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Solubility of salts, sulfates and oxides in hydrothermal vapor at 350-600°C and 50-300 bar

ANDRI STEFÁNSSON, SIGRÍÐUR MARÍA AÐALSTEINSDÓTTIR, ANNA BRÍET BJARKADÓTTIR, GUDMUNDUR SVERRISSON AND SAMUEL SCOTT

University of Iceland

Presenting Author: as@hi.is

Low density hydrothermal fluids play a fundamental role in the chemical evolution of the Earth‘s crust, ranging from volcanic to low-temperature environments. Such aqueous fluids are gas-like vapor and may contain variety of elements, yet their solubility and molecular chemistry is not well understood. Here we report results of solubility measurements of selected salts, sulfates and oxides in hydrothermal water at 350-600°C and 50-300 bar. The experiments were conducted using state-of-the-art U-tube reactor systems that allow fast and reliable solubility measurements over large range of temperatures and pressures. Following Pitzer and Papalan (1986) the experimental results were fitted assuming complete ion-paring of the molecular species in the vapor phase followed by successive hydration (H_2O addition) of such neutral gas moieties with increasing water pressure. The thermodynamic model describes the macroscopic nature of the hydration and solute solubility in vapor, that is characterized by increasing water cluster growth with increasing water pressure. In fact, with increasing water pressure, higher order clusters become significant with alkali metal chlorides ($XCl\cdot(H_2O)_n$, X = Li, Na, K, Rb, Cs), alkali metal sulfates ($Y_2SO_4\cdot(H_2O)_n$, Y = Na, K) and oxides ($SiO_2\cdot(H_2O)_n$) cluster sizes typically increasing from n 1-10 at 350-600°C and <300 bar. Based on the experimental results and data processing, thermodynamic values (ΔG_r, ΔH_r, ΔS_r, $\Delta C_{p,r}$) have been obtained for the solubility of the hydrated neutral gas compounds as a function of stepwise hydration (n), temperature and pressure, that in turn are used to model mineral saturation and speciation of solutes in high-temperature and low-pressure hydrothermal solutions. The project has received funding from the European Union’s Horizon 2020 under Grant Agreement #818169 (GeoPro).

Pitzer & Pabalan(1986) *Geochem. Cosmochim. Acta* 50, 1445-1454.