A new plagioclase-liquid hygrometer applicable to rhyolites

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Rhyolite is the most differentiated silicate magma type erupted on Earth and makes up some of the largest explosive eruptions (100-1000's km^3), including those at Yellowstone and Long Valley calderas. Documenting pre-eruptive water concentrations in these voluminos magmas is a prerequisite to understanding what controls their origin, evolution, and variable styles of eruption. To date, the most reliable method for obtaining information on pre-eruptive melt water concentrations in rhyolite melts has been the analysis of trapped melt inclusions in quartz phenocrysts. Owing to the lack of available phase-equilibrium data prior to 2009, application of the plagioclase-liquid hygrometer of Lange *et al* (2009) to high-SiO_2 rhyolites with sodic plagioclase ($<An_{35}$) involved an extrapolation beyond the calibration. In this study, we present a revised plagioclase-liquid hygrometer that is calibrated on an experimental data set tht includes several studies that have been published since 2009 (Tomiya *et al*, 2010; Martel, 2012; Waters *et al*, 2012; Castro *et al*, 2013) as well as additional studies on rhyodacite (Larsen 2005, 2006; Martel, 2006). Note that the study of Couch *et al* (2003) on a low-SiO_2 rhyolite (71 wt% SiO_2) was previously included in the Lange *et al* (2009) calibration. The new plagioclase-liquid model incorporates all volumetric and calorimetric data available in the literautre for the anorthite ($CaAl_2Si_2O_8$) and albite ($NaAlSi_3O_8$) standard-state exchange reaction, and the activities of the crystalline components are taken from Holland and Powell (1992). The dataset for calibration of the plagioclase-liquid hygrometer for rhyolites consists of 211 fluid-saturated plagioclase-liquid (rhyolite-basalt) equilibrium pairs from the literature. Four filters were applied to the data set: (1) crystallinity < 30%; (2) pure-H_2O fluid saturated; (3) compositional totals (including H_2O component) of 96-101% for hydrous quenched glasses; and melt viscosities are < 5.1 log_{10} Pa-s. The final dataset spans a range in liquid composition (45-79 wt% SiO_2), plagioclase composition (An_{17-95}), temperature (750-1244°C), pressure (0-400 MPa), and H_2O concentration (0-6.8 wt%). The standard error estimate for the model is ± 0.4 wt% H_2O and all liquid compositions are fitted equally well. The results are applied to rhyolitic magmas from Long Valley and Yellowstone, among others.