Introduction

The magnetic properties of the ilmenite-hematite solid solution are profoundly influenced by nanoscale microstructures associated with subsolvus exsolution and cation ordering. Slowly cooled rocks containing finely exsolved members of the hematite-ilmenite series have strong and extremely stable magnetic remanence, suggesting an explanation for some magnetic anomalies in the deep crust and on planetary bodies that no longer retain a magnetic field, such as Mars (McEnroe et al. 2001, 2002, 2004a–c; Kasama et al. 2004). This remanence has been attributed to a stable ferrimagnetic substructure originating from the coherent interface between nanoscale ilmenite and hematite exsolution lamellae (the so-called “lamellar magnetism hypothesis” Harrison and Becker 2001; Robinson et al. 2002, 2004). Rapidly cooled members of the hematite-ilmenite series, on the other hand, are well known for their ability to acquire self-reversed thermoremanent magnetization, which is related to the presence of fine-scale twin domains that form on cooling through the R3c → R3 cation ordering phase transition (Ishikawa and Syono 1963; Nord and Lawson 1989, 1992; Hoffman 1992; Binâ et al. 1999; Prêvot et al. 2001; Lagroix et al. 2005).

Lamellar magnetism and self-reversed thermoremanent magnetization are both consequences of the coupling between magnetic and cation ordering. This paper investigates the nature of this coupling through the development of an atomistic model...