American Mineralogist, Volume 110, pages 2007–2016, 2025

The effect of H_2O on the crystallization of orthopyroxene in a high-Mg andesitic melt

Lennart Koch[1,*], Renat R. Almeev[1,†], Stefan A. Linsler[1], Felix Marxer[1,‡], and François Holtz[1]

[1]Institut für Erdsystemwissenschaften, Abteilung Mineralogie, Leibniz Universität Hannover, Callinstr. 3, 30167 Hannover, Germany

Abstract

Near-liquidus crystallization experiments were performed on a high-Mg andesite from the Izu-Bonin-Mariana forearc to study the effect of H_2O on the orthopyroxene crystallization temperature. Experiments were conducted at 200 and 500 MPa in an internally heated pressure vessel at temperatures ranging from 1260 to 1075 °C. Orthopyroxene was the liquidus phase at both investigated pressures. H_2O contents in quenched glasses were quantified via Raman spectroscopy. The liquidus depression for orthopyroxene at 200 MPa can be described by the following equation: $\Delta T^{\text{dry liq}} = 26.02(\pm 1.84) \cdot C_{H_2O}{}^{0.933(\pm 0.050)}$, where $\Delta T^{\text{dry liq}}$ is the difference between the anhydrous liquidus temperature (in °C) and the liquidus at a specific melt water concentration C_{H_2O} (in wt%). The liquidus depression curve at 500 MPa can be described by a linear equation: $\Delta T^{\text{dry liq}} = 25.72(\pm 0.20) \cdot C_{H_2O}$. The experimental data set demonstrates that the orthopyroxene liquidus depression shows no significant pressure dependence with respect to absolute melt H_2O concentrations. Thermodynamic and petrological models predict a more pronounced nonlinear behavior and generally overestimate the role of H_2O on orthopyroxene liquidus depression at H_2O contents below 5 wt% while partly underestimating it at higher H_2O contents. Comparing our data set with experimental results taken from literature obtained for a high-Mg basaltic andesite and different boninites confirms the validity of our orthopyroxene liquidus parameterization for a wider range of melt compositions. A comparison with previous experimental data obtained for olivine and plagioclase shows that the effect of H_2O on the depression of the liquidus temperature of orthopyroxene is slightly lower than for olivine while the plagioclase liquidus temperature is depressed more significantly in the presence of H_2O. Our experimental data can be used for predicting liquidus temperatures for hydrous melts in which orthopyroxene appears as the liquidus phase. Moreover, the empirical parameterization can be incorporated in petrological models to improve modeling of crystallization paths of hydrous magmas.

Keywords: Orthopyroxene, crystallization, liquidus depression, high-Mg andesite, H_2O, Raman spectroscopy, Izu-Bonin-Mariana forearc, IODP Expedition 352