Seconds after impact: Insights into the thermal history of tektites

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Tektites are natural felsic glasses formed as a result of impact melting and subsequent quenching of distally ejected material upon hypervelocity impacts on Earth. Some tektites contain inclusions of lechatelierite (nearly pure SiO_2 glass), generally thought to be relicts of melted quartz grains. This study exploits the presence of these inclusions to extract information about tektite thermal histories by investigating chemical diffusion between molten silica and surrounding peraluminous felsic melt in natural tektites and experiments.

Concentration profiles across lechatelierite-host glass contacts in tektites indicate diffusion between the two melts at high temperature (*T*) prior to quenching. The profiles are typically a few 10's of microns wide; they are strongly asymmetric, steepening closer to the lechatelierite (indicative of diffusion coefficients, *D*'s, that are strongly dependent on composition, decreasing with increasing SiO_2 content); and they display evidence of multicomponent diffusion (e.g., uphill diffusion of K_2O).

In order to understand and interpret the concentration profiles observed in tektites, we performed high-*T* (1800-2400°C) melting experiments on mixtures of quartz plus tektite glass using an aerodynamic-levitation laser-heating apparatus. There are close similarities between the concentration profiles in the natural tektites and those in the experimental charges, including diffusion length scales, asymmetry, and the details of the shapes of the profiles for all analyzed oxides (including a maximum in the profiles of K_2O indicating uphill diffusion).

Concentration profiles of SiO_2 and Al_2O_3 in the experiments and tektites are well fit by an effective binary diffusion model assuming plausible dependence of their *D*'s on SiO_2. Additionally, seemingly complex concentration profiles (including the maximum in the K_2O profiles) simplify considerably if chemical potential profiles (based on MELTS calculations) rather than concentration profiles are considered. The widths of the concentration profiles of all major elements in the experiments are proportional to the square root of time at a given *T*, allowing *D*'s and their *T* dependence to be extracted from the experimental data. This information is sufficient to set quantitative constraints on the time-*T* histories experienced by tektites on time scales of 10^0-10^2 seconds after impact melting.