P, Cr, and Al zoning in komatiitic olivine

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The nearly ubiquitous presence in magmatic olivines of P zoning, often correlated with Cr and Al [1], suggests that these elements may help to clarify early stages of crystal growth that are otherwise inaccessible due to diffusive reequilibration of the dominant, divalent cations. Here, we describe zoning in olivine from unusually fresh, ~ 90 Ma komatiites of La Isla de Gorgona, Colombia [2, 3]. Komatiites are extreme among magmatic rocks in their ultramafic compositions; they are commonly thought to have high emplacement temperatures and a deep origin.

We mapped Ti, Fe, Cr, Al, and P in 40 olivines from five Gorgona thin sections taken from a jointed flow top, two randomly oriented spinifex zones, and two oriented spinifex zones. Olivines from the jointed flow top are skeletal-to-topolyhedral microphenocrysts. The random spinifex zones include chain, branching, and hopper forms; plate olivine dominates the oriented spinifex zone.

Most olivine is normally zoned in Fe; Cr, Al, and P distributions are spatially correlated with each other, but not with Fe; and Cr zoning is preserved even in altered regions where P and Al zoning is absent or obscured. Unlike most igneous olivine [1], Cr zoning in Gorgona olivine is more pronounced than for either Al or P, with P zoning frequently being the weakest, consistent with high whole-rock Cr and low P [3]. Al/Cr slopes from analyses of two olivines are very similar to Hawaiian microphenocrysts (1.7-1.8) but that from a random spinifex zone olivine is lower (0.3), implying a different substitution mechanism; positive Cr intercepts suggest that all Al is associated with Cr but not the reverse.

Microphenocrysts from the jointed flow top are oscillatory and sector zoned in Cr, Al, and P, most containing a single, sub-central, high-P core similar to Hawaiian phenocrysts [1]. Olivine in the random and oriented spinifex zones have a single Cr-rich band or oscillatory zoning parallel to the long axis. The oscillations vary in width (e.g., ~10 to 50 µm) and, occasionally, thin bands diverge at an angle from wider bands, suggesting merged crystals. The Cr-Al-P zoning in and skeletal nature of komatiitic olivine point to rapid crystal growth but this need not mean fast cooling rates.