Introduction

Water has been considered to significantly affect the physical properties of olivine. Previous studies showed that even several tens wt. ppm water could enhance Si and O self-diffusion rates, as well as creep rates by orders of magnitude. However, we note that their results might be experimental artifacts due to experimental difficulties. In this study, we systematically measured O self-diffusion coefficient in an iron-free forsterite single crystal at 8 GPa, 1600-1800 K, as a function of water content, showing that water has no meaningful effect on its self-diffusion rate.

Experimental procedure

- Sample
  - Dry forsterite single crystal
- Water-doping annealing
  - Talc + brucite water source
  - Graphite/Au + enstatite buffer
  - 8 GPa, 1600 K, 50 - 70 hours
- Deposition
  - Mg,SiO2 thin film (500 nm)
  - ZrO2 thin film (100 nm)
- Diffusion annealing
  - Talc + brucite water source
  - Graphite/Au + enstatite buffer
  - 8 GPa, 1600 K, 5 - 52 hours
- SIMS
  - Cameca 6f, Cs+ primary beam
  - Depth profiling mode
- FTIR
  - Before and after diffusion annealing

SIMS profile

Example of diffusion profile and SIMS crater

Water content

- Well controlled C\(_{\text{H}_2\text{O}}\) in the samples:
  - \(C_{\text{H}_2\text{O}}\) from <1 to <800 wt. ppm.
  - Homogenous \(C_{\text{H}_2\text{O}}\) in the crystal.

Conclusions

- Water has no meaningful effect on oxygen self-diffusion rate in forsterite (r = 0.05 ± 0.06).
- \(D_0\) is dominated by hopping of un-associated (OH)\(^-\) in hydrous forsterite.
- Effect of water on both \(D_\text{Si}\) and \(D_0\) are very small. By assuming the diffusion controlled olivine creep mechanism, the effect of water on upper mantle rheology is very small.

**Water has no effect on oxygen self-diffusion rate in forsterite**

**Conclusions**

- Water has no meaningful effect on oxygen self-diffusion rate in forsterite (r = 0.05 ± 0.06).
- \(D_0\) is dominated by hopping of un-associated (OH)\(^-\) in hydrous forsterite.
- Effect of water on both \(D_\text{Si}\) and \(D_0\) are very small. By assuming the diffusion controlled olivine creep mechanism, the effect of water on upper mantle rheology is very small.

---

**Figure Legends**

- Example of diffusion profile and SIMS crater
- Well controlled \(C_{\text{H}_2\text{O}}\) in the samples:
  - \(C_{\text{H}_2\text{O}}\) from <1 to <800 wt. ppm.
  - Homogenous \(C_{\text{H}_2\text{O}}\) in the crystal.
  - Constant \(C_{\text{H}_2\text{O}}\) before & after diffusion.
  - Comparable \(C_{\text{H}_2\text{O}}\) by FTIR and SIMS.
- Water has no significant effect on olivine rheology by assuming Si & O diffusion controlled creep mechanism.