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The viscosity of hydrous $NaAlSi_3O_8$ and granitic melts: Configurational entropy models

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ABSTRACT

We used configurational entropy theory to model the viscosity (η) of hydrous melts of $NaAlSi_3O_8$, haplogranite (SiO_2-$KAlSi_3O_8$-$NaAlSi_3O_8$), and complex (natural) granite composition from available measurements and recently published configurational heat-capacity data. The equation $\log \eta = A_e + B_e/TS^{conf}(T)$, where S^{conf} is configurational entropy, reproduces viscosity data for individual samples as well as or better than the empirical three-parameter TVF equation (defined below), and has the advantage of being based on thermodynamic theory. The variables A_e, B_e, and $S^{conf}(T_g)$, where T_g is glass transition temperature, were parameterized as a function of water content for compilations of viscosity data for hydrous $NaAlSi_3O_8$, haplogranite, and peraluminous granite melts. With the simplest assumption of ideal mixing between silicate and water components, configurational entropy models with between 4 and 10 fitting parameters reproduce experimentally determined η-T-X_{H_2O} relationships significantly better than previous literature models based on empirical equations. Our preferred configurational entropy models have root-mean-square deviations of 0.26 log units for $NaAlSi_3O_8$ (n = 77), 0.16 log units for haplogranite (n = 55), and 0.28 log units for peraluminous granites (n = 79). The best statistical fits to the data sometimes require thermodynamically unlikely variations in A_e, B_e, and $S^{conf}(T_g)$ as a function of water content, however, such that further calorimetry data are needed to extract accurate thermodynamic information from viscosity data sets for hydrous melts.

Keywords: Viscosity, configurational entropy, water, silicate melt, albite, granite