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Mineralogy and magnetic behavior of pyrrhotite from a 260 °C section at the KTB drilling site, Germany

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ABSTRACT

The ultradeep bore hole of the German Continental Deep Drilling Program (KTB) reached a depth of 9100 m and in situ temperatures of about 260 °C, offering an unique opportunity to study natural pyrrhotite. An integrative approach using optical methods, electron microprobe analysis, X-ray diffraction, transmission electron microscopy (see Pósfai et al. 2000), and temperature-dependent magnetic susceptibility measurements were used to characterize pyrrhotite types as a function of lithology and depth. We found a lithology-controlled distribution of pyrrhotite types to a depth of 8080 m, with ferrimagnetic, monoclinic 4C pyrrhotite (metal content 46.0 to 47.2 at%) as the dominant magnetic phase in gneisses and metabasic rocks. In the gneisses, a second pyrrhotite type with higher metal concentrations (46.9 to 48.2 at%) and antiferromagnetic behavior also occurs. At depths greater than 8080 m (in situ temperature > 230 °C) antiferromagnetic pyrrhotite, predominates in all lithologies. That 4C pyrrhotite does not occur below 8080 m, suggests that 4C is unstable above 230 °C in these rocks. Instead of 4C, a 5C type with a ferrimagnetic structure occurs below 8080 m. Thermomagnetic experiments indicate that the metal-poor Weiss-type pyrrhotite is stabilized by oxygen that causes the formation of magnetite during heating. From our observations on natural pyrrhotites we suggest that the magnetic λ-transition is related to the growth of ordered nA pyrrhotite domains to single domain size.