

The Deep Earth Water Model for Metal Chloride Complexing in the Crust and Upper Mantle

SOPHIA E ECONOMON AND DIMITRI A. SVERJENSKY

Johns Hopkins University

Presenting Author: seeconomon@gmail.com

Magnesium is the fifth most geochemically abundant element in Earth's crust and is a major constituent of seawater, along with chloride, sodium, and sulfate. However, in crustal hydrothermal fluids at mid-ocean ridges, magnesium is a trace element. In contrast to crustal fluids, experimental studies of chloride-free fluids in equilibrium with peridotite report high concentrations of magnesium [1], and chloride-rich fluids have been observed in diamond inclusions [2]. As such, magnesium must be a major constituent of deep Earth fluids, and magnesium chloride complexing becomes increasingly relevant at high temperatures and pressures (e.g., during mantle metasomatism and diamond formation). However, these magnesium complexes remain largely unconstrained for the deep Earth. In order to improve this situation, experimental data for silicate mineral solubilities in chloride-rich fluids have been analyzed. Data from Luce et al. (1985) [3] at 2 kilobars and 500, 600, and 700° C for the concentration of magnesium in equilibrium with talc + quartz and the concentration of calcium in equilibrium with tremolite + talc + quartz as well as forsterite solubility data from Macris et al. (2020) [4] at 10 kilobars and 800 and 900° C were regressed to retrieve new equilibrium constants for MgCl_2 . The Deep Earth Water Model (DEW) [5] $\log(K)$ values for CaCl_2 , CaCl^+ , and MgCl^+ were also investigated and revised. These refined values improve the DEW model's predictive capabilities for chloride complexing at elevated temperatures and pressures, enabling quantitative predictions of mineral solubilities, aqueous speciation, and chemical mass transfer modeling of metasomatic processes in the interiors of rocky planetary bodies.

[1] Kessel, Pettke, and Fumagalli (2015), *Contrib. Mineral. Petrol.* 169, 37

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

[3] Luce et al. (1985), *Geochim. Cosmochim. Acta.* 49, 529–538

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

[5] Sverjensky, Harrison, and Azzolini (2014), *Geochim. Cosmochim. Acta.* 129, 125–145

