Melt Rheology and Glass Formation

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Melt Rheology

The rheology of molten silicates has been the subject of a century of investigation. Current empirical models for Newtonian melt viscosity are adequate for many applications in petrological and volcanological modelling. Structure-based models have been proposed but no one has delivered yet a complete validation of any of these models.

In detail - potentially in petrologically important detail - the rheology of silicate melts contains a number of features that are not yet sufficiently well modelled. In particular, the high viscosity – high pressure regime of silicate melts will require detailed mapping before the grand conclusions of silicate melt viscosities can be developed.

Glass Formation

The departure of molten silicate from the viscous state forms the central event of explosive volcanism. The glassy products of all eruptions can shed light on the conditions of eruptions themselves. Tracking the path of glass formation in molten silicates has revealed a wide range of phenomena in the petrogenesis of these rocks and many new frontiers await exploration.

Some of the currently identifiable areas of progress in both areas will be reviewed. Some potential next steps will be presented.

Dynamics of organic carbon sedimentation and bottom oxygen and their impact on phosphorus retention in Lake Simcoe: reactive-transport modeling and experimental study.

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Introduction

Lake Simcoe experiences cultural eutrophication associated with point and non-point loading sources. Efforts to reduce total phosphorus (P) inputs to Lake Simcoe since the 1990s, have resulted in significant annual load reductions to the lake [1]. This lake still suffers from excessive growth of filamentous algae, macrophytes, and low hypolymnetic oxygen concentration. Despite a good understanding of the total P budget, our knowledge about the potential for bioavailable P loading from the sediments is limited. The impact of dynamic conditions at sediment–water interface, such as organic carbon flux and oxygen concentration, on phosphorus retention remains unknown. In this study, phosphorus sediment retention in three basins, that experienced distinct sedimentation dynamics, has been investigated experimentally and theoretically. Using diagenetic reaction-transport modeling and sediment core analysis, we investigated the effects that variations in the organic carbon loadings and oxygen bottom concentration, had on the availability of sediment P.

Methods and Results

We performed phosphorus sequential fractionations of sediments during summer stratification and under ice-cover. Phosphorus binding forms have been divided into four operational groups: apatite-bound-P, organic P, inorganic redox-sensitive P (iron-hydro-oxides-bounded) and loosely-bound P, that is in equilibrium with P dissolved in pore water.

The following rank was determined for the P in the sediment apatite-P > organic-P > redox-sensitive-P > loosely bound-P. It was found that the largest amount of P is bound in the sediment as apatite-P, essentially stable in respect to redox conditions. The model results are in agreement with the measured flux of total phosphate to the system and the fractionation data of phosphorus binding forms. A sensitivity analysis was undertaken to identify the most significant parameters, demonstrating that variations in sedimentation rate, and bottom water oxygen concentration, have the largest impact on P diagenesis.

[1] Hiriart-Baer et al. (2011) *Temporal trends in phosphorus and lacustrine productivity in Lake Simcoe inferred from lake sediment, Journal of Great Lake Research,* **37**, 764-771.