

Migration and fixation of chlorine by a deuteric reaction replacing magnetite with biotite

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Cl-bearing biotite which had been formed by metasomatic reaction between magnetite and magmatic aqueous fluids was founded in the gabbro-pegmatite anorthosites from the Lower Zone of the Murotomisaki Gabbroic Intrusion (MGI; 220m thick). In this presentation, we discuss activities and behaviors of aqueous fluid and Cl within the pegmatites on the basis of the above textural observation and whole-rock and apatite chemistry.

The MGI is a sill-like layered intrusion at the Cape Muroto, Shikoku, Japan. The crystal growth zone (GR) of the Lower-Zone (olivine gabbros) contains abundant podiform gabbro pegmatites of varying sizes (Hoshide & Obata, 2009). The pegmatite has an internal layered structure consisting of an anorthositic roof on the top, a pegmatitic filling in the middle, and a picritic floor. The anorthositic roof of the pegmatite is higher in Cl content in whole rock than the surrounding gabbros (hereinafter called 'host gabbro'). Nonetheless, the apatites from the anorthositic roofs are lower in Cl (0.2-0.9 wt%) than that in the host gabbros, which varies greatly between different grains in composition ranging from 0.3 to 2.7 Cl wt%. It is important to note that the apatite from the host gabbros shows an inverse relationship between Mg and Cl.

In the anorthositic roof of the pegmatite, host magnetite that contains ilmenite exsolution lamellae has been partly or completely replaced by biotite that contains significant amount of Cl. Whereas, magnetites in the host gabbro, which occur as discrete grains, are free from such alteration. Replacing biotites in the anorthositic roof are characterized by their higher Cl contents (ca. 1 wt%) and lower Mg-number ($Mg\# = 14-17$) than those from the host gabbro (Cl = ca. 0.1 wt%, $Mg\# = 71-75$). By the modal and chemical analysis of biotite, it was found out that most of Cl in the anorthosites is contained in the biotite, which apparently has formed by replacing magnetite after the ilmenite exsolution.

Other important observation regarding the Cl content is the inverse relationship of Cl content between the whole rock and the apatite for the anorthosite. As the variation of MgO contents in the apatites is thought to reflect that of the MgO content in the melt, the negative correlation between Cl and MgO in the apatite observed from the host gabbro should indicate that the Cl content has increased in the melt with the advance of melt fractionation. On the other hand, apatites from the anorthositic roof of the pegmatite are comparable in MgO content to the Mg-poor ones in the host gabbro. Therefore, it appears that the apatites in the anorthositic roof are those that have crystallized from more fractionated late-stage melts than those crystallized in the host gabbro. The fact that apatite from the anorthositic roof is poor in Cl despite of the high whole-rock Cl content cannot be explained solely by the crystallization differentiation and suggests that the melt has already been depleted in Cl when apatite started to precipitate.

Such a phenomenon can be accounted for in terms of exsolution of a fluid phase from a fractionated melt in the pegmatitic pods as follows. As Cl is strongly partitioned into a fluid phase

or (a vapor) at high pressures (e.g. Alletti et al., 2009), the exsolution of fluid phase will cause a depletion of Cl in the melt and then the apatite which precipitates from such melt will be poor in Cl. It is inferred that the exsolved Cl-rich fluid may have reacted with the magnetite in the pegmatite-forming the Cl-bearing biotite, probably in subsolidus, thus fixing the Cl contained in the fractionated fluids. As such the replacement texture does not occur in the host gabbros, it is plausible that this deuteritic reaction was confined within the anorthositic roof of the pegmatite. We emphasize that the Cl-enriched fluid was not of an external origin but of an internal origin that had been generated from the fractionated melt within the podiform gabbro pegmatites.

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