

AMORPHOUS MATERIALS: PROPERTIES, STRUCTURE, AND DURABILITY[†]

The viscosity of hydrous NaAlSi₃O₈ and granitic melts: Configurational entropy models

ALAN G. WHITTINGTON,^{1,*} M. ALI BOUHIFD,² AND PASCAL RICHEL³

¹Department of Geological Sciences, 101 Geology Building, University of Missouri-Columbia, Columbia, Missouri 65211, U.S.A.

²Department of Earth Sciences, Oxford University, Parks Road, Oxford OX1 3PR, U.K.

³Physique des Minéraux et des Magmas, IGP, 4 place Jussieu, 75252 Paris Cedex 05, France

ABSTRACT

We used configurational entropy theory to model the viscosity (η) of hydrous melts of NaAlSi₃O₈, haplogranite (SiO₂-KAlSi₃O₈-NaAlSi₃O₈), and complex (natural) granite composition from available measurements and recently published configurational heat-capacity data. The equation $\log \eta = A_e + B_e/TS^{\text{conf}}(T)$, 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 $S^{\text{conf}}(T_g)$, where T_g is glass transition temperature, were parameterized as a function of water content for compilations of viscosity data for hydrous NaAlSi₃O₈, 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 - $X_{\text{H}_2\text{O}}$ 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 NaAlSi₃O₈ ($n = 77$), 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 $S^{\text{conf}}(T_g)$ 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