A temporal link between mantle metasomatism and kimberlite magmatism: evidence from olivine Mg-Fe diffusion profiles in metasomatized peridotite xenoliths, Jericho kimberlite, Northwest Territories

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Kimberlites are volcanic rocks formed from small-volume magma-crystal mixtures that are thought to form by interaction between subcontinental mantle peridotites and infiltrating metasomatic magmas or fluids (proto-kimberlite model). There is a temporal link between the emplacement of the Jericho kimberlite (Northwest Territories) and aqueous metasomatism affecting two xenoliths carried therein. The harzburgite xenoliths contain a primary assemblage of olivine, orthopyroxene, and garnet with accessory clinopyroxene, chromite, and phlogopite. The garnets feature reaction rims of phlogopite and spinel, and in the less altered sample orthopyroxene exhibits reaction rims of diopside and K-richterite (?). Phlogopite lines the grain boundaries throughout much of the less altered xenolith. In both samples, olivine contains overgrowth rims of more fayalitic olivine that are spatially associated with the secondary minerals. The growth of phlogopite and amphibole clearly represents a metasomatic influx of water and alkalis; by association the olivine rims represent the same event. Zoning profiles through the olivines show weakly diffuse contacts between cores and rims. Mg-Fe diffusion models were used to constrain the timescales between metasomatism and kimberlite eruption (quenching). At temperatures similar to those determined or expected for kimberlite magmas (1400-1000°C), the models show that the metasomatic olivine rims were annealed for durations ranging on the order of one to 300 days. Even if it is assumed that annealing during magmatism had no effect on Mg-Fe diffusion (which is physically impossible), and that

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the crystals resided in relatively cold temperatures of 800°C, only ~15 years diffusion time is permitted. Considering that kimberlites attain temperatures of ~1050–1170°C at relatively late stages, these results indicate that hydrothermal metasomatism occurred within days of kimberlite magmatism at Jericho. These findings support the proto-kimberlite model, and indicate a water-rich proto-kimberlite fluid. Further studies of samples such as these may provide firm source-to-surface average magma ascent rates, and better constrain the composition of the proto-kimberlite fluids.