Anorthite dissolution in basaltic melt

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Kinetics of mineral dissolution/growth have been long studied to understand diverse magmatic processes, such as magma crystallization and assimilation. The dissolution and growth of plagioclase, a common igneous mineral in Earth, Moon and other planets, is often encountered in igneous petrology and, e.g., lunar magma ocean evolution. However, the investigation of its kinetics has been limited, and the relative role of interface reaction and mass transfer is not known.

We carried out time-series diffusive dissolution experiments of anorthite (An#95) in basaltic melt at 1280-1500 °C and 0.5 GPa conditions, using ½ inch piston cylinder asparatus. The data show that interface melt composition depends on experimental duration for the sets of experiments at 1280°C, and 1330°C, while such dependence cannot be resolved at higher temperatures (1400°C, and 1500°C). The dissolution distance also deviate from pure diffusion control. That is, the data indicate that interface reaction plays a role in controlling the dissolution of anorthite at ≤ 1400°C for short-duration experiments. Monte Carlo simulation was used to numerically simulate the compositional diffusion profiles in the basaltic melt, incorporating the roles of both interface reaction and diffusion. Effective binary diffisivities (EBD) of Al_2O_3, TiO2, FeO_t, and MgO, Al_2O_3 concentration at anorthite saturation (C_s), and reduced interface reaction rate (V_a) were obtained from the simulation. Temperature and compositional dependence of EBD of Al_2O_3 in this study and literature data is examined and the variation of Al_2O_3 EBD can be related to melt composition variation, with higher degree of polymerization reducing Al_2O_3 EBD. Dependence of C_s is fitted to approximate the anorthite saturation condition in basaltic melt. And for the first time, we've experimentally obtained the reduced interface reaction rate V_a for anorthite dissolution, and its temperature dependence.

In addition to providing the reduced interface reaction rate data as well as saturation and diffusion data, our results can be used to model diffusive and convective anorthite dissolution and growth in basaltic melts. Specifically, we will discuss modeling results for the kinetics and dynamics of convective anorthite growth in a lunar magma ocean to explore the conditions for the formation of an anorthite crust.