A predictive model for cation diffusion in periclase

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Understanding rates of diffusion in periclase is essential for understanding chemical transport in Earth's lower mantle. Cation diffusion through periclase is faster than through any other major crystalline phase in the lower mantle, and thus provides an upper limit on the bulk diffusive transport that is possible in the absence of fluids.

The variation in diffusivity among different cations is controlled by their ionic properties, including size, charge, polarizability and electron configurations. No clear relationships among ionic properties and diffusivity have previously been recognized in periclase, despite the existence of a large diffusion database. The trends are obscured by variations in diffusivity that are likely due to the variable chemical purity of the MgO crystals used in the experiments. Here we take advantage of constraints provided by diffusion and ionic conductivity studies on doped MgO crystals to compare the cation diffusion data at a common vacancy concentration. Clear trends emerge between diffusivity and ionic size, charge, polarizability and crystal field stabilization energy. These trends are parameterized to provide a predictive expression for cation diffusion rates in periclase over a broad range of conditions relevant to Earth's lower mantle.

^{40}Ar-^{39}Ar geochronology and PT estimations on garnet-hornblende-muscovite-plagioclase schists from the Kheis Belt, South Africa

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The Kheis Belt on the western margin of the Kaapvaal Craton, South Africa, is often referred to as a thin-skinned fold and thrust belt. However, Humphreys *et al.* [1] indicated that the schists of the Palaeoproterozoic Groblershoop Formation within the Kheis Belt reached equilibrium conditions between 600-700°C and 8-11 kBar. The schists of this study contain a main mineral assemblage of grt+hbl+plag+musc+epi+qtz with accessory chlorite, biotite, ilmenite and rutile. The peak metamorphic mineral assemblage is represented by grt+hbl+musc and the plagioclase has an Ab content of 0.83. The garnet and hornblende have inclusions of quartz, epidote and ilmenite, indicating a greenschist facies mineralogy assemblage. This is oldest assemblage preserved in the sample. Preliminary modeled results, obtained by equilibrium phase diagrams based on bulk composition were calculated for the NaCaKFMASH system with the program Theriak/Domino [2, 3]. These diagrams indicate that the garnet and hornblende growth started at 520°C and 9.5-10 kBar. An increase in Mg in the rims of the garnets points to a prograde reaction. PT conditions went up during garnet growth and reached a possible maximum at 660°C and 12.5 kBar. At higher temperatures kyanite becomes stable and this is not present in the samples. It is unlikely that the temperature reached above 660°C. Retrograde chlorite postdates all other minerals. 40Ar-39Ar dating on both muscovite and hornblende gave 1147±4 Ma and 1141±3 Ma. These ages are related to the Namaqua Orogeny and the agreement between the cooling ages of muscovite and hornblende arguments for a rapid uplift. Therefore are these ages thought to represent cooling ages that can be directly correlated with the peak metamorphic conditions.

[1] Humphreys *et al.* (1991) *S. Afr. J. Geol.* **94**, 170–173.
[2] De Capitani (1994) *European Journal of Mineralogy,* **72**.
[3] De Capitani (1994) *Jahrestagung der Deutschen Mineralogischen Geselleschaft* **6**, 48.