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A low-temperature phase diagram for ilmenite-rich compositions in the system Fe_2O_3-$FeTiO_3$

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Abstract

An approximate low-temperature, metastable phase diagram is drawn for the system $(1 - X)$ Fe_2O_3-$(X)FeTiO_3$. It is based on published and new magnetic data from nine synthetic samples with bulk compositions in the range $0.6 < X < 1.0$. Fields are plotted for (1) the paramagnetic phase (PM); the Fe_2O_3-rich ferrimagnetic phase (FM); (2) the $FeTiO_3$-rich antiferromagnetic phase (AF); and (3) a re-entrant spin-glass phase (RSG). In addition, two subfields are plotted: (1) FM′, a subfield of the FM-phase, which occurs below a characteristic temperature T_K, at which the magnetic susceptibility drops sharply on cooling, and (2) PM′, a subfield of the PM-phase (traditionally called superparamagnetic) forms below a sharp rise in susceptibility at T_S, and exhibits measurable dispersion in the magnetic susceptibility at $T < T_S$.

The diagram is drawn with a bicritical point, $T_{\lambda\lambda'}$, at $X \approx 0.87$, $T \approx 39$ K, which is the intersection of second-order magnetic phase boundaries for the paramagnetic → ferrimagnetic [PM(PM′) → FM] transition, $T_C(X)$, and the PM(PM′) → AF transition, $T_N(X)$. In addition, the RSG phase is plotted as one of four stable phases at $T_{\lambda\lambda'}$, a construction that is not required by the phase rule, but is strongly favored by the physics of competition between the incompatible magnetically ordered structures of the FM- and AF-phases.

These phase relations are at such low temperature as to be of little consequence for terrestrial magnetism, however, they may well be essential for interpreting the magnetism of the Moon, Mars, and other cold planets. These phase relations are also essential for the characterization of fine natural and synthetic intergrowths, and for understanding magnetic materials for low-temperature technological applications.

Keywords: Hematite-ilmenite, magnetic properties, spin glass, phase diagram