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Oxidation state of the lower-mantle revealed by micro-XANES measurements

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The valence state of iron in mantle-derived minerals has been investigated as an indicator of redox condition of the earth's interior. However, it was reported that the valence state of iron in lower-mantle minerals is controlled by the crystallographic structure of the host minerals and is not sensitive to the redox conditions of the lower-mantle. Alternatively, we focus our attention on chromium. Chromium is mostly found as $Cr^{3+}$and Cr^{6+}in terrestrial minerals. However, minerals formed in extremely reduced conditions can contain Cr^{2+}in their crystal structure. Thus, the presence of Cr^{2+}in a mineral could be an indicator of the reduced environment. Diamonds which contain the lower-mantle minerals as inclusions are the deepest sourced materials. They are the only source which can provide direct information about the lower-mantle. In this study, we investigated the oxidation state of chromium in natural lower-mantle mineral, ferropericlase, using XANES spectroscopy.
Chromium and Iron K-edge X-ray absorption near-edge structure (XANES) spectra were obtained on three natural ferropericlase inclusions. These inclusions were picked up from diamonds originated from the lower-mantle, and were buried in epoxy mounts. XANES spectra were recorded in the fluorescence mode at the BL4A of the Photon Factory, KEK, Japan. Relative content of $Cr^{2+}$was calculated using the method described by Eeckhout et al. (2007).
The obtained results revealed that divalent chromium are present in the natural ferropericlase and that the lower-mantle is reduced condition. The Cr^{2+}proportion to the total Cr content varied among the samples in the range of 3 to 10%. In contrast, no remarkable difference was observed in the valence state of Fe among the samples. Thus, the valence state of Cr in ferropericlase can be a indicator of the redox environment in the lower-mantle.

Keywords: Diamond, Lower mantle