American Mineralogist, Volume 85, pages 1128–1142, 2000

Solubility behavior of water in haploandesitic melts at high pressure and high temperature

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ABSTRACT

The solubility of H_2O in three melt compositions along the haploandesite join $Na_2Si_4O_9$-$Na_2(NaAl)_4O_9$ (0, 3, and 6 mol% Al_2O_3) was determined as a function of pressure and temperature from 0.8 to 2.0 GPa and 1000 to 1300 °C. Water solubility is a linear (or near-linear) positive function of pressure (16–18 mol% H_2O/GPa) at constant temperature, and a negative near-linear function of temperature (1–2 mol% H_2O/100 °C) at constant pressure. The solubility is correlated negatively with Al_2O_3 content of the melts.

Partial molar volume of H_2O in the melt, $\overline{V}_{H_2O}^{melt}$, was derived from solubility isotherms (1000, 1100, 1200, and 1300 °C) at 0.8, 1.05, 1.3, 1.65, and 2.0 GPa pressure. Values range between 7.8 and 12.8 cm^3/mol, and decrease with increasing Al_2O_3 content. In the pressure-temperature range studied, $(\partial \overline{V}_{H_2O}^{melt}/\partial T)_P$ ranges from -7.1 ± 0.810^{-3} to $-5.6 \pm 1.3 \cdot 10^{-3}$ cm^3/mol °C, becoming slightly less negative as the melts become more aluminous.

The $\overline{V}_{H_2O}^{melt}$ values were combined with published partial molar volume information for anhydrous oxides in silicate melts to estimate densities of water-rich dacitic magmas in shallow magma chambers associated with explosive volcanism. For a chamber of constant bulk composition during a comparatively short explosive event, such as that of Mount Pinatubo in June 1991 or Mount St. Helens in May 1980, the average density of the magma after eruption is ~3% higher than before the eruption occurred. Furthermore, because of removal of overburden during an eruption, the H_2O saturation value of remaining magma is less than that prior to eruption. From density calculations of the residual hydrous magma after eruption, its density decreases from top to bottom in the magma chamber. Consequently, this magma is gravitationally unstable.