Evaluation of the magnetite exsolution abundance and valence state of iron in single plagioclase crystal separated from Doshi gabbro

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Knowledge about the secular change of paleointensity through the earth’ s history is important for the evolution of life and solid earth. Recent paleomagnetic studies have focused on single silicate crystals, such as quartz (Tarduno et al., 2010), zircon (Sato et al., 2015), and plagioclase (Kato et al., 2018). In particular, plagioclase is expected to provide reliable paleomagnetic information for a long era, because there are fine-grained and rod-shaped magnetite in the crystals as exsolution lamellae. Such exsolved magnetite, however, does not always exist in plagioclase crystals of various rock samples, and its formation mechanism has not understood yet. It is expected that the magnetite formation is caused by decreasing of maximum solubility of iron in plagioclase crystal during cooling process of rocks. In addition, important factors controlling the exsolution of magnetite are cooling speed of crystal, iron concentration, and valence state of iron in plagioclase. In the previous study (Nakada et al., 2019), the iron valance in plagioclase was compared to the existence of exsolved magnetite using single plagioclase crystal separated from different gabbro. The results show that the content of exsolved magnetite was higher in the plagioclase with lower valence state, suggesting that the valence state of iron is an important factor. In this study, we prepared the plagioclase crystal from the Doshi gabbro, northwest of Tanzawa tonalitic complex, which shows clear zonal structure of exsolved magnetite parallel with the chemical zoning structure. In order to investigate the formation mechanism of magnetite exsolution, we measured iron valence of plagioclase in the submicron spot and compared with the abundance of exsolved magnetite around the measured spot. To describe fine exsolution lamellae, thin sections with double-side polished were made. Subsequently, we observed the sample by polarizing microscope and electron microscope, analyzed the composition of plagioclase by EPMA, high-resolution element map by XRF and valence state of iron by K-edge X-ray absorption fine structure analysis (XANES). The abundance of exsolved magnetite has measured in the image analysis using Image J software. We observed more exsolved magnetite in the middle or late stage of plagioclase growth. The iron valence of plagioclase in each spot was 2.47 to 2.56, but there was no relation with the abundance of exsolution. On the basis of the above information, we estimated the iron valence state in plagioclase crystal before the magnetite exsolution from iron valence measurement and abundance of exsolved magnetite. We will also discuss the possible formation mechanism of magnetite exsolution.

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