High temperature inter-mineral Cr isotope fractionation: ionic model constraint and implication for mantle xenoliths from North China Craton

J. SHEN[1]*, Z. FANG[1], L. QIN[1]*, Q. ZHANG[1], Y. XIAO[2], H. YU[1]

[1]CAS Key Laboratory of Crust – Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, China (*Correspondance: sjlcwqqq@ustc.edu.cn & lpqin@ustc.edu.cn)

[2] State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, PO Box 9825, Beijing 100029, China.

Recent works have proposed that Cr isotopes could be fractionated during high-temperature processes (partial melting of peridotite and fractional crystallization of basaltic magma), as a result of solid-melt Cr isotopic fractionation [1, 2]. In both processes heavier Cr isotopes are preferentially incorporated into solid phases, leaving isotopically lighter melt phases. Interestingly, Cr isotopes are fractionated in the opposite direction from Fe isotopes, that the melts are enriched in heavier Fe isotopes [3-5]. However, so far, inter-mineral Cr isotopic fractionation behaviour for mantle minerals is still poorly constrained.

Here, we present a prediction for equilibrium Cr isotopic fractionations among major mantle minerals using the ionic model [4, 6]. According to Cr valences and associated coordination environments in different minerals, the model calculation predicts a general order of $\delta^{53}Cr_{Spl} > \delta^{53}Cr_{Cpx}$, $\delta^{53}Cr_{Opx} > \delta^{53}Cr_{Ol}$, which is similar to previous inter-mineral Fe isotope fractionation [4]. Our Cr isotopic analyses of minerals from Beiyan lherzolites confirm the measureable and systematic fractionations in Cr isotope ratios between different minerals (except Opx-Cpx pair), which are consistent with the model speculations. This fractional order could effectively account for the opposite fractionation trends between Cr and Fe isotopes during partial melting and crystallization, that Spl/chromite (high $\delta^{53}Cr$ and $\delta^{56}Fe$) dominates Cr isotope fractionation, and Ol (low $\delta^{53}Cr$ and $\delta^{56}Fe$) dominates Fe isotope fractionation.

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