The kinetics of dissolution of nepheline ($NaAlSiO_4$)

Mwakio P Tole, Antonio C Lasaga, Carlo Pantano, William B White*

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Abstract

Nepheline shows first order, congruent dissolution rates, followed by a lowering of the rates due to precipitation of new phases from solution, initially aluminium hydroxides, and later, as the activity of silica in solution increases, amorphous aluminosilicates. The reaction rates obey the law (Tole and Lasaga, 1981; tole, 1982, 1984, 1985): $R_{imeas} = R_{idias} - \sum_j R_{iprec}$ where R_{imeas}, is the measured rate of input of ton i into solution during dissolution of nepheline, R_{idias} is the true rate of nephelinedissolution, and $\sum_j R_{iprec}$ is the rate of removal of ion i from solution, either by precipitation or adsorption, summed over all the precipitated phases, j, that incorporate the ion, i.

This law predicts that the concentration of ion, i, in solution should increase asymptotically to a steady state value, C_{finnal}, determined by the ratio of the rate of input of i into solution by nephelinedissolution and the rate of its removal from solution by precipitation or adsorption, such that, for a first order precipitation reaction, $C_{final} = \frac{Ak_+}{A'k_-} + C_{ieq}$ where A is the surface area of nepheline, k_+ is the dissolution rate constant, A' is the surface area over which precipitation or adsorption takes place, k_-. is the precipitation or adsorption rate constant, and C_{ieq}, is the equilibrium concentration for ion i in contact with the precipitated phase.

At low pH, rates of dissolution (R_{idiss}) obey the law: $R_{idiss} = k_+(\alpha_{H+})^{1.0}$, while at high pH, the rate law is $R_{idiss} = k_+(\alpha_{H+})^{-0.2}$.

Nephelinedissolution rates (R_{idiss}) exhibit a minimum in the pH range 5–7.

Initial rates of consumption of protons indicate that in the acid pH region, a positively charged complex is formed on the nepheline surface by adsorption of protrons. It is postulated that it is the rate of breakdown of the surface complex so formed which determines the rate of dissolution of nepheline.

Activation energies for the dissolution of nepheline are in the range 53–77 kJ/mole.

Addition of 3 m NaCl to the aqueous solution at pH 5 and 60°C lowers the dissolution rate by an order of magnitude.

The most stable conditions (*i.e.* conditions under which a mineral is least reactive) for nepheline are in the pH range $5 \leqslant \text{pH} \leqslant 7$, and in highly saline aqueous solutions.