

AMPHIBOLE STABILITY IN H₂O-UNDERSATURATED CALC-ALKALINE MELTS

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The upper stability limit of amphibole in silicate melts has previously been shown to increase in temperature when the mole fraction of H₂O in the fluid phase in equilibrium with the melt was decreased from 1.0 to 0.5. New experiments on amphibole stability in melts of andesite composition show that the amphibole stability limit also decreases in temperature when mole fraction H₂O in fluid is less than 0.5; these experiments imply that there is an isobaric temperature maximum of stability. At 5.5 kb this maximum occurs at a melt composition of 4.5 percent H₂O for andesite composition. The maximum at 5.5 kb may be explained by a change in amphibole breakdown from an incongruent melting reaction to a dehydration reaction. Calculations in the pressure range 0-10 kb indicate that the isobaric temperature maximum of amphibole stability occurs at a mole fraction of H₂O in the fluid phase ranging from 1.0 to 0.4, depending on total pressure. The maximum may represent either a melting or a dehydration reaction. Calculations also suggest that above 8 kb amphibole is as stable in silicate melt when the mole fraction of H₂O in the fluid phase is 0.3 as when the mole fraction is 1.0. Such conditions affirm the possibility of hydrous partial melting of amphibole-bearing basalt in the earth's mantle to form the calc-alkaline series.

1. Introduction

In recent years increasing attention has been paid to the roles of H₂O and of H₂O-bearing minerals in the earth's lower crust and upper mantle, especially with regard to the generation of basaltic and calc-alkaline magmas. Several recent studies have investigated the stability of hydrous minerals in silicate liquids undersaturated with H₂O [1-3]. These studies have demonstrated that the upper temperature stability limit of hydrous phases in H₂O-undersaturated melts may be higher than their stability limit in H₂O-saturated melts. New experiments on melting relations in andesite include runs which demonstrate that the upper stability limit of amphibole may either increase or decrease in temperature over a range of degrees of H₂O-undersaturation.

2. Definitions

In this paper H₂O-saturation refers to a system in which the fugacity of H₂O in a melt phase ($f_{\text{H}_2\text{O}}^m$)

equals $f_{\text{H}_2\text{O}}^o$, the fugacity of pure H₂O at the same temperature and total pressure. Strictly speaking, every system therefore is H₂O-undersaturated ($f_{\text{H}_2\text{O}}^m$ less than $f_{\text{H}_2\text{O}}^o$), because a small amount of solids dissolves in the fluid. However, in thermodynamic calculations these solids are ignored, and although 'H₂O-saturation' may be theoretically impossible, its meaning is clear. In experiments described herein, a fluid phase of H₂O + CO₂ is always present, such that $f_{\text{H}_2\text{O}}^m$ equals H₂O fugacity in the fluid phase, $f_{\text{H}_2\text{O}}^{fl}$. This paper assumes ideal mixing of H₂O in that fluid ($f_{\text{H}_2\text{O}}^{fl} = f_{\text{H}_2\text{O}}^o \times X_{\text{H}_2\text{O}}^{fl}$). Standard states of phases as defined here are consistent with standard state set B of Anderson [4], whose method was used for dehydration calculations.

3. Experimental techniques

Runs were made in Pd-Ag capsules in an internally-heated pressure vessel from 2 to 8 kb and in a piston-cylinder apparatus at 10 kb. Undersaturation of the melt was achieved by adding oxalic acid (H₂C₂O₄ · 2H₂O) to the sample capsule. In the sealed capsule at

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