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Distribution of trace elements between mantle rock minerals: observational evidences of diffusive equilibrium and its implications

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Analysis of the trace element contents in kimberlites from various provinces around the world, including South Africa, India, and Yakutia (Siberia, Russia), reveals remarkable similarity of the maximum abundances. In addition, the abundances of the rare earth elements (REE) in the South African kimberlites are highly coherent between individual elements. I suggest that the observed similarity of the trace element patterns may result from a common physicochemical process operating in the kimberlite source region, rather than from peculiar source compositions and magmatic histories. The most likely candidate for such a process is a porous melt flow (percolation) accompanied by a diffusive exchange with the host rocks. On the whole, the abundance of a trace element in the percolating melt depends upon melt fraction, thickness traversed, proportions of modal minerals (modal composition), and the element contents in the host rock minerals. However in the limit of full saturation the accumulated abundance turns out to be independent neither of the melt fraction nor of traversed thickness. Besides, if the distribution of trace elements between the modal minerals of the source rock corresponds to diffusive equilibrium then the saturated abundance does not depend on the modal composition as well. The indicator of the diffusive equilibrium is the equality of reduced abundances (the abundance divided by the partition coefficient) calculated for modal minerals. Using the observations of the REE in xenoliths from kimberlites of Somerset Island and South Africa I demonstrate that for heavy REE the clinopyroxene and garnet reduced abundances are well correlated

indicating the equilibrium distribution of these elements. The reduced abundances of light REEs demonstrate large scatter. As, simultaneously, the sum of the light REE contents in the modal minerals is small compared to the bulk rock abundances the observed distinctions are the result of a recent metasomatism most probably due to the kimberlitic magma that entrained the xenoliths. The observed difference of the distribution of the light and heavy REEs are then due simply to the difference of the diffusion coefficients. This allows to estimate a characteristic lifetime of a kimberlite source.