Rapid clinopyroxene growth in deep magmas: The symptoms

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Igneous minerals respond to the thermodynamic and chemical evolution of magmas in which they form, and may preserve aspects of their environment as chemical and textural fingerprints. We examined clinopyroxene phenocrysts from an ankaramite flow of East Maui volcano (Hawaii), with the intention of constraining intensive conditions of crystallization. The crystals exhibit cryptic sector zoning with $(Al + Ti + Na)_{\{-111\}} = (Si + Mg + Cr + Ca)_{\{110\},\{100\},\{010\}}$, crystallographically aligned subcrystals, and inclusions of melt and Cr-spinel – all features that suggest growth was influenced by component mobility and interface kinetics. Experiments [1] indicate that the pattern observed in Maui clinopyroxene occurs when crystals grow at high degrees of undercooling ($-\Delta T > 45$ °C). Evidently, basalt produced during Maui's postshield magmatic stage achieved rapid growth despite low cooling rate deep within or below the edifice. Although the clinopyroxene compositions are unlikely to preserve the intensive conditions of magma storage (and thus limiting the application of thermobarometry), sector zoning phenomena provides opportunities to constrain the time scales of crystal growth, from minutes to weeks (10^{-6} to 10^{-9} m/s in [1]).

[1] Kouchi, Sugawara, Kashima & Sunagawa (1983), *Contrib. Mineral. Petrol.* **83**, 177 – 184.