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Biotite dehydration, partial melting, and fluid composition: Experiments in the system $KAlO_2$-FeO-MgO-SiO_2-H_2O-CO_2

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Abstract

Biotite solid-solutions are a significant H_2O reservoir in the lithosphere, and the assemblage Bt+Opx+Kfs+Qtz is commonly used to estimate a_{H_2O} in high-grade metamorphic and magmatic rocks. Here we report experimental constraints on subsolidus mineral equilibria involving biotite and orthopyroxene in the system $KAlO_2$-MgO-FeO-SiO_2-H_2O-CO_2. Our experiments address the question of stability of biotite of a given X_{Fe} in the assemblage Bt+Qtz±Sa, or the stability of the assemblage Opx+Sa±Qtz. Clemens (1993) and Clemens et al. (1997) concluded that CO_2 has no effect other than to lower a_{H_2O} and thereby raise the solidus T. Our data at $X^{Fl}_{H_2O} < 1$ extend these conclusions to encompass Fe-bearing systems more similar to natural rocks. From a comparison of experimental data and calculated isopleths of biotite composition in the divariant assemblage Bt+Opx+Kfs+Qtz+fluid, it appears that phlogopite-annite solid-solutions must be significantly non-ideal (at $T <$ 800 °C) or that enstatite-ferrosilite solid-solutions must have negative values for their Margules-type parameters. Ignoring these factors would result in any calculated a_{H_2O} values being too low. Although various models allow us to estimate X_{H_2O} in H_2O-CO_2 fluids, we are still unable to use biotite equilibria to estimate a_{H_2O} accurately during high-grade metamorphism and magma crystallization. We also consider qualitatively the effects Fe-Mg biotite solid-solution on partial melting equilibria in fluid-poor (rock-dominated) systems in which hydration-dehydration reactions control the fluid composition.