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Sound velocity measurements for iron alloys at Earth core pressures and universal relations between solid and liquid

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When we consider the structure of Earth's interior, the sound velocity is one of the important physical properties of the interior materials because it can be directly compared with the seismological data which can yield the physical properties of the Earth's interior. Although it needs to measure the sound velocity of the interior material under high pressure and temperature, the sound velocity measurement of the materials on the condition over 200 GPa and 4000 K, such as the core condition, is technically difficult in static compression technique (e.g. diamond anvil cell: DAC) (1-4). Therefore, in such high pressure and temperature, dynamic compression technique, such as gas gun, is used. Although some works about the sound velocity of pure iron have been done by gas gun (5-7), it is not enough to discuss about the Earth's core which consists of iron alloy. Although Badro et al. (8) and Fiquet et al. (9) measured compressional sound velocity for several iron alloys (FeO, FeSi, FeS, FeS_2, and Fe_3C) at room temperature by inelastic x-ray scattering (IXS) at the DAC, the sound velocity data of liquid iron alloy is very few (10, 11).

We performed laser-shock experiments of liquid iron alloys at HIPER system of Gekko-XII laser in Institute of Laser Engineering, Osaka University (12). We measured the sound velocities of iron alloys (Fe-Ni-Si system) under Earth's core conditions. The sound velocities were measured by side-on radiography (13). Our data of sound velocity and density for pure iron and the data from previous studies of liquid iron (5, 6, 14) indicate a linear sound velocity-density relation, at least up to 800 GPa, which is in good agreement with Birch's law (15). The sound velocity for iron alloys and the data from previous studies of liquid iron alloyed with O and S (10, 11) were linearly related to the density of the alloy, suggesting that Birch's law is also applicable to the liquid phase of iron alloys. Our work and the previous results (3, 5, 6, 10, 11, 14) suggest that generally the sound velocity as a function of density has the same slope ratio of approximately 1.5 between the solid and liquid phases for iron, iron alloys, and Earth's core (17). The sound velocity in the liquid phase is about 10% lower than in the solid phase at melting point density. These relations between solid and liquid along the Hugoniot are universal for metals.

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References

1. H. K. Mao et al., Nature 396, 741 (1998).
2. H. K. Mao et al., Science 292, 914 (2001).
3. G. Fiquet et al., Science 291, 468 (2001).
4. J. F. Lin et al., Science 308, 1892 (2005).
5. J. M. Brown, R. G, McQueen, J. Geophys. Res., 91, 7485 (1986).
6. J. H. Nguyen, N.C., Holmes, Nature 427, 339 (2004).
7. K. Shigemori et al., Eur. Phys. J. D 44, 301 (2007).
8. J. Badro et al., Earth Planet. Sci. Lett. 254, 233 (2007).
9. G. Fiquet et al., Phys. Earth Planet. Inter. 172, 125 (2009).
10. H. Huang et al., J. Geophys. Res. 115, B05207 (2010).
11. H. Huang et al., Nature 479, 513 (2011).
12. C. Yamanaka et al., Nucl. Fusion 27, 19 (1987).
13. K. Shigemori et al., Rev. Sci. Instrum. 83, 10E529 (2012).
14. J. W. Shaner et al., Shock Waves in Condensed Matter, pp. 135?138 (1988).
15. F. Birch, Geophys. J. R. Astron. Soc. 4, 295 (1961).
16. P. M. Nasch et al., J. Geophys. Res. 99, 4285 (1994).
17. A. M. Dziewonski, D. L. Anderson, Phys. Earth Planet. Inter. 25, 297 (1981).

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