Diffusion and Distribution of Rare Earth Elements in Olivine

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The rare earth elements (REE) are important tools for unravelling petrogenetic processes. In mantle studies, garnet and pyroxene REE compositions are widely used, however, REE systematics of olivine, the most abundant mineral in the upper mantle, have received much less attention. The scarcity of olivine REE data reflects the technical challenges encountered when analysing at the low parts per billion concentration range. The limited data available for olivine often display unexpected light REE (LREE) enrichment that is generally attributed to analytical artefacts and/or contamination from inclusions and grain boundaries and surfaces [1-3]. Similar anomalous REE patterns are found in other minerals with low LREE abundances; e.g. zircon [4].

Here we use a novel approach to extract quantitative data from 2-dimensional laser ablation ICP-MS maps [5] to further study the origin of the unexpected LREE enrichment in olivine. The spatial distribution of light vs. other REE clearly demonstrate that the anomalous LREE pattern is due to diffusion into olivine. Core to rim increases in the LREE are found in olivine adjacent to a more enriched phase, such as plagioclase or clinopyroxene. Diffusivity of these elements in the adjacent phase affects the extent of diffusion, for example, a greater magnitude of enrichment is observed for olivine that borders plagioclase rather than clinopyroxene. The crystallographic orientation may also influence distribution of LREE in olivine grains cut in thin section. Diffusion may be pervasive, with even the cores of smaller crystals showing apparent LREE enrichment and slightly anomalous REE patterns.

We examine the link between this process and the anomalous LREE patterns in olivine in the literature, and discuss the future potential for olivine REEs as petrogenetic tools.

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