Abstract

Hydrogen and Sulfur in Metallic Iron in the Core of Mars

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Light elements are needed to explain the observed density deficit of Earth's Fe-Ni core [1]. Given their cosmochemical abundance and siderophile character at high pressures and high temperatures, silicon, sulfur, oxygen, carbon and hydrogen are strong candidates. For Mars, large amounts found in SNC meteorites [2] make sulfur the primary candidate to enter the martian core. Ringwoodite from the martian mantle being in direct contact with the core and being known to store large amounts of water [3], the incorporation of hydrogen into the core through mantle-core interactions should also be considered [4]. In this study, we explore the tertiary Fe-H-S system at the pressure and temperature (P, T) conditions representative of that of Mars' core.

For this, we study materials in the Fe–FeS_2 compositional range together with hydrogen in a pulsed laser-heated diamond anvil cell combined with in-situ X-ray diffraction performed at the 13IDD beamline of the Advanced Photon Source. From XRD, we find that instead of forming a single Fe–H–S alloy at (P, T) conditions relevant to Mars' core, we form separate FeH_x and FeS phases. We also find that FeS and FeH_2 formed phases appear to be stable at lower pressures than previously reported in the literature: orthorhombic FeS(VI) is found to be stable at pressures down to 10 GPa where monoclinic FeS(III) is reported to be the stable structure in the H-free system [5]. Similarly, FeH_2 is found to be stable at pressures where dhcp-FeH is found to be the stable phase in the S-free system [6]. The stabilization of FeS and FeH at lower pressures can therefore be associated with incorporation of hydrogen and sulfur in the crystal structure of respective phases.

These results will help constrain the melting relations between liquid and solid iron alloys and bring new insights on the potential influence of hydrogen and sulfur on the geodynamo of planetary cores, which in turn can tell about the thermal regime of the planet. Our data can also be key in the interpretation of seismic data collected during the InSight mission on Mars.

References

1. Poirier J P. Physics of the earth and planetary interiors, 85(3-4):319–337, 1994.
2. Stevenson D J. Nature, 412(6843):214, 2001.
3. Pearson D, et al. Nature, 507(7491):221, 2014.
4. Shibazaki Y, et al. Earth and Planetary Science Letters, 287(3-4):463–470, 2009.
5. Ono S and Kikegawa T. American Mineralogist, 91(11-12):1941–1944, 2006.
6. Pépin C, et al. Physical Review Letters, 113(26):1–5, 2014.