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Verwey 転移温度への圧力の影響
Effects of pressure on the Verwey transition temperature of magnetite

佐藤 雅彦 [1*], 山本 裕二 [2], 西岡 孝 [2], 小玉 一人 [2], 綱川 秀夫 [1]
Masahiko Sato[1*], Yuhji Yamamoto[2], Takashi Nishioka[2], Kazuto Kodama[2], Hideo Tsunakawa[1]

[1] 東京工業大学理工学研究科地球惑星科学専攻, [2] 高知大学
[1]Dept. Earth Planet. Sci., Tokyo TECH, [2]Kochi University

The Verwey transition of magnetite is one of the basic issues in the rock magnetism, since the magnetic property measurement using low temperature cycle (LTD, field cooling/ zero-field cooling method, and so on) is a powerful tool for identifying magnetic minerals of rocks.

Mori et al. (2002) reported that the Verwey transition temperature (Tv) decrease with applied pressure by measuring the electrical resistivity on single crystalline samples. In contrast, Rozenberg et al. (2007) observed increase in the transition temperature with pressure by X-ray diffraction and Mossbauer experiment under high pressure. Therefore the Tv change with pressure has been controversial. Recent developments of experimental techniques enable us to measure sample magnetizations under high pressure (Gilder et al., 2002; Kodama and Nishioka, 2005; Sadykov et al., 2008). We focus on the Verwey transition of magnetite and conducted systematic experiment under a pressure of up to 0.9 GPa.

In the sample preparation, natural magnetite of large crystal was crushed by hand and sieved in an ultrasonic bath to be 45-60 micrometers in size. The pressure cell used in the present study is made of CuBe and zirconium oxide (Kodama and Nishioka, 2005). Samples are placed into a Teflon capsule As a pressure transmitting fluid, we used a 1:1 mixture of Fluorinert NO. FC70 and NO. FC77. To calibrate the pressure inside the cell we placed small chip of indium whose transformation temperature is given as a function of pressure (Jennings and Swenson, 1958).

We performed thermal demagnetization of a saturation isothermal remanent magnetization (SIRM) imparted in a magnetic field of 2.5 T at 10 K using a Quantum Design Magnetic Property Measurement System (MPMS). Samples were cooled from room temperature to 10 K in zero-field. A 2.5 T field was applied at 10 K and then measurements of the magnetic moment upon warming started. Measurement frequency upon warming from 10 K was 1 K between 90 K and 140 K, with coarser temperature step below 90 K and above 140 K.

Systematic changes in magnetization intensity curve were observed under high pressure in the present study. Under atmospheric pressure, the sample magnetization down sharply at the known Verwey transition temperature. Applying a pressure, there is a little decrease in magnetization in approaching Tv from below, followed by a sharp decline of magnetization due to the Verwey transition. The Tv values identified as a sharply declined temperature gradually shifts to be lower with pressure (2 K/GPa). After decompression, the magnetization curves recovered the original one at an atmospheric pressure.

This supports the results by Mori et al. (2002) and suggests that the Verwey transition may be caused by the electron hopping. Combining other low temperature cycles, we will discuss behaviors of magnetite concerning the Verwey transition.
Keywords: Verwey transition, high pressure