

New insights on crystal growth and dissolution by investigating micro-scale entities.

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Abstract

A new approach to the study of crystal growth/dissolution kinetics is reported, that involves measuring the time-evolution of entire isolated micro-crystals or micro-etch pits in macro crystals via a variety of microscopic techniques (2D and 3D).^{1,2} By coupling such measurements to finite element diffusion models, the importance of mass transport to the overall rates can be elucidated readily. Furthermore the approach reveals directly plane-specific intrinsic kinetics free from diffusional effects. Investigations on gypsum (CaSO₄·2H₂O) highlight notable sensitivity to solution stoichiometry (Ca²⁺ and SO₄²⁻ ratio) which results in different crystal and pit morphology³. In summary, the method is powerful in linking microscopic observations to macroscopic rates and is expected to be of general applicability.

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Metasomatic control of water in garnet and pyroxene from Kaapvaal craton mantle xenoliths

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Fourier transform infrared spectrometry (FTIR) and laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) were used to determine water, rare earth (REE), lithophile (LILE), and high field strength (HFSE) element contents in garnet and pyroxene from mantle xenoliths, Kaapvaal craton, southern Africa. Water enters these nominally anhydrous minerals as protons bonded to structural oxygen in lattice defects [1,2]. Pyroxene water contents (150-400 ppm in clinopyroxene; 40-250 ppm in orthopyroxene) correlate with their Al, Fe, Ca and Na and are homogeneous within a mineral grains and a xenolith. Garnets from Jagersfontein are chemically zoned for Cr, Ca, Ti and water contents. Garnets contain 0 to 20 ppm H₂O.

Despite the fast diffusion rate of H in mantle minerals [3], the observations above indicate that the water contents of mantle xenolith minerals were not disturbed during kimberlite entrainment and that the measured water data represent mantle values. Trace elements in all minerals show various degrees of light REE and LILE enrichments indicative of minimal to strong metasomatism. Water contents of peridotite minerals from the Kaapvaal lithosphere are not related to the degree of depletion of the peridotites. Instead, metasomatism exerts a clear control on the amount of water of mantle minerals. Xenoliths from each location record specific types of metasomatism with different outcomes for the water contents of mantle minerals. At pressures ≤ 5.5 GPa, highly alkaline melts metasomatized Lihobong and Kimberley peridotites, and increased the water contents of their olivine, pyroxenes and garnet. At higher pressures, the circulation of ultramafic melts reacting with peridotite resulted in co-variation of Ca, Ti and water at the edge of garnets at Jagersfontein, overall decreasing their water content, and lowered the water content of olivines at Finsch Mine. The calculated water content of these melts varies depending on whether the water content of the peridotite (2 wt% H₂O) or individual minerals (<0.5-13 wt% H₂O) are used, and also depend on the mineral-melt water partition coefficients. These metasomatic events are thought to have occurred during the Archean and Proterozoic, meaning that the water contents measured here have been preserved since that time and can be used to investigate viscosity and longevity of cratonic mantle roots [4].

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