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Redox control on chromium isotope behaviour in silicate melts

PIERRE BONNAND[1], EMILIE BRUAND[2], ANDREW MATZEN[3], MATTHEW JERRAM[4], BERNARD J WOOD[5], MAUD BOYET[6] AND ALEX N HALLIDAY[4]

[1]Laboratoire Magmas et Volcans, Université Clermont-Auvergne
[2]Laboratoire Magmas et Volcans
[3]University of Oxford
[4]Columbia University
[5]Earth Sciences, University of Oxford
[6]Université Clermont Auvergne

Presenting Author: pierre.bonnand@uca.fr

Transition metal isotopes are particularly useful for understanding the conditions under which magmatic processes occur. Moreover, those with more than one oxidation state (e.g. Cr^{2+}, Cr^{3+} and Cr^{6+}) may also provide powerful constraints on the evolution of the redox state of the mantle. By investigating the Cr isotopic compositions in both magnesiochromite and silicate melts during experiments performed at 1300 °C and under controlled redox conditions ($-12 < \log fO_2 < -4$), this study presents the first experimental petro-isotopic investigation of Cr isotope fractionation and reveals clear systematics between Cr concentration, isotopic compositions and fO_2. Two series of experiments were performed to study (a) the dissolution of a natural magnesiochromite into Cr-free silicate melts (series A) and (ii) the crystallisation of magnesiochromite from Cr-doped silicate melts (series B). In agreement with previous studies, the Cr solubility in the silicate melts at equilibrium with magnesiochromite is strongly controlled by oxygen fugacity. Melts produced at low fO_2 are enriched in Cr compared to more oxidised melts. In series A experiments, the Cr isotopic composition of silicate melts are lighter than the initial chromite starting material. The experiments, performed under reduced conditions, reveal that Cr isotopic compositions of the silicate melts are correlated with fO_2. This demonstrates that, as for the Cr solubility, Cr isotopes are sensitive to fO_2 and could be used to track changes in redox conditions in high-temperature processes. Furthermore, the Cr isotopic compositions of silicate melts that are reacted under more oxidising conditions are much lighter than those of melts equilibrated with magnesiochromite at lower oxygen fugacity. The observed variations can be explained by changes in bonding environment for Cr under oxidised conditions in the silicate melts and/or in the magnesiochromite grains. Similarly, the second set of experiments designed to study fractional crystallisation (series B) suggest that Cr isotope fractionation is larger under oxidising conditions.