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Diffusion of Lu, Ce and Eu in orthopyroxene

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The distribution of rare earth elements (REE) in igneous rocks and minerals provides information regarding the extent of partial melting of the mantle sources in the Earth or other planetary bodies. In terrestrial mantle rocks, pyroxenes are one of the main hosts of REE, with the characteristic geochemical patterns being dependent on the rates of melting and extraction and mineral-melt partitioning. A correct interpretation of REE patterns, as well as the interpretation of geochronological data, is thus dependent on the evaluation of whether equilibrium between solid and melt was achieved. Therefore, a good knowledge of diffusion rates is essential to correctly evaluate the effect of diffusive fractionation of REE during partial melting processes. We measured diffusion coefficients for Eu, Lu and Ce in orthopyroxene (X_{Fe}=0.1) using thin film diffusion couples produced by pulsed laser deposition. Diffusion experiments were conducted in CO-CO_2 vertical gas mixing furnaces in the temperature range of T = 950 – 1100 °C and fO_2 = 10^{-7} to 10^{-11} Pa. Depth profiles were acquired using time of flight – secondary ion mass spectrometry (TOF-SIMS), which allowed to resolve low concentration regions of the diffusion profiles. We found faster diffusion rates for Lu, Eu and Ce than previously reported for orthopyroxene and diopside [1,2], but comparable activation energies to the ones obtained in recent studies for Lu in diopside [2] and Nd in orthopyroxene [3]. Our results suggest that Lu diffusion is dependent on Lu concentration and fO_2, indicating a different diffusion mechanism than for Eu and Ce. Additionally, we observed a trend of decreasing diffusivity with increasing ionic radii. The reported data may have important implications for the Lu-Hf systematics. Our results show that if the system is subject to extended periods of high temperatures, the diffusive loss of ^{176}Lu in opx might be more significant than previously estimated, possibly leading to erroneous Lu-Hf ages.

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