# Mineralogical study on magnetite exsolution and host plagioclase crystal

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Since natural plagioclase crystal sometimes contains fine-grained magnetite as an exsolution lamellae, single plagioclase crystals are used for recent paleointensity study (e.g. Kato et al., 2018). Especially, plagioclase in plutonic rocks can record average paleointensity due to their long cooling time scale (Tunakawa et al., 2009). However, such magnetite esxolution in plagioclase does not always observed in plutonic rocks. Moreover, magnetite exsolution in plagioclase sometime shows heterogeneous distribution in each plagioclase crystals. Because maximum solubility in plagioclase decreases during cooling, magnetite lamellae formation is restricted by chemical composition of whole rock and plagioclase. Furthermore, its formation is restricted by valence state of iron in each crystal, because divalent and trivalent iron are required for magnetite crystallization.

The sample investigated in this study was collected from the Doshi gabbro, northwest of Tanzawa tonalitic complex. Plagioclase crystals in the gabbro show that magnetite lamellae exsolve along oscillatory zoning in plagioclase. To describe fine exsolution lamellae, thin sections with double-side polished were made. Afterward we observed the sample by polarizing microscope and electron microscope and analyzed composition of plagioclase by Electron-Probe-Micro-Analyzer. We obtained high resolution X-ray fluorescence mapping of Fe and Ca followed by Fe K-edge X-ray absorption near-edge structure (XANES) analysis at the BL37XU of SPring-8.

In polarizing microscope observation, magnetite exsolutions with grain size up to a few microns show parallel orientations and most of them appear prolate spheroid morphology. In element mapping of Ca, plagioclase crystals have multiple oscillatory zonations and magnetites are exsolved at the area of lower anorthite content. Distribution of iron in plagioclase is almost uniform except for the rim. In XANES analysis, valence state of iron in plagioclase vary in from 2.47 to 2.55, and correlated with anorthite content.

Oscillatory zoning of plagioclase generally reflects their crystallization process, and anorthite rich plagioclase is usually crystallized in the early stage of crystallization. It is known that trivalent iron is easier to be distributed to plagioclase than divalent iron form melt (Lundgaard & Tegner 2004). According to the correlation between anorthite content and valence state of iron, trivalent iron is distributed to higher anorthite content area. In other words, during a process of plagioclase crystallization, divalent iron is distributed to lower anorthite content area. In another aspect, partition coefficient of iron to plagioclase depends on oxygen fugacity in magma chamber. Mineralogical features of magnetite exsolution and host plagioclase crystal suggest that there are multiple origins of the magnetite exsolutions in plagioclase even in single crystal.

 

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Keywords: Magnetite exsolution, Plagioclase

 