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Morin-type transition in 5*C* pyrrhotite

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Abstract

We report the discovery of a low-temperature spin-flop transition in 5*C* pyrrhotite at ~155 K that is similar to those seen in hematite at 260 K and FeS (troilite) at 440 K. The 5*C* crystal was produced by annealing a 4*C* pyrrhotite crystal at 875 K to produce a change in the vacancy-ordering scheme that developed during cooling. The 5*C* structure is confirmed by single-crystal X-ray diffraction and the stoichiometry and homogeneity by electron microprobe and SEM BSE mapping. Resonant ultrasound spectroscopy (RUS), heat capacity, and magnetization measurements from room temperature down to 2 K are reported. The transition is marked by a steep change in elastic properties at the transition temperature, a peak in the heat capacity, and weak anomalies in measurements of magnetization. Magnetic hysteresis loops and comparison with the magnetic properties of 4*C* pyrrhotite suggest that the transition involves a change in orientation of moments between two different antiferromagnetic structures, perpendicular to the crystallographic *c*-axis at high temperatures and parallel to the crystallographic *c*-axis at low temperatures. The proposed structures are consistent with a group theoretical treatment that also predicts a first-order transition between the magnetic structures.

Keywords: Pyrrhotite, palaeomagnetism, mineralogy, crystal structure