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Compressional and shear wave velocities for polycrystalline *bcc*-Fe up to 6.3 GPa and 800 K

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Abstract

The cores of the Earth and other differentiated bodies are believed to be comprised of iron and various amounts of light elements. Measuring the densities and sound velocities of iron and its alloys at high pressures and high temperatures is crucial for understanding the structure and composition of these cores. In this study, the sound velocities (v_P and v_S) and density measurements of body-centered cubic (*bcc*)-Fe were determined experimentally up to 6.3 GPa and 800 K using ultrasonic and X-ray diffraction methods. Based on the measured v_P, v_S, and density, we obtained the following parameters regarding the adiabatic bulk K_S and shear G moduli of *bcc*-Fe: K_{S0} = 163.2(15) GPa, $\partial K_S/\partial P$ = 6.75(33), $\partial K_S/\partial T$ = –0.038(3) GPa/K, G_0 = 81.4(6) GPa, $\partial G/\partial P$ = 1.66(14), and $\partial G/\partial T$ = –0.029(1) GPa/K. Moreover, we observed that the sound velocity–density relationship for *bcc*-Fe depended on temperature in the pressure and temperature ranges analyzed in this study and the effect of temperature on v_S was stronger than that on v_P at a constant density, e.g., 6.0% and 2.7% depression for v_S and v_P, respectively, from 300 to 800 K at 8000 kg/m^3. Furthermore, the effects of temperature on both v_P and v_S at a constant density were much greater for *bcc*-Fe than for ε-FeSi (cubic B20 structure), according to previously obtained measurements, which may be attributable to differences in the degree of thermal pressure. These results suggest that the effects of temperature on the sound velocity–density relationship for Fe alloys strongly depend on their crystal structures and light element contents in the range of pressure and temperature studied.

Keywords: *bcc*-Fe, high pressure, planetary core, sound velocity, ultrasonic method