*American Mineralogist, Volume 89, pages 1673–1679, 2004*

# Crystal nucleation in hydrous rhyolite: Experimental data applied to classical theory

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## ABSTRACT

Feldspar nucleation rate data obtained by laboratory decompression of hydrous silicate melt are interpreted in view of the classical theory of nucleation (CNT) and a non-classical variation, the diffuse-interface theory (DIT). The nucleation rate data can be modeled by the CNT formalism only if the interfacial free energy ($\sigma$) is allowed to vary as a function of composition. The values thus obtained vary by a factor of four (0.024–0.100 J/m$^2$) and decrease systematically over a sixfold increase in dissolved $H_2O$ content (0.8–4.8 wt%). This result is qualitatively consistent with the effects of dissolved $H_2O$ on the liquid-vapor interfacial free energy in haplogranite magma (Mangan and Sisson 2000) and the liquid-crystal interfacial free energy in the one-component Li-disilicate system (Davis et al. 1997).

The DIT states that the interfacial region between the bulk solid and bulk melt has thermodynamic properties intermediate between these phases, and that $\sigma$ is defined as the difference between the interfacial enthalpy ($H_{int}$) and interfacial entropy ($TS_{int}$). If the DIT model is correct, the nucleation rate data for feldspar may indicate that: (1) dissolved $H_2O$ content controls the spatial distribution of enthalpy and configurational entropy around incipient crystals, and (2) the spatial gradients of these potentials diverge during devolatilization.

This study suggests that crystal nucleation studies may yield insights into the structure and thermodynamics of hydrous melts; likewise, experimental studies are important for refining a physical understanding of nucleation phenomena. Our results can be applied to quantitative numerical models of ascent-driven magma crystallization.