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Chemistry and Physics of the Earth's Core

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The range of alloying components responsible for lowering the Earth's core density below that of pure iron is large, with perhaps no dominant element responsible for the overall density deficit. Carbon is one possible candidate and may have been alloyed with liquid iron under conditions of Earth's early formation. Thermodynamic calculations have also suggested that precipitation of a carbide phase from sulphur-rich Fe melts may form a solid Fe-C phase within the inner core (IC). Compression data for phases in the iron-carbon system are sparse and we report measurements of the equation of state (EOS) and phase-transition behaviour of Fe_3C (cohenite, orthorhombic, *Pnma*) to 50 GPa performed at the European Synchrotron Radiation Facility (ESRF) in a diamond-anvil cell. Cohenite occurs as one of the intermetallic phases in quenched iron melts and the synthetic phase (cementite) was obtained by electrochemical extraction from an annealed high-carbon steel (0.5wt% C) containing some Mn. The diffraction data showed no evidence for a structural phase transition and a Vinet EOS fit gave a bulk modulus K_0 = 162 GPa with K'=6.4, consistent with an Fe_3C IC. The presence of some impurity in the IC may be responsible for the seismologically-observed elastic anisotropy, models of which have so far depended on experimental measurements and theoretical predictions of the elastic moduli of hcp iron under pressure. The transverse-optical, doubly-degenerate (E_2 g) phonon mode in hcp metals is Raman active and can provide information on their dynamics under compression and here we report new optical measurements of this phonon in hcp-iron and rhenium to 60 GPa, placing the first direct constraints on the pressure-dependence of the elastic constant C_{44}. The calculated pressure dependence of this constant agrees well with first-principles theoretical predictions in both Fe and Re, in contrast with measurements derived from recent nonhydrostatic, lattice-strain, x-ray techniques.