

Diffusion-driven D/H fractionation in silicates during hydration, dehydration and degassing

M. ROSKOSZ^{1*}, D. LAPORTE², E. DELOULE³, J. INGRIN⁴, L. REMUSAT¹, C. DEPECKER⁴, H. LEROUX⁴

¹IMPMC, CNRS, Sorbonne Université, UPMC, MNHN, IRD (*corresponding author: mathieu.roskosz@mnhn.fr)

²LMV, CNRS, OPGC; Université Blaise Pascal

³CRPG, CNRS, Université de Lorraine

⁴UMET, CNRS, Université de Lille

Understanding how degassing occurs during accretion and differentiation is crucial to explain the water budget of planetary bodies. In this context, the hydrogen isotopic signature of water in mantle minerals and melts is particularly useful to trace reservoirs and their interactions. Nonetheless, little is known on the influence of mantle processes on the D/H signatures of silicates. In this study, we performed controlled hydration/dehydration experiments. We explore the possibility that diffusion-driven fractionation could affect the D/H signature of partially hydrated amorphous or molten silicates and nominally anhydrous minerals (NAMs).

High purity synthetic fused silica samples were annealed at between 200 and 1000°C at 20 mbar water partial pressure for 1 to 30 days. Dehydration of initially hydrated silica was also performed at 1000°C for a few hours. A set of rhyolitic samples previously synthesized in order to study bubble nucleation during magma decompression was also analyzed. Finally a natural grossular monocystal (Zillertaler Alps, Austria), partially dehydrated in air at 800°C for 10 hours was studied. Water content and speciation were measured both by Fourier-Transform Infra-Red and Raman spectroscopies. Isotopic analyses were performed with the IMS 1270 and 1280 ion microprobes.

The silica samples, the rhyolitic glasses and the grossular monocystal exhibit typical water concentration profiles. In all cases, water speciation does not change significantly along concentration profiles. Concerning D/H signatures, no isotopic variation is detectable across amorphous silica and rhyolitic glasses. The situation is however very different in the grossular monocystal. A strong isotopic gradient appears correlated to the water concentration profile. Our data are interpreted in terms of diffusion mechanisms in both amorphous (and molten) silicates and NAMs. Hydration, dehydration and magma degassing are probably not able to promote large diffusion-driven fractionation of hydrogen in amorphous silicates. Conversely, the diffusion of water through the structure of NAMs affects the overall isotopic composition of dissolved water.