples, although the B-rich fluid infiltration postdates schistosity formation, staurolite includes or partly overgrows the Tur crystals formed simultaneously with the Tur-rich vein, suggesting that the Tur vein was formed under relatively high-temperature condition slightly after the peak metamorphism.

These aqueous fluids are likely to have moved upwards through the veins to the MCT and to the Higher Himalayan Crystallines (HHC) where P-T conditions above water-saturated solidus of muscovite-bearing pelitic rocks are estimated. In the hanging wall side of the MCT in the Dhankuta area, patches of Tur-bearing leucogranites are found in the migmatitic Grt-Ms-Bt gneisses. One of these leucogranite samples gave the U-Pb zircon age of 25.9 +/- 2.3 Ma, and other gneiss sample from the same area gave U-Pb zircon age of ca. 17 Ma (Sakai et al. 2014). These ages are well consistent with the ages of High Himalayan leucogranites (HHL, Searle et al. 2010), which is commonly tourmaline-bearing, so segregation and extraction of these B-bearing melts is a likely process of the HHL formation. Therefore, input of aqueous fluids released from or passed through the MCT zone into the HHC can be an important process for the formation of HHL (e.g., Le Fort et al., 1981).

Keywords: aqueous fluid, quartz veins, tourmaline, partial melting, leucogranite, Himalayas