Squeezing water from a stone: H_2O in lower crustal granulites & deep, hydrous fractional crystallization

EMILY J. CHIN[1] SEAN T. CURRAN[1] G. LANG FARMER[2]

[1]Scripps Institution of Oceanography, UC San Diego, e8chin@ucsd.edu
[2]CIRES, University of Colorado Boulder

A considerable amount of water (H_2O) is locked within continental crust. While distribution of such H_2O decreases with depth as hydrous minerals become unstable, significant H_2O is bound to crystal lattice defects in nominally anhydrous minerals (NAMs) in the deep crust. Yet, few data exist on H_2O of lower crust, compared to over a decade of research on hydration state of the upper mantle. Here, we report H_2O concentrations, analyzed *in situ* on petrographic thin sections by SIMS, in NAMs of Proterozoic granulite xenoliths erupted in Devonian kimberlite of the State Line District (SLD), Colorado, USA. Bulk rock and mineral major element compositions testify to a mafic, igneous heritage, with mineralogy dominated by pyroxenes, garnet, plagioclase, and rutile, ilmenite, apatite. SLD granulites are more Fe-rich and Si-poor compared to MORB and do not overlap MORB cumulates. Instead, SLD granulites are similar to pyroxene and garnet-rich rocks (“arclogites”) ascribed to subduction magmatism. Despite granulite-facies equilibration, SLD xenoliths preserve H_2O contents of 560, 347, 85 ppm in clinopyroxene, orthopyroxene, and garnet, respectively. Note that, due to cooling from near-solidus conditions to ~750°C, measured H_2O reflect minimum bounds from lowered solubility with falling temperature. However, H_2O inter-mineral ratios fall within experimental D values, indicating that even if cooling decreased absolute H_2O concentration, H_2O partitioning between minerals reflect equilibrium. Using reconstructed D_{bulk}, calculated melt H_2O contents last in equilibrium with the xenoliths range from ~1.5 wt% H_2O for most primitive (Mg#69) xenolith to ~5 wt% H_2O for evolved (Mg#55) xenoliths. Such H_2O contents are significantly higher than primitive MORB (0.1wt.%), and imply hydrous primary melt to crystallize such cumulates. Our results underscore the importance of deep fractional crystallization as a primary driver for water-rich nature of arc magmas. From the perspective of geologic history of North America, SLD xenoliths could represent arc cumulates associated with Proterozoic accretion of the Yavapai arc terrane.