

Grain boundary mobility of siderophile elements in MgO

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Siderophile elements are key in understanding the Earth's history, particularly the platinum group elements and their long-lived isotopes. These elements are highly concentrated in the core relative to the silicate mantle, and a mechanism for core-mantle communication is of great interest to those interested in both the Earth's segregation history as well as the identification of a unique chemical fingerprint that is characteristic of the deep mantle. Elements such as the highly and moderately siderophile elements (HSE and MSE) that are quite incompatible in the lattices of mantle rocks may be present and mobile in the grain boundaries of these phases, thus providing a reservoir for the storage and transport of these important elements. The grain boundary mobility of several HSE and MSE has been investigated in polycrystalline MgO, a deep mantle analog.

The experimental strategy required the presynthesis of MgO wafers to obtain an equilibrium microstructure. Powdered metal particles were smeared on each side of the wafer; the upper horizon with the diffusing element of interest or 'source' (Ir, Os, Rh, Au, Pt, Ru, Re, W, Mo, Cu) and the lower horizon with the 'sink' element, usually Pt. Since the source elements are highly incompatible in the lattice (and likely have very low lattice diffusivities), alloying of the source element with the initially pure Pt particles implies a grain boundary diffusion pathway. The wafers were placed in a piston-cylinder assembly and held at 1600°C and 2.5 GPa for 5-50 hours. The run products were analyzed by electron microprobe (EMP) by measuring the concentration of the source element in the Pt particles.

The results indicate that all of the elements studied are mobile in the polycrystalline MgO. Grain boundary transport caused 0.07-95% alloying with the Pt layer. The cumulative fluxes of source atoms through the MgO layer were estimated and these values span nearly 3 orders of magnitude: Pt, Os and Re display the smallest; W is about an order of magnitude greater; Au, Ir, Ru, Mo, and Cu all have similar values ~6 times that of W; and Rh has the largest flux with ~25 times that of W. It is worth noting that not all of the Pt blebs of a given experiment had the same amount of source element: Ir levels range from 3-18% across the sample and Rh levels range from 25-95%. This indicates that not all grain boundaries are equally conductive pathways for diffusion, but that grain boundary diffusion may present a fast pathway for core-mantle transfer of trace siderophile elements.