



Trace element diffusion in natural clinopyroxene: Faster than we thought?

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Trace element diffusion through the lattices of silicate minerals is one of the fundamental mass-exchange mechanisms in terrestrial chemical reactions and is frequently the limiting factor in such reactions. Therefore it is important to test whether the diffusive properties of minerals measured in the laboratory agree with those found in nature. Here we report a study of diffusion in clinopyroxenes from the ocean crust.

Major and trace element compositions of the constituent clinopyroxene in oceanic gabbros from ODP Hole 735B were investigated by a combined in-situ analytical study with ion probe, and electron microprobe. Continuous core to rim zoning profiles of trace element were found to be well developed and preserved in Hole 735B. Petrological modelling shows that the observed mineral zonations were not caused by any primary magmatic growing process such as in-situ crystallization of trapped melt or simple crystal accumulation. Instead, pervasively migrating late stage melts along grain boundaries account for the formation of trace element zoning. By numerical modelling of these diffusion profiles the apparent diffusivities of 13 trace elements (REE, Y, Cr, Sr, and Zr) in clinopyroxene from the lower oceanic crustal gabbros have been evaluated. The apparent diffusivities of 13 trace elements in clinopyroxenes are quite similar, in contrast to the observed large differences in experimental data. This suggests that there is only small, if any, differential transport between light and heavy REE in clinopyroxene during migration of melt through the oceanic lower crust. This observation gives a possible explanation of the scarcity of large diffusive fractionation among REEs in clinopyroxenes predicted by experimental data in mantle peridotites that have suffered melt extractions.

The diffusion rates of these elements are in the same range as the experimentally determined diffusion rate for Al-Si inter-diffusion between clinopyroxene and basaltic melt. A Tschermak's or jadeite type coupled substitution may have been responsible for the exchange of trivalent and tetravalent elements between clinopyroxene and melt.