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A pressure-induced, magnetic transition in pyrrhotite: Implications for the formation pressure of meteorites and diamonds

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Meteorites and diamonds encounter high pressures during their formation or subsequent evolution. These materials sometimes contain magnetic inclusions of pyrrhotite. Because magnetic properties are sensitive to strain, pyrrhotite can potentially record the shock or formation pressures of its host. Moreover, pyrrhotite undergoes a pressure-induced phase transition between 1.6 and 6.2 GPa, but the magnetic signature of this transition is poorly known. Here we report room temperature magnetic measurements on multi- and single domain pyrrhotite under non-hydrostatic pressure up to 4.5 GPa. We find that the ratio of magnetic coercivity and remanence follows a logarithmic law with respect to pressure, which can potentially be used as a geobarometer. Due to the greater thermal expansion of pyrrhotite with respect to diamond, pyrrhotite inclusions in diamond experience a confining pressure at the Earth's surface. Applying our experimentally derived magnetic geobarometer to pyrrhotite-bearing diamonds from Botswana and the Central African Republic suggests the pressures of the pyrrhotite inclusions in the diamonds range from 1.3 to 2.1 GPa. These overpressures constrain the mantle source pressures from 5.4 to 9.5 GPa, depending on which bulk modulus and thermal expansion coefficients of the two phases are used. We are now trying to develop magnetic barometers on other magnetic phases to apply to meteorites, ultimately to constrain the minimum pressure in which the meteorite formed and, hence, information regarding the planetesmal's size, and/or depth, in which the meteorite was derived.