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ABSTRACT:

Case Studies of Self-Stress Beyond the Elastic Limit and Mechanism of Li Diffusion in the Olivine Structure

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Atomic (/ionic) diffusion plays an important role in the study of many geological and mineralogical processes. Examples include determination of the timescales of many processes (e.g. residence times of magmas before volcanic eruptions), and the understanding of solid state creep of silicate minerals that underlies plate tectonics on Earth. In the course of these studies many observations and technical developments are made that are relevant to the general understanding of diffusion in solids. I will discuss two such recent developments in this talk.

A crystal is strained when ions of different sizes exchange places. The elastic effect of such strain has been studied for long. Certain minerals (garnets, perovskites, pyroxenes) show solid solutions involving a wide range of cations (and hence molar volumes) where we have now observed that diffusive strain can exceed the elastic limit and induce the formation and mobilization of planar defects. This results in the development of subgrain boundaries and chaotic (rather than planar) diffusion fronts and in the extreme case, the formation of grain boundaries with growth of new grains. This behavior may have applications in the production of new materials as well as in the understanding of degeneration of materials.

The second development is related to the ability to measure and model isotopic as well as elemental concentration gradients in solids. Li is found to diffuse in olivine simultaneously by an interstitial as well as a vacancy mechanism. This leads to (a) interesting shapes of concentration profiles, (b) complex dependencies of diffusion rates on various intensive variables (e.g. partial pressure of oxygen), and (c) novel means of measurement of concentrations of vacancies and other defects.