

Spectroscopic and calorimetric study of synthetic françoisite-(Nd): Nd[(UO₂)₃O(OH)(PO₄)₂]•5H₂O

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Françoisite-(Nd), Nd [(UO₂)₃O(OH)(PO₄)₂]•5H₂O, is a good model of a mixed f-element solid that may form as the result of anthropogenic actinide infiltration, particularly in locations where phosphate amendments (apatites, polyphosphates etc) may be used in remediation technologies. Thus, to better understand the environmental fate of relevant f-element solids, characterization and calorimetric studies are required.

Françoisite-(Nd) characterization studies including chemical digestion, thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), attenuated total reflection infrared spectroscopy (ATR-IR), Raman spectroscopy and x-ray powder diffraction (XRD) were conducted. In addition, preliminary enthalpy of formation results, measured using high-temperature oxide melt solution calorimetry, and by applying the appropriate thermodynamic cycle, are also presented.

Volcanic and tectonic hydrothermal systems in Iceland

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Over 20 active volcanic geothermal systems are known within the active belts of volcanism in Iceland and by their margins. Tectonic geothermal systems are widespread in older formations where tectonic movements have created secondary permeability, in particular on the American plate and the Hreppar microplate.

The fluids of both volcanic and tectonic systems are most often meteoric by origin. However, on the Reykjanes Peninsula in SW-Iceland, the geothermal fluid is seawater or a mixture of fresh water and seawater. Waters that do not contain a seawater-groundwater component are low in Cl due to the low content of this element in basaltic magma and basaltic rocks. Fluids in young volcanic geothermal systems that lie straddle the plate boundary typically contain fugitive components derived from the magma heat source such as CO₂, H₂S, Cl and B. This is, however, not so for mature volcanic systems that have drifted away from the plate boundary due to crustal accretion and been cut off from their magma heat source. In these systems, aqueous Cl/B ratios are the same as those of the basalt host rock but they may be lower in young volcanic systems.

In tectonic geothermal systems at temperatures as low as ~50°C all dissolved major aqueous components, except for Cl, B and SO₄ are typically controlled by close approach to local equilibrium with hydrothermal minerals. The same applies to fluids of volcanic geothermal systems. However, CO₂ supply from the magma heat source may not be sufficient to saturate the solution with carbonate bearing minerals except when fresh magma is intruded into the roots of such systems as was the case at Krafla during the 1975-84 volcanic episode. In contrast to CO₂, both aqueous H₂S and H₂ concentrations seem to be controlled by close approach equilibrium with hydrothermal minerals assemblages. Generally, local equilibria with respect to redox reactions generally do not seem to be attained. These reactions are too slow relative to fluid through-flow for equilibrium to be closely approached.

The heat source to the volcanic geothermal systems of Iceland is typically shallow, at 2-3 km depth, even shallower. When this is the case, fluid at the base of the convection cell will be sub-critical. Some of the Icelandic volcanic systems may have a core of steam immediately above the heat source. When the steam rises, it heats up the above-lying body of groundwater, possibly up to the boiling point, thus creating a two-phase fluid.