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Iron species in plagioclase: Towards the understanding on magnetite exsolution in plagioclase

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Natural plagioclase crystal sometimes contains fine-grained magnetite in the texture. The fine-grained magnetite inclusions are originated from two phenomenon with different temperature: one is included during plagioclase crystal growth and the other is exsolved from host plagioclase crystal at subsolidus condition. Unravelling the origin of these inclusions is important for its application to geophysical studies, while the exsolution mechanism of magnetite in plagioclase is not well understood.

We performed speciation analysis of Fe in single plagioclase crystals separated from two different gabbros to understand the crystallization mechanisms of magnetite exsolution. Iron species in single crystals were measured using Fe K- and L_{III}-edge X-ray absorption fine structure (XAFS) analysis. The K-edge pre-edge analysis showed variation of the averaged valence state of Fe in plagioclase crystals even if separated from the same gabbro, which was also confirmed by the L_{III}-edge analysis. The K-edge pre-edge analysis also suggests the various degrees of contribution from tetrahedral Fe. The mixing of tetrahedral and octahedral Fe underestimates the averaged valence state of Fe for the K-edge pre-edge analysis, thus we adopted the L_{III}-edge result for the valence state of Fe in plagioclase crystals. Iron K-edge extended XAFS (EXAFS) analysis of two plagioclase crystals separated from the same gabbro clearly showed different coordination environment. Weakening of EXAFS oscillation was recognized for one sample, since two Fe–O bonds (Fe^{3+}–O_1 and Fe^{2+}–O_2) cancelled the oscillation each other out. The EXAFS spectrum of the other plagioclase crystal suggested the homogeneous distribution of Fe. The contents of exsolved magnetite in these crystals are nearly identical, indicating that the exsolution of magnetite in plagioclase crystal had been completed before the temperature decreases to stop ordering of Fe ions in tetrahedral sites.