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Fluorine impacts on the stabilities of hydrogen defects in olivine

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Although great progress has been made in understanding the distribution and cycling of water in the mantle (e.g. Peslier et al. 2017), there still exist many inconsistencies and uncertainties. Recent studies have shown that mantle is also the fluorine (F) reservoir (e.g., Guo and Korenaga 2021). Because of the similar size andnature of fluorine and hydroxyl, their chemical behavior are linked. Therefore, fluorine is expected to play a role in the distribution and cycling of water in the mantle, which is yet poorly known.

Here, we carried out studies on fluorine impacts on the stabilities of hydrogen defects in olivine, including O-H bonding behavior at high temperatures and hydrogen diffusion. The samples are the synthesized fluorine-free forsterite, forsterite with 1480 ppm fluorine and a nature forsterite with 308 ppm fluorine from Pamir, Tadzikistan. The results show that (1) the presence of fluorine may improve the storage capacity of hydrogen defects related to Si vacancies. (2) The hydrogen defects coupled with fluorine are more temperature-dependent than those uncoupled. (3) The presence of fluorine reduces the bulk diffusion coefficient of hydrogen related to silicon defects by about one order of magnitude, and enhances the diffusion activation energy from 439 ± 21 kJ/mol for the forsterite with 1480 ppm to 287 ± 3 kJ/mol for the F-free forsterite.

These results suggest that the influence of fluorine should be taken into account when evaluating the magma ascent rate using hydrogen diffusion, and the F-bearing olivine will have a better preservation of water than the F-free olivine.

[1] Peslier A.H., Schonbachler M., Busemann H. & Karato S.I. (2017), *Space Science Reviews* **212**, 743-810.

[2] Guo M. & Korenaga J. (2021), Proceedings of the National Academy of Sciences of the United States of America **118**, e2116083118.