Incorporation and diffusion of noble gases in grain boundaries

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Although noble gases are powerful tools to provide invaluable informations 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. If correct, it implies that: (i) the diffusion parameters used to determine the size of the mantle heterogeneities are underconstraints and (ii) actual models underestimate the diffusivity of noble gases and thus the size of the mantle heterogeneities.

To better constrain the amount of noble gases which can be stored at grain boundaries and to obtain reliable diffusion parameters, we performed new experiments following the protocol designed by [2]. Experiments with different grain sizes have been performed in order to determine the influence of the volume of grain boundaries on the noble gas incorporation and diffusion. Results show two diffusion domains characterized by different activation energy. At low temperature, diffusion is dominated by grain boundary whereas high temperature corresponds to the lattice diffusion [2]. Our results highlight the importance of grain boundaries as preferantial diffusion pathways for noble gases.

It should be noted that samples show different transition temperatures. Such a variability could depend on grain size (the volume of grain boundaries) and/or on the temperature when grain boundaries were entirely depleted. If the last hypothesis is correct, bulk diffusion can also be affected by grain boundaries at high temperature.

[1] Hiraga T. *et al*. (2004) *Nature*, 427, 699-703.
[2] Burnard P. G. *et al*. (2015) *Earth and Planet. Sci. Let.*, 430, 260-270.