

Effect of pressure and sulfur content on sound velocity in liquid Fe-S to 20 GPa

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In order to understand the structure and composition of the molten core of the terrestrial planets such as Mars, it is important to know the physical properties of liquid Fe alloys at high pressure and high temperature. Sound velocity is a key physical property because it can be directly compared with seismic observations. However, longitudinal sound velocity (V_p) measurements of liquid Fe alloy by ultrasonic methods combined with multi anvil apparatus have been limited to below 8 GPa (e.g. Nishida et al. 2016). We therefore have been developing and improving the techniques. Here we report the latest results of sound velocity measurements of liquid Fe, $\text{Fe}_{80}\text{S}_{20}$, and $\text{Fe}_{57}\text{S}_{43}$ up to 20 GPa corresponding to the Martian core mantle boundary (CMB).

High-pressure and high-temperature experiments were conducted at BL04B1 beamline of SPring-8 and AR-NE7A beamline of KEK PF. Sound velocity was measured using ultrasonic pulse-echo method. The starting materials were pellets consisting of Fe, and mixture of Fe and FeS powders. Chemical analyses of the run products were conducted using FE-EPMA to evaluate contamination from surrounding materials.

The V_p of liquid $\text{Fe}_{57}\text{S}_{43}$ were lower than that of liquid $\text{Fe}_{80}\text{S}_{20}$ in all of the conditions of up to 20 GPa. However, the pressure dependence of V_p of liquid Fe is different from that of both liquid $\text{Fe}_{80}\text{S}_{20}$ and $\text{Fe}_{57}\text{S}_{43}$. The V_p of liquid $\text{Fe}_{80}\text{S}_{20}$ is $\sim 10\%$ slower than that of liquid Fe at 5 GPa (the lunar core condition) while they are almost equal to each other at 20 GPa (the Martian CMB). The effect of sulfur on V_p depends largely on pressure. The V_p in liquid Fe-S monotonically decreases with increasing sulfur content at the lunar core condition while the V_p may have local maximum at intermediate composition under the Martian core condition (20-40 GPa).

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