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Implication of the residual pressure recorded in quartz inclusions in granet from high T metamorphic terranes

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Quartz inclusions in garnet from metamorphic terranes reveal residual pressure depending on the metamorphic pressure and temperature of their entrainment (Enami et al, 2007). The residual pressure occurs due to the difference in elastic properties of host garnet and quartz inclusions and also due to the pressure and temperature change according to the exhumation path. The residual pressure can be measured by Raman micro-spectroscopy, and the results are consistent with those estimated by a simple elastic model of the sphere-in-hole problem (Enami et al, 2004). This is an important progress in metamorphic petrology, because it represents a new development of metamorphic barometry independent of thermodynamic methods.

However, several problems have remained to be solved in the application of this method. One problem is the applicability of this method to high temperature metamorphic terranes in which low - high transition can occur in quartz. This study aims to solve this problem and examined quartz inclusions in garnet from the Higo Metamorphic Rocks, one of the high T metamorphic terrane of Cretaceous in age in Central Kyushu.

The studied are is Kosa district, Kumamoto Prefecture, which is the same area studied by Maki et al (2004). Here we adopt the metamorphic zonal mapping after Maki et al (2004): biotite zone, garnet - cordierite zone, and orthopyroxene zone from north to south. This study newly defined the muscovite - out isograd and the tourmaline - out isograd in the studied area. The peak metamorphic temperatures are about 600 C at the muscovite - out isograd and about 800 C at the orthopyroxene isograd, which are estimated by the granet - biotite thermometer and the petrogenetic grid (Maki et al, 2004).

We examined eight samples collected from the area between the muscovite - out isograd and the orthopyroxene isograd by Raman micro-spetroscopy. According to Enami et al (2004), we made plots of Dw1 vs Dw2. In the plots we found two kinds of data: one plotted in the first quadrant (both Dw1 and Dw2 are positive) and the other plotted in the third quadrant (both Dw1 and Dw2 are negative). The two kinds of data are taken from the same garnet grain. The latter data has not been reported by Enami et al (2004) who studied mostly high pressure metamorphic rocks. We interpret that the data plotted in the first quadrant show compressive stress and the data plotted in the third quadrant do tensile stress as suggested by Enami et al (2004).

The peak metamorphic pressure and temperature condition of this area is likely to have reached the stability field of high quartz (Obata et al, 1994, Osanai et al, 1998, Yoshimrua, 2004, Maki et al, 2004 and Miyazaki, 2004). Therefore quartz inclusions showing tensile stress may be originally high quartz when they are entrained in the host garnet. The high quartz will transform into low quartz when the host rock crosses the transition curve during the exhumation, and the volume decrease by about 1 per cent associated with the transition may cause tensile stress in the garnet. Quartz inclusions showing compressive stress from the same garnet grain may have been entrained in garnet when the rock crosses the transition curve from high temperature side in the retrograde path. Therefore we assume that quartz inclusions with compressive stress have been entrained at the low- high transition temperature and evaluated the entrainment pressure by combining the residual stress measured by Raman micro-spectroscopy and the elastic model. The result shows 0.35 - 0.5 GPa, independent of sample location in the area. The estimated pressure is higher by 0.1 - 0.3 GPa than the peak metamorphic pressure estimated by Maki et al (2004) and also by Miyazaki (2004), and lower than the pressure by 0.3 - 0.5 GPa recorded in a calc-silicate granulite in the same area reported by Maki et al (2009).

Keywords: garnet, quartz, residual pressure, high T metamorphic terrane, Raman micro-spectroscopy, elastic interaction