The compositional dependence of Fe, Mn, Mg, and Ca diffusion in garnet

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The composition of the host crystal is a principal determinant of rates of intracrystalline diffusion for Fe, Mn, Mg, and Ca in garnet, exerting influence as great or greater than any other factor. Experiments demonstrate that when other factors are held constant, diffusion coefficients will vary over ~4.5 $\log_{10}$ units across the temperature range 800 -1400 °C; over ~2.7 $\log_{10}$ units across the pressure range 0-8.5 GPa; and over ~1.5 $\log_{10}$ units across the range of $f\mathrm{O}_2$ from IW to MH. But the variation across the range of natural compositions can, by itself, be as large as 5 $\log_{10}$ units.

Systematics in this compositional dependence do not emerge from the existing experimental database, which is restricted largely to compositions near binary joins between end-members. The variability among experimental determinations is so large that one cannot judge with confidence whether the spread in values represents erroneous data or manifests genuine differences in diffusivity for different host compositions.

These difficulties are resolved by new data obtained by modeling the evolution of stranded diffusion profiles in partially resorbed natural garnets. These new data extend the database on diffusion rates into the natural quaternary system, and to lower temperatures. Suites of profiles from two occurrences (the Llano Uplift of central Texas and the aureole of the Makhavinekh Lake Pluton, northern Labrador) yield diffusivities that are consistent with down-temperature extrapolation of experimental studies and that reveal systematics in the dependence of diffusivity on composition. As determined previously for REEs (Van Orman et al., 2002, *CMP* 142:416), diffusion rates for Fe, Mn, Mg, and Ca in garnet do not conform to theories based on elastic-strain models. However, all data (except for two clearly discrepant experimenal studies) fit a simple model in which the pre-exponential factor in an Arrhenius expression for each self-diffusion coefficient is a linear function of the host crystal's unit-cell dimension.

With this model, self diffusion coefficients for Fe, Mn, Mg, and Ca in natural garnets can be specified to within ±0.8 $\log_{10}$ units (95% confidnece level) for nearly all garnet compositions across the full range of relevant temperatures, pressures, and oxygen fugacity encountered in Earth's crust and upper mantle.

Metamorphism of Neoproterozoic Kerala Khondalite Belt: A study on fluid deposited graphite

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We have measured the short-range parameters like crystallite size, interplanar spacings, unit cell parameters of the natural graphite sample from the Achankovil shear zoneof Neoproterozoic Kerala Khondolite Belt, by using powder XRD, Laser Raman and XPS methods. The graphite samples show all the strong lines corresponding to the hexagonal graphite with P6$_3$/mmc space group with the unit cell constants a= 0.2463nm c= 0.6814nm. In addition to these strong lines, there are few weak lines at 0.208, and 0.197 nm corresponding to the presence of rhombohedral polytype of graphite. This rhombohedral graphite is thermodynamically unstable allotropic form of graphite with a space group D_{3d}^5 with unit cell constants a= 0.2567 nm and c= 1.0063nm. On the basis of the intensity ratio of the (101) diffraction peaks for both hexagonal and rhombohedral phase, the content of rhombohedral phase within this sample is estimated to be up to 25-35 %. The presence of rhombohedral phase indicates that the samples contain fluid deposited graphite, a solid carbon from natural carbon-bearing fluids such as those containing CO_2, CO, and CH_4. The nature of the fluid deposited graphite has also been confirmed independently by X-ray photoelectron spectroscopic (XPS) studies. Laser-Raman spectroscopic studies on the samples show Raman bands at 1580 to 1586 cm^{-1} (ordered peak), 1350 to 1355 cm^{-1} (disordered peak) and second order peak at 2726 cm^{-1}. The value of the intensity ratio of ordered to disordered peak (0.095 to 0.100) indicates the peak metamorphic conditions of the host rocks corresponding to sillimanite zone. The values of interplanar spacing d002 (0.334 nm), crystallite size (or stacking height) of 54.80 nm and the degree of graphitisation 139.5 indicate the peak metamorphic temperature of the host rock is about 780 ± 30 ^{0}C, and hence the high-temperature nature of the Achankovil shear zone shear zone.