Hydrofluoric acid solution calorimetric investigation of the effects of anorthite component on enthalpies of K-Na mixing in feldspars

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ABSTRACT

Enthalpies of solution have been measured at 50 °C in 20.1 wt% hydrofluoric acid under isoperibolic conditions for a nine-member K-Na ion-exchange series based on a disordered oligoclase specimen containing 23.1 mol% anorthite (An) component. The series displays positive enthalpies of K-Na mixing, but magnitudes are substantially reduced relative to An-free analogs. Volumes of K-Na mixing for the series are similarly reduced; the asymmetry of these with respect to composition is the opposite of that for alkali feldspars. Lower magnitudes of the mixing properties are probably related to the shortened compositional range of this series, relative to normal alkali-feldspar series, and to a 23% An structural background against which the energetic effects of K-for-Na substitution are dampened.

INTRODUCTION

Most minerals are not simple binary solutions, yet knowledge of the thermodynamic mixing properties of minerals is confined primarily to binary systems. If thermodynamic data are to be used to predict phase equilibria in natural systems, it is essential to know the effects of third and fourth components on thermodynamic mixing behavior. For enthalpy, third-component effects on binary mixing properties have been systematically investigated on few systems (Hovis and Roux 1993).

The binary mixing properties of alkali feldspars have been studied extensively. Currently there are reliable data for enthalpies of K-Na mixing (Hovis 1988), volumes of K-Na mixing (Waldbaum and Thompson 1968; Waldbaum and Robie 1971; Hovis 1986; Kroll et al. 1986; Hovis and Navrotsky 1995), and entropies of K-Na mixing (Hovis et al. 1991). From these same studies we also know the effects of Al-Si distribution on enthalpies and volumes. Additionally, we have been able to estimate the effects of short-range order (Hovis et al. 1991; Haselton et al. 1983; Hovis and Navrotsky 1995) on the thermodynamic behavior of these minerals. Lastly, we have studied the effects of temperature on both enthalpies (Hovis and Navrotsky 1995) and volumes of mixing (Hovis and Graeme-Barber, 1997). Because of this solid foundation of data, feldspars are excellent for the study of the thermodynamic effects of additional chemical components.

Most naturally occurring feldspars are at least ternary solutions, so it is a natural extension of work on alkali (K, Na) feldspars to quantify the effects of anorthite component on thermodynamic mixing properties. As an initial step in investigating the KAISiO₄ (Or)–NaAlSiO₄ (Ab)–CaAl₂Si₂O₈ (An) ternary system, therefore, we synthesized a K-Na series of feldspars having moderate An content and studied their volumes and enthalpies of mixing.