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Olivine in kimberlites: metasomatism of the deep lithospheric mantle

Carole Cordier, Lucie Sauzeat, Nicholas Arndt, and Anne-Marie Boullier
University of Grenoble, ISTerre, Grenoble, France (carole.cordier@ujf-grenoble.fr)

Most kimberlites contain abundant mantle microxenoliths (nodules) and xenocrysts, mainly composed of olivine. We present here a geochemical and microstructural study of nodules from well-preserved type-I kimberlites from Kangamiut region in Greenland, the sequel of a preliminary study of Arndt et al. (2010). A striking feature of these and many other kimberlites is the wide range of olivine composition (Fo83 to Fo94) from nodule to nodule in a single kimberlite sample, contrasting with the olivine homogeneity within a single nodule (variation of less than 0.5 mol. %). We defined three chemical zones within normally zoned nodules based on Fo and Ni variations. Xenocrystic cores have high and constant Fo and Ni contents. Outer rims crystallized from the kimberlitic magma have constant Fo content (Fo88) coupled with significant decrease in Ni content (from 2500 to 500 ppm). Transition zones between cores and rims, along grain boundaries and along fluid inclusion trails have variable Fo content (Fo93 to Fo88) but roughly constant Ni content (from 3000 to 25000 ppm) and their composition mimics that defined by the nodules. Microstructural study of transition zones associated with curvilinear grain boundaries suggests these zones are produced during fluid-assisted plastic deformation. We propose that the transition zones formed during reaction of mantle peridotite with CO_2-rich fluid, a process that removes the pyroxene and garnet components. The compositional variations of the transition zones monitor at the fine scale the processes that produce the chemical variability of olivine from nodule to nodule. We propose that the range of olivine composition records the position of sample relative to fluid-rich zones, grain boundaries for transition zones and larger conduits for broader scale variations registered in the nodules. This conclusion implies that metasomatic processes that produced the range of olivine composition and removed pyroxene and garnet from the initial peridotite occurred within the lithospheric mantle and not within the kimberlite magma during it ascent toward the surface.

Arndt, N. T.; Guitreau, M.; Boullier, A. M.; Le Roex, A.; Tommasi, A.; Cordier, P. & Sobolev, A. V. (2010): Olivine, and the origin of kimberlite. Journal of Petrology, 51, 573-602.