Behavior of light elements in the Earth's evolution: In-situ high pressure and high temperature neutron observations of iron-silicate-water system

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The Earth's core is considered to consist of Fe alloy and some light elements (O, S, Si, H, C). Hydrogen (H) is the most abundant element in the universe and one of the promising candidates existing in the Earth's core. However, its amount dissolved in the core and its process are still unknown because H cannot be detected by X-ray diffraction and it easily escapes from iron by the release of pressure. Recently, H content in *fcc*-Fe at high pressure and high temperature (high-PT) has been determined using in-situ neutron diffraction measurements [1], suggesting that H had preferentially dissolved into iron in the very early stage of Earth's formation. To clarify the pertitioning of multi light elements between iron hydride (not pure iron) and silicates, we have focused on sulfur (S) and investigated its effect on hydrogenation of iron. Initial sample composition of Fe:$Mg(OD)_2$ (or MgO):SiO_2=2:1:1 of molar ratio with 5wt.% of S simulates an ideal condition of the primitive Earth. In-situ high-PT neutron experiments up to 7 GPa, 1000K were performed using a six-axis multi-anvil press installed at the beamline (PLANET) in the pulsed-neutron facility, J-PARC. We analyzed neutron diffraction patterns and found that the volume of *fcc*-Fe was significantly increased, whereas a sub-product of FeS and the sample without water showed no change. The formation of FeS was promoted in the existence of water but its hydrogenation was negligible, suggesting that both S and Fe were not mobile and could not react with each other without water. H and S can be preferentially incorporated into solid Fe at lower-T before melting. The other light elements could have dissolved into molten iron hydride and/or FeS in the later process of Earth's core-mantle differentiation at much higher-PT condition.

[1] Iizuka-Oku *et al* (2017) *Nature Commun.* **8**, 14096