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The effects of silica and water on the viscosity of hydrous quartzofeldspathic melts

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Abstract

The viscosities of hydrous melts (0.65 to 2.8 wt% H_2O) with quartzofeldspathic compositions corresponding to Ab, $Ab_{74}Qz_{26}$, and $Ab_{48}Qz_{52}$ (mole proportions calculated on the basis of eight oxygen atoms; Ab = $NaAlSi_3O_8$, Qz = Si_4O_8) have been determined between 980 and 1375 °C at pressures between 190 and 360 MPa using the falling sphere technique. The use of large bubble-free hydrous glass cylinders (placed in internally heated pressure vessels) previously prepared and already containing markers and platinum spheres allows falling distances up to several centimeters to be measured with a precision of ±50 to 200 μm. This results in a precision of ±15% relative or less for most viscosity data (±10% relative or less if the temperature is known within ±5 °C).

For a water content of 2.8 wt% H_2O, viscosity increases with increasing Qz content. In the investigated viscosity range, no significant deviation from Arrhenian behavior is observed and the activation energy of viscous flow increases slightly with decreasing water content of the melt (for Ab). Combining the experimental data obtained in this study with data for a haplogranitic composition investigated previously by Schulze et al. (1996) shows that the viscosities, and hence, the activation energies of viscous flow are similar for compositions with the same atom ratio (Si + Al)/(H + Na + K) (SA/HNK). Thus, melt viscosity is constant if Al, charge balanced by Na or K, is exchanged with Si + H (H incorporated as OH or H_2O). The viscosities (in dPa·s) of all investigated hydrous haplogranite compositions with water contents ranging between 0.7 and 8.2 wt% H_2O can be calculated to better than ±0.15 log units using the expression:

$$\log\eta = -1.8 + [940 + 5598\cdot(\mathrm{SA/HNK})^{0.3774}]\cdot 1/T$$

where T is expressed in Kelvin and varies from 1073 to 1650 K.