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Redox proxy behaviours during partial melting of mantle lithologies

D. NOVELLA[1,*], J. MACLENNAN[1], O. SHORTTLE[1,2], J. PRYTULAK[3] AND B.J. MURTON[4]

[1] Department of Earth Sciences, Univ. of Cambridge, UK
(*correspondance: dn345@cam.ac.uk)
[2] Institute of Astronomy, Univ. of Cambridge, UK
[3] Department of Earth Sciences, Durham University, UK
[4] National Oceanography Centre, Univ. of Southampton, UK

Mantle oxygen fugacity (fO_2) reflects Earth's formation and evolution, and is potentially sensitive to the effects of subducted crustal material. Yet, estimates of mantle fO_2 using basalts are hampered by its modification during partial melting and fractionation, affecting both Fe^{3+}/Fe_{tot} [1] and redox-sensitive trace element proxies such as V [2]. Even though many studies have estimated mantle fO_2, its value remains uncertain, with estimates often varying by >1 log unit in the same materials. This discrepancy might be caused by the different response of redox proxies to melting and fractionation processes and/or the presence of lithological heterogeneities in the mantle.

Here, we examine the behaviour of the redox-sensitive trace element concentrations and V stable isotopic compositions in basalts from the Reykjanes Ridge (near Iceland) with their measured Fe^{3+}/Fe_{tot} [3, 4]. These samples are well-characterized in terms of temperature of formation and mantle sources [5], and therefore are ideally suited to examine and compare geochemical proxies of redox conditions during mantle partial melting. The new geochemical dataset is combined with thermodynamic melting/mixing models to fit the observed variation in crustal thickness, trace element contents and fO_2.

We find that increases in Fe^{3+}/Fe_{tot} are associated with source variability, rather than the melting process, while the signal from redox sensitivity trace elements appears to be overwhelmed by silicate melting and fractional crystallization processes. V isotopes are not sensitive to source Fe^{3+}/Fe_{tot} variations at the level seen in Reykjanes Ridge basalts.

Our data are consistent with an increasing contribution from oxidised, subducted mafic crustal materials in the source regions of Reykjanes Ridge basalts as Iceland is approached.

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