Formation of Fe-rich volatile-bearing phases in the deep lower mantle

HONGSHENG YUAN[1], LI ZHANG[1], LIANJIAN MAN[1], DUCK YOUNG KIM[1], DMITRY POPOV[2], YUE MENG[2], ERAN GREENBERG[3], VITALI PRAKAPENKA[3]

[1] Center for High Pressure Science and Technology Advanced Research (HPSTAR), Shanghai 201203, China (hongsheng.yuan@hpstar.ac.cn; zhangli@hpstar.ac.cn; lianjian.man@hpstar.ac.cn; duckyoung.kim@hpstar.ac.cn)

[2] HPCAT, X-ray Science Division, Argonne National Laboratory, Argonne, IL 60439, U.S.A. (ymeng@anl.gov; dpopov@anl.gov)

[3] GeoSoilEnviroCARS, University of Chicago, Chicago, Illinois 60637, USA. (erangre@gmail.com; prakapenka@cars.uchicago.edu)

The observation of hydrous ringwoodite with ~1 wt.% H_2O as a diamond inclusion indicates the transition zone is, at least locally, very wet [1]. Furthermore, the recent discovery of Ice-VII and halite inclusions at pressures as high as 24 GPa in diamonds provides direct evidence for the existence of saline fluid at least down to the shallow lower mantle[2]. To understand the interaction of volatile cycles (water and Cl) with the Fe-bearing lower mantle, we performed experiments to simulate the behavior of deep volatiles in laser-heated diamond anvil cells (DACs) under high pressure-temperature (*P-T*) conditions corresponding to the deep lower mantle. The phase assemblages were determined by a combination of *in-situ* synchrotron multigrain X-ray diffraction (XRD) and *ex situ* transmission electron microscope (TEM) analysis. In the system MgO-Al_2O_3-Fe_2O_3-SiO_2-H_2O containing ~7 wt.% water, the hydrous Fe-bearing δ-phase coexists with both bridgmanite (Bdg) and post-perovskite (pPv) in a broad *P-T* range of 104–126 GPa and 1900–2500 K, whereas the pyrite-type (py) FeOOH phase was only observed coexisting with the pPv phase by *in situ* XRD. *In situ* XRD data further revealed that saline fluid reacts with Fe-bearing pPv to form a previously unknown cubic phase of $FeCl_2$ that adopts the identical space group of *Pa-3* with that of the py-phase FeOOH. Seismic observations have shown that subducting slabs can enter the lower mantle, and reach the the base of the mantle, and therefore, formation of the very dense Fe-rich volatile-bearing phases in the lowermost mantle may provide important clues for deep volatile cycles.

[1] D. G. Pearson *et al.*, Nature **507** (2014).
[2] O. Tschauner *et al.*, Science **359** (2018).