American Mineralogist, Volume 95, pages 870–875, 2010

^{57}Fe Mössbauer spectroscopy and electrical resistivity studies on naturally occurring native iron under high pressures up to 9.1 GPa

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Abstract

We report the pressure dependence of the Mössbauer spectra and the electrical resistivity up to 9.1 GPa at room temperature for a native iron sample collected from the Precambrian Chaibasa shales, Singhbhum Craton, Eastern India. The Mössbauer spectroscopy of the sample at ambient conditions yields isomer shifts and magnetic hyperfine field values that confirm the presence of Fe^0 oxidation state. Many theories have been put forward to explain the origin of this native iron including a Precambrian meteoritic impact. High-pressure Mössbauer spectroscopic measurements using diamond anvil cell (DAC) showed a constant isomer shift up to 5.6 GPa with a subtle variation of -1.07×10^{-3} mm/s/GPa followed by sharper change -4.3×10^{-3} mm/s/GPa above 6.3 GPa, a pressure much lower than the usual value reported for metallic iron. Further increase of pressure to 9.1 GPa results in the emergence of a tiny peak at ~0 isomer shift indicating the onset of the martensitic phase transition of iron from the body-centered-cubic (bcc) to hexagonal-close-packed (hcp) transition 4 GPa lower than the transition pressure normally observed for pure iron. This phase transition in the native iron is confirmed by high-pressure electrical resistivity study. Lowering of the transition pressure could be due to nucleation of hcp by stacking faults caused by shock metamorphism resulting from the Precambrian impact in the region.

Keywords: Mössbauer spectroscopy, high pressure, diamond anvil cell, native iron, Precambrian impact, electrical resistivity, XPS spectroscopy