

Mineral Solubility in Complex Saline Aqueous Fluids at Crustal and Upper Mantle Conditions

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Transport of heat and materials, as well as chemical reactions in geologic systems, are driven and controlled by fluids. Current approaches to thermodynamic modeling of fluid-driven processes typically invoke only simple, dilute H₂O or H₂O-CO₂ fluids. However, these assumptions have significant shortcomings, when compared to data on natural fluids. Natural geologic fluids are commonly rich in non-electrolyte (e.g. CO₂, CH₄, N₂), and electrolyte solutes (e.g. Na⁺, K⁺, Fe²⁺, Cl⁻) (Galvez et al, 2015). Fluid-inclusion studies reveal that highly saline fluids are common in many environments including subduction zones, metamorphic complexes, and magmatic-hydrothermal systems – indicating that fluids are significantly more complex and contain high concentrations of various solutes. High salinities strongly affect activity-composition relationships in thermodynamic modeling, and mixing high salt contents with gas-rich fluids (i.e., containing CO₂ and other volatiles) expands the pressure-temperature limits of fluid phase immiscibility which partitions solutes and affects mineral stability relations (Bowers and Helgeson, 1983). Thus, thermodynamic models accounting for multi-component, multi-phase fluids are needed for robust modeling of reactions and mass/energy transport in natural systems.

In this study, we combine successful elements from previous modeling of quartz solubility in multicomponent fluids (Akinfiyev and Diamond, 2009) with a recent model for solubilities of various minerals in H₂O (Dolejš and Manning, 2010), to develop a new generic model for the solubilities of minerals in saline geologic brines across a wide range of geologically important *P-T-X*_s conditions. Current modeling uses the experimental mineral solubilities of quartz, calcite, corundum, fluorapatite, fluorite, and rutile in order to determine the effects of pressure, temperature, and salinity on the density, volume of mixing, and solubility products for these minerals. Our approach represents fluid-rock reactions involving multiple components over wide ranges of bulk salinity, ranging from subduction zones and high-grade metamorphic environments to crustal hydrothermal systems.