Phosphorus-rich pyroxene in mantle xenoliths

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Numerous recent reports of detailed crystal zoning patterns and anomalous enrichment in phosphorus (P) have focused mainly on olivine from various settings [1-4]. P enrichment and zoning in olivine have been attributed to rapid crystal growth and development of disequilibrium as well as to growth from P-rich melts. Here we report the comparatively novel observation of elevated P in pyroxenes from glass-bearing veins and pockets in a previously undescribed xenolith from Cima Volcanic Field-CVF, California; H.G. Wilshire (sample *Ci-1-105*) and in newly collected mantle xenoliths from the Middle Atlas, Morocco. Analytical techniques included optical microscopy, electron microprobe and laser-ablation Inductively Coupled Plasma Mass Spectrometry. We examine whether the P concentrations in pyroxene (Px), although unusual, are in fact anomalous compared to the adjacent glass concentration, consider possible mechanisms for P enrichment, and correlate the P enrichment in Px with indicators of metasomatism.

The petrogenetic history of each glassy region involves melt intrusion, reaction with host minerals, cooling accompanied by crystal growth, quench of glass, and possibly later modifications. Secondary P-rich pyroxenes (P_2O_5 ~ 0.6 wt%) in a glassy pocket in the CVF xenolith are homogeneous and surrounded by P-rich glass. They reflect fairly slow near-equilibrium pyroxene growth after the melt temperature became close to the host rock, with P concentration in the melt buffered by apatite saturation. In the Moroccan xenoliths, pyroxenes in a glassy vein exhibit concentric zoning with P_2O_5 from 0.05 wt% (core) to ca. 0.3 wt% (intermediate) and then from 0.8 wt% (inner rim) to 1.2 wt% (outer rim). We attribute this to an accelerating rate of crystal growth, with onset of a diffusive boundary layer pile-up effect and excess P incorporation near the pyroxene rim.

[1] Maisonneuve et al. (2016) *CMP* **171**(6), 1-20. [2] Mallmann et al. (2009) *CMP* **158**, 485–504 [3] McCanta et al. (2016) *MAPS* **51**, 520-546 [4] Boesenberg and Hewins 2010) *GCA* **74**, 1923-1941.