Geophysical Research Abstracts
Vol. 13, EGU2011-5427, 2011
EGU General Assembly 2011

A Model for the Calorimetric Glass Transition Temperature: Applications to Natural Systems

Kelly Russell (1), Jim Nicholls (2), and Daniele Giordano (3)

(1) Earth & Ocean Sciences, University of British Columbia, Canada (krussell@eos.ubc.ca), (2) Geology & Geophysics, University of Calgary, Canada, (3) Institute of Earth Sciences, CSIC Lluis Solé i Sabaris, Barcelona, Spain

Naturally-occurring glasses form under a variety of geological conditions. Glass commonly exists as the main constituent in silicic volcanic rocks and in rapidly cooled mafic rocks. It also occurs in rocks with cooling histories that are substantially slower, for example the interiors of flows or mantle xenoliths. The purpose of this paper is to provide constraints on inferring the T - Xmelt conditions for glass formation in natural magmatic systems. Specifically, we present an empirical model of predicting the thermodynamic glass transition temperature (Tg) as a function of melt composition. Operationally the model produces temperature-dependent expressions for the heat contents of a silicate melt and glass of known composition. The point of intersection of the heat content curves for glass and melt defines the calorimetric value of Tg.

From the petrological perspective, the thermodynamic value of Tg is an important limiting value for the temperature conditions at which many magmatic processes take place. Glass formation is a boundary between changing environmental states. Above Tg, rates of nucleation, crystallization and vesiculation are fast enough to significantly affect magmatic processes. Conversely, where the T - Xmelt path of the magma intersects the Tg of the melt, glass forms and many magmatic processes effectively cease.

Our model is constructed from experimental calorimetric heat content and differential scanning calorimetric (DSC) heat capacity measurements on silicate melts and glasses produced over the past 15-20 years. Calorimetric data in the model include: over 500 experiments on 60 melt compositions and 250 observations on 30 glass compositions. Additional constraints on the model derive from thermodynamic or independent estimates of the thermodynamic Tg. The model reproduces most of the measured calorimetric-values of Tg to within 30oC. The model provides volcanologists with a tool for tracking (Tmagma - Tg) through magmatic processes such as fractional crystallization, vesiculation, partial melting. At a minimum, the model provides geothermometric constraints on magmatic systems by converting glass compositions into minimum pre-eruption temperatures. The model also provides petrogenetic insight into the origins of melts found as inclusions in phenocryst assemblages and as veins and pockets in mantle xenoliths.