The physics of molten silicates: From simple systems to natural magma

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As witnessed at the beginning of the century by systematic determinations of silicate phase diagrams, the relevance of magma physics to igneous petrology has long been recognized. Until a couple of decades ago, however, the measurement and interpretation of physical properties of silicate melts were neglected by Earth scientists. This contrasted with the extensive work made by physical chemists, metallurgists and ceramists.

The situation changed dramatically in the early 70's when Bottinga and Weill published seminal papers showing that both the density and viscosity of molten silicates could be accurately predicted as a function of temperature and composition from the experimental data gathered for a limited number of simple systems. Beginning in Carmichael's laboratory, much experimental and modelling effort has then been made to satisfy the diversity of geochemical needs.

For the density of melts, subsequent models represent simple, successful extensions of Bottinga and Weill's empirical work in terms of temperature or composition ranges. For the viscosity, in contrast, the complex composition and temperature dependences requires a firmer theoretical understanding to be accounted for quantitatively. If the so-called configurational entropy theory appears to provide such a theoretical framework, it remains to work out the composition dependence of the configurational entropy. For other properties such as the heat capacity or the compressibility, available models of prediction give various degrees of precision.

In this paper, an attempt will be made to rationalize the reasons for the successes and limitations of these models. Critical in this respect are the *configurational* properties that are linked to the temperature-dependent structure of melts. The role of short and medium range order will be discussed, along with the basically pairwise nature of interatomic interactions. Also discussed will be the difficulties of entropy modelling for systems where speciation is unknown and mixing is not ideal.

References

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