Micro-XANES determination of oxidation states of V, Cr, and Fe in olivine-hosted glass inclusion and groundmass glasses of Martian primitive basalt Yamato 980459

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The redox condition of magma controls the stability and composition of crystallizing and volatile phases in Martian meteorites, which are the best proxy to estimate the evolution of the Martian interior. In the current study, direct analyses of the oxidation states of V, Cr, and Fe were conducted using the XANES measurements equipped with a micro-sized X-ray beam. We first applied the μ-XANES technique to olivine-hosted glass inclusion and groundmass glass of Martian meteorite Yamato 980459 (Y98), which is thought to represent a primary melt composition. A comparison between these two phases will provide information on the transition of fO_2 condition during the basalt magmatism. Mass balance calculations indicated that, while chromite and pyroxene affected Cr and Fe K-edge XANES spectra, the contribution of these minerals was minimal for V. The pre-edge peak intensity of V K-edge XANES enabled the estimation of the fO_2 for inclusion and groundmass glasses. The analyzed fO_2 was IW±0.0 and IW+0.7 for the glass inclusion and the groundmass glass, respectively. This fO_2 difference indicates that the redox condition of the Y98 parent magma evolved during magma ascent and emplacement. Since Y98 is believed to have evolved in a closed system, our finding suggests that fractional crystallization and/or ascent of magma potentially induced the fO_2 increase. This study shows that the μ-XANES technique enables us to determine the fO_2 condition by only measuring a single phase of glassy compounds, and thus, it is useful to discuss the redox condition of volcanic rocks even if they do not crystallize out a pair of phases utilized for conventinoal oxybarometers.