

# The solubility and complexation of Ce, Y and Er in hydrothermal fluids at varying pH and salinity between 350 and 500 °C

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Rare earth elements (REE) are a rapidly developing resource due to their increased use in advanced technologies [1]. In REE ore deposits, metal mobility is controlled by the stability of REE minerals [2-5] and the ligands with which they complex. Current thermodynamic models often incorrectly predict the solubility of these elements in high temperature fluids due to a lack of experimental and thermodynamic data at supercritical conditions [1-5]. Here we use batch-type Inconel 625 Parr reactors to investigate synthetic  $\text{ErPO}_4$ ,  $\text{YPO}_4$  (xenotime structure), and  $\text{CePO}_4$  (monazite structure) solubility between 350 °C at  $P_{\text{SAT}}$  and 500 °C at 500 and 700 bar with varying starting pH (2, 3, 4, 7, and 10) and salinities (0.01, 0.1, and 0.5 molal NaCl). Numerical simulations are performed using the GEM-Selektor code package [6] and MINES database [7].

At 350 °C and 0.01 m NaCl, Ce shows the highest solubility followed by Y and Er. All REE demonstrate high solubility at low pH and decreased solubility at mildly acidic pH. At alkaline conditions, only Ce showed increased solubility at 350 °C. Erbium demonstrates a similar solubility pattern at 450 °C. The predicted Er solubility is up to 2 orders of magnitude higher than the experimental solubility, however modeled speciation trends match experimental data and indicate Er chloride and hydroxyl species dominance at acidic and alkaline conditions, respectively. As a function of increasing chlorinity, Er becomes more soluble at low pH and the solubility minimum shifts to higher pH indicating increased chloride species stability. These results highlight the need for high temperature experimental data to better predict the behavior between light and heavy REE in supercritical fluids. This material is based upon work supported by the Department of Energy under Award Number DE-SC0022269.

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