

RECENT INVESTIGATIONS OF TEMPERATURE MAGNETIC
HYSTERESIS OF HEMATITE NEAR THE MORIN TEMPERATURE

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This paper presents results of investigation of the temperature magnetic hysteresis of hematite, $\alpha\text{-Fe}_2\text{O}_3$, near the Morin temperature. The investigation is performed by application of the Gouy method for magnetic susceptibility measurement in the temperature range from 170 to 300K.

INTRODUCTION

Magnetic properties of hematite, $\alpha\text{-Fe}_2\text{O}_3$ have been investigated by many scientists (e.g. /1/). A particularly great number of papers deals with the investigation of the Morin phase transition at which hematite passes from the pure antiferromagnetic to a weakly ferromagnetic state. Determination of the Morin temperature has shown that T_M depends on a number of factors, e.g. conditions of material formation, previous treatment, impurities and, in the case of polycrystalline materials, on grain size too. Besides, a series of investigations /2-5/ has shown that near the Morin temperature there occurs temperature magnetic hysteresis (TMH).

Remanent magnetization of a monocrystal of the mineral origin is measured in /3/. The existence of TMH has been noticed, and it is determined that, if the sample is previously exposed to cyclic thermal treatment under the same conditions, the reproductive hysteresis loops are obtained. The remanent magnetization for a powder sample is measured in /4/ and the "zig - zag" phenomenon^a of the magnetization change with a change of the number of cycles is observed. In a recently published paper /2/ it is shown that for polycrystalline hematite sample the TMH loop width is 10° . Finally, in /5/ are presented the data obtained in the investigation of linear magnetic birefringence for monocrystal doped with Mn^{3+} ions; TMH loop width near T_M is only $1^\circ - 2^\circ$. Besides, in /5/ are also observed the interesting phenomena in the range of lower temperatures.

In this paper are presented the results of investigation of TMH based on magnetic susceptibility measurement. So far as we could learn, TMH for hematite has not been investigated by means of this method. We have recently presented results of similar investigations in a narrow temperature interval /6/.

EXPERIMENT

Measurement of magnetic susceptibility is performed by application of the Gouy method. The sample investigated is made out of a high purity alpha - Fe_2O_3 powder ($>99,998\%$, Koch-Light). Measurements are performed at different maximum field intensities in the pole gap of the electromagnet. The experimental results shown in Figs. 1. and 2. are obtained at 4,1 and 7,1 kG and in the temperature interval from 170 to 300 K.

MEASUREMENT RESULTS

The measurement results presented in Figs. 1. and 2. indicate that when pass from 4,1 to 7,1 kG: a) magnetic susceptibility decreases; b) heating and cooling curves shift toward higher temperatures and, c) TM-hysteresis loop narrows.

As for TMH we can also say that, according to our measurements it disappears near the temperature $(223 \pm 0,5)$ K while a little higher temperature corresponds to the field $H = 7,1$ kG. The above data agrees with those given in literature. According to /2/ the lower limit of TMH lies at 213 K, according to /3/ at 223 K, while according to /5/ TMH disappears approximately between 230 and 215 K what depends on the magnetic field intensity that changes between 0,3 and 20 kG. But, according to /5/ TMH occurs again in the range of lower temperatures in high intensity fields.

A certain difference is observed in the range of higher temperatures, T_{TM} , as shown in Figs. 1. and 2.: at $H=7,1$ kG a tendency for cycle closing like at T_{TM} is noticed while at $H=4,1$ kG this closing should occur probably at a considerable higher temperature. The difference could probably be explained by a difference in the magnetic field intensity influence and the nature of TMH /7/. It is possible that hematite shows both kinds of TMH: Magnetic field smooths TMH of the first kind which is connected to the process of magnetization mechanism, while TMH of the second kind connected with the crystal structure remains in the stronger field. This effect has not been previously investigated so it is hard to say if this conclusion is correct.

