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Magnetic properties of iron at high pressures

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Although fluid motion in the outer core is commonly thought to generate the Earth's magnetic field, its geometry and secular variation may not rely on fluid mechanics alone. A strongly paramagnetic or, although doubtful, ferromagnetic inner core could have an important influence on the magnetic field surrounding it. Previous studies on the magnetic state of hexagonal closed packed (hcp) Fe, the best candidate for the phase of iron in the core, have come to diverse conclusions. To help solve this problem, we studied the magnetic properties of Fe at high pressures employing two very different approaches. The first allowed direct visual characterization of the magnetization by immersing Fe particles in a fluid pressure medium then observing the interaction (or lack thereof) of the particles with an external magnet. Stress in the cell was perfectly hydrostatic, e.g., no stress gradient existed. The attraction of Fe to an applied magnetic field at 17.7 GPa and 262 C suggests hcp Fe exists either in a paramagnetic or ferromagnetic state. In the second approach we built a system that measures magnetic hysteresis parameters in a diamond anvil cell. We measured the hysteresis loops of 99% pure Fe under pressure from 0 to 21 GPa. We find that saturation remanence and maximum susceptibility decrease from 0 to ca. 10 GPa, then slightly increase thereafter, likely coincident with the phase transition.