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Experimental calibration of the effect of H_2O on plagioclase crystallization in basaltic melt at 200 MPa

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Abstract

Crystallization experiments were conducted at 200 MPa to determine the effect of small amounts of H_2O on the liquidus temperature of basaltic melts in which plagioclase is the liquidus phase. The H_2O concentrations in the quenched glasses, determined by infrared spectroscopy and Karl-Fischer titration, ranged from 0.02 to 4.2 wt% H_2O. The dry liquidus temperature at 200 MPa was estimated from experiments at 1 atm (H_2O-free) and from the known pressure dependence of plagioclase crystallization temperature. The effect of water (expressed as wt% H_2O) on the plagioclase liquidus temperature is nonlinear and diminishing with increasing melt H_2O concentrations. According to our new experimental data, it can be empirically predicted with following equation:

$$(T^{\mathrm{DRY}} – T^{\mathrm{WET}}) = 76.99 \cdot C_{\mathrm{H_2O}}^{0.71}$$

where $C_{\mathrm{H_2O}}$ is the water concentration in the melt (wt%), T^{DRY}, and T^{WET} are plagioclase crystallization temperatures in water-free and water-bearing systems, respectively.

The relationship between $C_{\mathrm{H_2O}}$ and liquidus temperature worked out in this study is valid for a range of basaltic compositions, ranging from high-alumina basalts to basaltic andesites. The combination of the empirical equation predicting the liquidus depression of plagioclase with previous models predicting the olivine liquidus curve is useful to determine the liquidus temperature in various H_2O-bearing basaltic systems in which either plagioclase or olivine is the liquidus phase.

Keywords: Crystallization, H_2O, MORB, plagioclase, liquidus, FTIR, KFT