Storage and diffusion of helium in olivine grain boundaries

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Although noble gases are powerful tools to provide information on mantle heterogeneities, only their physical parameters in the mineral lattice are considered. However, it has been shown that most incompatible elements are preferentially stored at grain boundaries in polycrystalline rocks and not in mineral lattice [1]. Because noble gases are incompatible elements as well, grain boundaries should also be a preferential site of storage at depth as suggested by naturally deformed sample [2]. If correct, it implies that diffusion of noble gases in polycrystalline material still remains unknown.

To better constrain the noble gases incompatibility and mobility in upper mantle rocks, we performed new experiments following the protocol designed by [3]. Doping and diffusion experiments have been performed to (i) determine if grain boundaries are a potential storage site and (ii) quantify the mobility of He in polycrystalline (fine grain) olivine. We also present a theoretical study to assess how the calculated diffusion parameters change if initial concentration profile is heterogeneous in the starting samples. Results show that whatever the initial concentration profiles across the samples, the resulting activation energies are almost identical, which consolidates the coexistence of two diffusion domains (lattice and grain boundaries) in polycrystalline olivine [3].

The results show different transition temperatures between the two diffusion domains, which seems to depend on the fraction of He stored within grain boundaries. If correct, bulk diffusion could then be affected by grain boundaries at high temperature.

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[3] Burnard P. G. *et al.* (2015) *Earth and Planet. Sci. Let.,* 430, 260-270.