

THE EFFECTS OF VOLATILES ON THE VISCOSITY AND HEAT CAPACITY OF CALC-
ALKALINE BASALTIC AND BASALTIC ANDESITE LIQUIDS

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ABSTRACT

Calc-alkaline basaltic magmas are volumetrically important at continental and island volcanic arcs, yet their thermal and physical properties are poorly described. These basaltic magmas are characteristically hydrous, and although they largely erupt effusively they may also exhibit explosive behaviour. The quantitative description of the viscosity and heat capacity of hydrous calc-alkaline basaltic liquids is the first step needed in the accurate modelling of their behaviour, and ultimately in the modelling of multi-phase magmas.

The viscosity and heat capacity of a suite of four calc-alkaline liquids, two basalts and two basaltic andesites containing water or combinations of $\text{H}_2\text{O} \pm \text{F} \pm \text{CO}_2$, were measured at superliquidus and supercooled conditions using parallel-plate, concentric-cylinder, and falling-sphere viscometry techniques, and differential scanning calorimetry techniques. The results highlight the compositional dependence of the effects of water (and other volatiles) on viscosity and heat capacity. Water's effect on viscosity gets smaller with increasing depolymerization. The same is true for fluorine. Moreover, the effects of water and fluorine on viscosity are nearly additive, although that of fluorine is less than that of water. Hydrous calc-alkaline basaltic liquids are extremely fluid at eruption temperatures, and complete degassing from the magma chamber to the surface only results in a small viscosity increase of the order of 10-100 times. The calorimetry results show that water has no effect on the heat capacity of glasses, and that the configurational heat capacity at the glass transition gets larger with increasing depolymerization and with increasing water content.