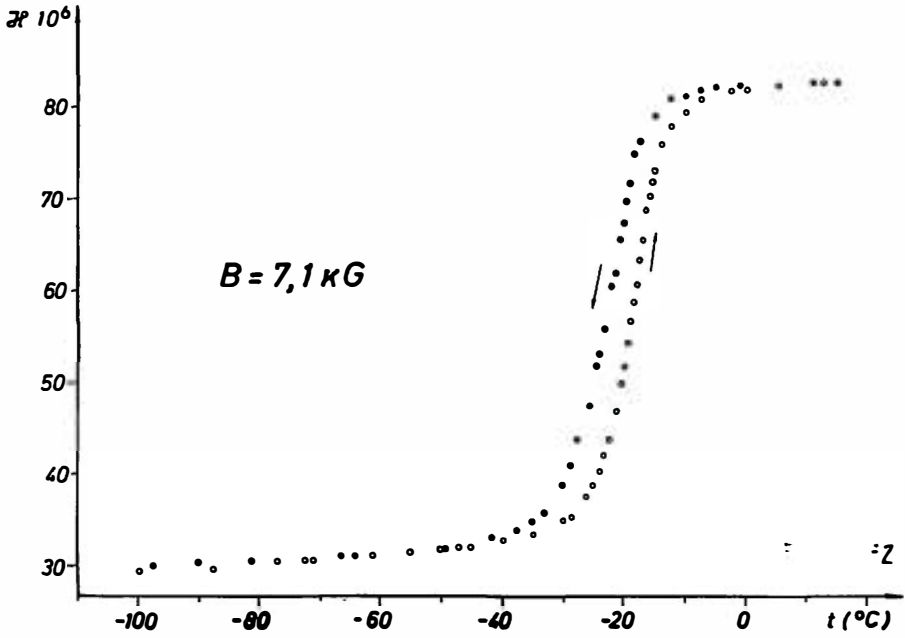


Fig. 2.

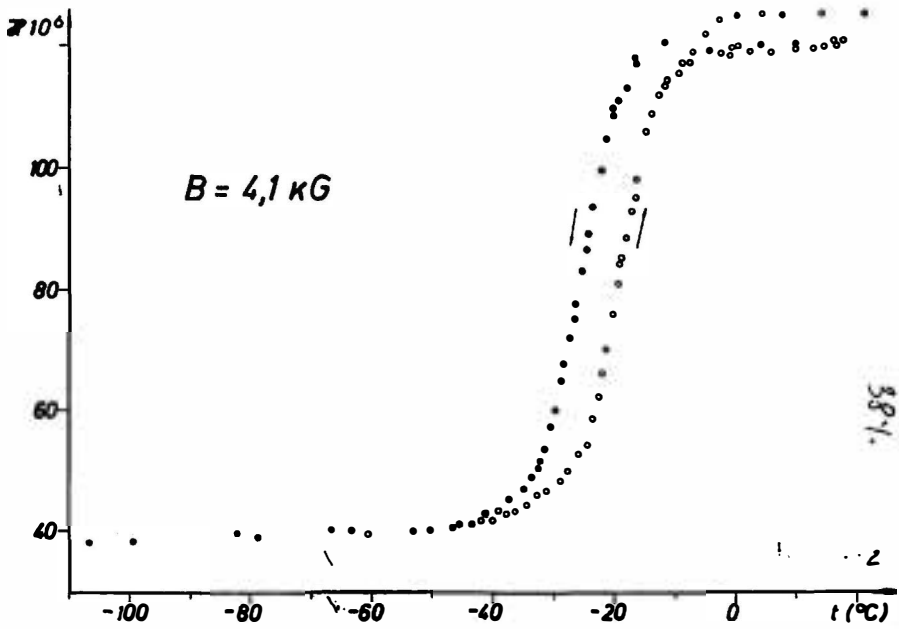


Fig. 1.

TMH AND THE MORIN TEMPERATURE

Definition of T_M is somewhat uncertain due to TMH. The Morin temperature can be determined from the position of the inflection point on curve $\mathcal{C}(T)$ in the range of phase transition, as for all diffuse phase transitions /8/. A difference in positions of the inflection points on heating and cooling curve equals this uncertainty. Figs. 1. and 2. present the following values for T_M :

Table 1. Morin temperature determined from the position of inflection point

field intensity	H	4,1 kG	H	= 7,1 kG
heating curve	T_M	254,8 K	T_M	254,8 K
cooling curve	T_M	248 K	T_M	250,5 K
difference	T	6,8°	T	4,3°
mean temperature	T_M	= 251,4 K	T_M	252,7 K.

Judging from the above mentioned data it follows that the values of T_M , determined on the basis of heating curves for 4,1 kG and 7,1 kG are equal within the limits of error, while T_M values determined on the basis of cooling curves shift toward higher temperatures when the field intensity increases. A opposite effect is observed in monocystals (e.g. /9/).

FINAL REMARKS

The values of T_M determined in these experiments are a little lower than those previously obtained in a similar experiment ($T_M = (257 \pm 0,5)$ K /6/). This can probably be explained by a difference in the purity of the samples investigated although the substances were obtained from the same producer in both cases.

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