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Complexity of Volatiles in Ultramafic Planetary Mantles

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Planetary volatiles are the fluids in a planet's crust, mantle, and atmosphere and play a crucial role in all surface processes, including planetary habitability. Discussions of planetary volatiles often focus on water, carbon, nitrogen, and sulfur as the main elements of these fluids [1], but it appears that magnesium-rich mantles may be common in our solar system, e.g., Earth, the Moon, Mars, meteorites, and Io [2]. As such, the fluids in these mantles may be rich in magnesium and silica, as seen in fluid inclusions in diamonds [3], and in experimental studies of chloride-free fluids in equilibrium with peridotite [4]. If magnesium is a major constituent of deep planetary fluids, magnesium-chloride complexing could become increasingly relevant at high temperatures and pressures. However, these magnesium complexes remain largely unconstrained for deep fluids. In order to improve this situation, experimental data for silicate mineral solubilities in chloride-rich fluids have been analyzed. Data at 2 kilobars and 500 - 700o C [5] for talc + quartz and tremolite + talc + quartz solubilities, as well as data at 10 kilobars and 800 and 900o C [6] for forsterite solubility were regressed to retrieve new equilibrium constants for MgCl2. The Deep Earth Water Model (DEW) [7] log(K) values for MgCl+, CaCl+, and CaCl2 were also investigated and revised. New experimental data for magnesium solubility in chloride-bearing fluids in equilibrium with peridotite indicate the need to consider an additional magnesium-bearing chloride complex. Planetary volatiles are more complex in nature than previously expected, and building effective models to predict their compositions is key to understanding volatile cycling on the terrestrial worlds of our solar system.

[1] Bodnar (2005), Elements 1, 9-12

[2] Palme et al. (2014), Treatise on Geochem. 2, 15-36

[3] Weiss et al. (2015), Nature. 524, 339–342

[4] Kessel et al. (2015), Contrib. Mineral. Petrol. 169, 37

[5] Luce et al. (1985), Geochim. Cosmochim. Acta. 49, 529-538

[6] Macris et al. (2020) Geochim. Cosmochim. Acta 279, 119–142

[7] Sverjensky et al. (2014), Geochim. Cosmochim. Acta. 129, 125–145