

Compression of hcp Fe-Si-H alloy to 130 GPa

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The light elements in the Earth's core have not been identified yet, but hydrogen is now collecting more attention because recent planet formation theory suggests that large amount of water (e.g. 10 to 100 times seawater) should have been brought to the Earth during the late stage of its formation. Hydrogen is a strong siderophile element and thus it is possibly present in the core. The effect of hydrogen on the property of iron alloy is little known yet. Moreover, the presence of ~ 6 wt.% silicon has been also strongly supported by geochemical and cosmochemical arguments. Here we report hydrogenation of Fe_{0.88}Si_{0.12} (6.5 wt.% Si) alloy and the compression behavior of Fe_{0.88}Si_{0.12}H_{0.8} alloy to 130 GPa at room temperature. Fe_{0.88}Si_{0.12} foil was loaded into a diamond anvil cell (DAC), and then liquid hydrogen was introduced at temperatures below 20 K. The results demonstrate that the octahedral sites of Fe-Si-H alloys are not fully occupied by hydrogen unlike the case of FeH and as a consequence Fe_{0.88}Si_{0.12}H_{0.8} is formed under hydrogen-saturated condition. The compressibility of hcp Fe_{0.88}Si_{0.12}H_{0.8} is similar to that of pure iron. Assuming that liquid and solid alloys have identical density and ideal solution of hydrogen and silicon in the hcp phase, we found that the observed density profile in the outer core may be reconciled with Fe_{0.88}Si_{0.12}H_{0.4}. It means that the amount of hydrogen corresponding to about 90 times seawater could be in the Earth's core. This study suggests that Fe-Si-H system is a plausible chemical composition of the core.

Keywords: Light elements, Core formation, Hydrogen, Silicon, High pressure, Diamond anvil cell (DAC)