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Pyrrhotite varieties from the 9.1 km deep borehole of the KTB project

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ABSTRACT

We used transmission electron microscopy (TEM) to study pyrrhotite from the German Continental Deep Drilling ("Kontinentale Tiefbohrung," KTB) project. Our goals were to determine the distribution of structure types with depth and to establish relationships between the bulk thermomagnetic behavior and the microstructures of pyrrhotite. In samples from the deep section of the borehole (9080 m below surface, which is equivalent to an in-situ temperature of ~260 °C), the dominant variety of pyrrhotite is 1C that has a mostly disordered vacancy distribution. Faint, diffuse superstructure reflections in the selected-area electron diffraction (SAED) patterns indicate some nC-like ordering occurs, probably in small domains. In addition to the disordered pyrrhotite, a 5C type is also present. According to bulk thermomagnetic measurements, pyrrhotite grains from 9080 m are antiferromagnetic at room temperature; we attribute this behavior to the dominance of the disordered 1C type. In the upper section of the hole (at 564 and 2325 m) several pyrrhotite varieties occur, but the 4C type is most common, in agreement with the ferrimagnetic character of most pyrrhotite grains.

Optical microscopy of pyrrhotite grains that are covered with a magnetic colloid reveal intergrown ferrimagnetic and antiferromagnetic lamellae. TEM images show that these grains are intergrowths of 4C, 5C, and nC types. We interpret these microstructural variations to be responsible for the variation in magnetic properties within single pyrrhotite grains.