高温変成岩中に含まれる長石のリンによる組成累帯構造からみる黒雲母形成過程

中村文[1]、河上哲生[1]
[1] *京都大学大学院理学研究科*

Constraining the formation process of biotite utilizing the chemical zoning of phosphorus in feldspars in high temperature metamorphic rocks

Aya Nakamura[1], Tetsuo Kawakami[1]
[1]*Kyoto University*

The biotite-garnet gneiss from Akarui Point, Lützow-Holm Complex, East Antarctica is mainly composed of garnet (Grt), biotite (Bt), sillimanite (Sil), alkali feldspar (Afs), quartz (Qtz) and plagioclase (Pl). Kawakami et al. (2008) estimated the peak metamorphic pressure and temperature condition of Akarui Point to be 7.7-9.8kbar and 770-790 ^{o}C. White et al. (2001) calculates that pelitic rock can produce up to 20-30vol% of melt under the peak *P-T* condition through the dehydration melting process, so it is quite possible that the studied sample experienced dehydration melting of biotite. Garnet partly replaced by the intergrowth of biotite and albite-rich plagioclase (termed "Bt-Pl intergrowth" hereafter) is locally present in this rock. Between the biotite in the Bt-Pl intergrowth and adjacent alkali feldspar in the rock matrix, two significant textures are found: (i) In alkali feldspar, a domain with perthitic texture and that with anti-perthitic texture are found within a single crystal (Fig. 1). (ii) At the contact between alkali feldspar and biotite, serrate projections of biotite are developed against alkali feldspar, and they are selectively developed next to orthoclase lamella (Fig. 2). These textures are probably formed as the biotite grew by consuming potash in alkali feldspar. The formation of texture (i) possibly occurred through the reaction Or + (H_2O in fluid or $melt_1$) + (Fe, Mg from Grt or $melt_1$) → Bt + Ab (+ $melt_2$) (reaction A) at 750-825 ^{o}C (possibly 800-820 ^{o}C) before the formation of lamella in alkali feldspar ended, and that of texture (ii) occurred after the formation of lamella (Nakamura et al., 2009).

The alkali feldspar adjacent to the Bt-Pl intergrowth has phosphorus-poor (P-poor) core and phosphorus-rich (P-rich) rim. The chemical zoning of phosphorus does not coincide with those of potassium and sodium or with the variation in the exsolution texture of the alkali feldspar. Therefore, taking into account the sluggish intracrystalline diffusion of P in alkali feldspar, its phosphorus zoning is possibly unchanged from its formation, and thus the formation of P-rich rim possibly predated the formation of texture (i). The plagioclase grains in the Bt-Pl intergrowth are as rich in P as the rim of the alkali feldspar grains. Therefore, it is likely that the formation of P-rich rim of alkali feldspar and the plagioclase in the Bt-Pl intergrowth texture occurred nearly at the same time, i.e., the formation of the Bt-Pl intergrowth replacing garnet took place before the formation of texture (i). The Bt-Pl intergrowth texture, which was possibly produced at the retrograde process, was formed above the temperature at which the reaction A occurred (750-825 ^{o}C). The formation of biotite by consuming garnet requires the infiltration of H_2O. Taking into account the temperature of Bt-Pl intergrowth formation (>750-825 ^{o}C), H_2O should have been incorporated in melt. The plagioclase in the Bt-Pl intergrowth, which is rich in phosphorus, is therefore likely the product of melt-related process. The similarity in the P-content at the rim of alkali feldspar with the plagioclase suggests that the rim of the alkali feldspar can also be the product of melt-related process.

In alkali feldspar in the rock matrix, the significant chemical zoning in terms of phosphorus is locally observed around coarse-grained apatites. The phosphorus content in alkali feldspar is high around apatite grains and decreases with distance form them continuously. Such a chemical zoning is not found around apatite included in garnet. The change of the phosphorus content is independent of the grain boundaries and orientations of alkali feldspar crystals. These characteristics are best explained if we consider that P-rich alkali feldspar is the crystallization product of the P-bearing melt. The consideration that P-rich parts of the feldspars are the product of the melt-related process as discussed above permits this interpretation. These alkali feldspar grains sometimes also have P-poor core, and the discontinuous chemical zoning of phosphorus in alkali feldspar implies that the P-poor core should be already present as a solid phase when P-rich rim of alkali feldspar crystallized from the P-bearing melt.

The biotite-sillimanite aggregate in the rock matrix is often surrounded by the P-rich plagioclase grains that locally accompany P-poor core. At least part of them was possibly formed by the crystallization of melt during the retrograde process. Information on the chemical zoning of P in feldspars enables to link the infiltration of melt or fluid and the formation process of microtextures in high-temperature metamorphic rocks.

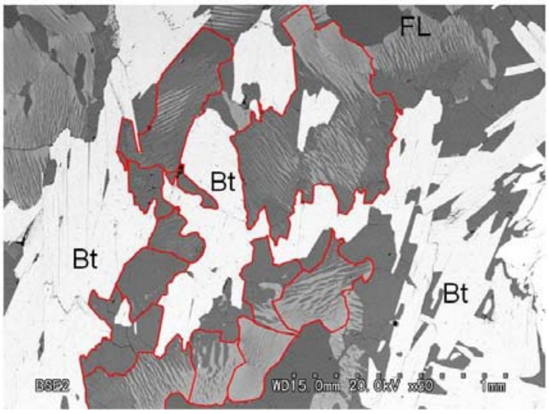

Figure 1. back scattered image of alkali feldspar partly with anti-perthitic texture and albitic plagioclase

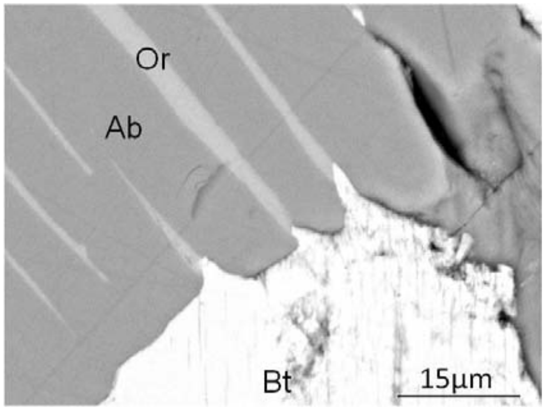

Figure 2. back scattered image of serrate projections of biotite

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