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Low temperature properties of single 80 to 200 μm magnetite grains

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We report the results of low-temperature (LT) magnetic measurements performed on three single grains of magnetite, 80 to 200 μm in size. The smallest grain is hydrothermally grown, of nearly spherical shape. The two others originate from crushed and ball-milled samples; they are about 130 and 200 μm in size, respectively, and more irregular in shape. All three grains show a well defined Verwey transition. The Verwey temperature T_V is highest (123.5 K) for the hydrothermal grain indicating a nearly ideal stoichiometry and absence of stress. Two other grains yield Verwey temperatures of 116.7 and 116.5 K, respectively, suggesting a higher degree of non-stoichiometry and/or stress.

In all three grains we observe distinct indications for the development of twin boundaries in the low-temperature monoclinic phase. LT SIRM(5 T) after zero-field cooling (ZFC) is larger than after high-field cooling (HFC) in 5 T. Low-field cooling (LFC) in fields up to 30 mT leads to still larger LT SIRM(5 T) values reaching a maximum around 15 mT.

Heating curves of LT SIRM(5 T) after ZFC or LFC show considerable steps below T_V which largely disappear with increasing cooling field. These steps are probably related to domain reorganization influenced by the presence of twin boundaries. Their relation to metastable domain configurations is further supported by the fact that repeated ZFC measurements yield different heating and re-cooling curves.

We also observe that some information about the LT remanence state is inherited by the high temperature (HT) cubic phase above T_V. This results in different heating and re-cooling curves.