ISSN 2409-9066. Sci. innov. 2015, 11(2): 31—34 doi: http://dx.doi.org/10.15407/scine11.02.031

Ponomarenko, O., Brik, A., Dudchenko, N., and Yushin, O.
Semenenko Institute of Geochemistry, Mineralogy and Ore Formation, the NAS of Ukraine, Kyiv

METHOD FOR TRANSFORMATION OF WEAK MAGNETIC MINERALS *(HEMATITE, GOETHITE)* INTO STRONG MAGNETIC MINERAL *(MAGNETITE)* TO IMPROVE THE EFFICIENCY OF TECHNOLOGIES FOR OXIDIZED IRON ORE BENEFICIATION

A new method for relatively simple transformation of the weak magnetic minerals (goethite (α-FeOOH) and hematite (α-Fe2O3)) into the strong magnetic mineral (magnetite (Fe3O4)) has been developed. The structure and magnetic characteristics of goethite and hematite have been showed to transform in the presence of starch at relatively low temperatures (in the range of 300–600 °C). The results obtained have opened up new opportunities for the development of effective technologies for oxidized iron ore beneficiation.

Keywords: magnetite, hematite, goethite, and structural transformation.

The present-day iron ore beneficiation techniques for the production of iron ore are very low-efficient if apply to highly oxidized iron ore. The ore components of oxidized ferruginous quartzites (*hematite-goethite*, *goethite*, and *red dirt*) are mainly dispersed nonmagnetic phases, hematite and iron hydroxides (*hydro-hematite, goethite*, and *limonite*) which practically cannot be beneficiated using traditional methods. These ores are piled, occupy large areas, and adversely affect the environment. Therefore, the development and introduction of new energy efficient techniques for beneficiation of such iron ores can significantly raise the profitability of the use of oxidized iron ores for producing iron ore concentrates and for addressing the environmental problems of the iron ore bearing regions.

The creation of new technological methods for oxidized ferruginous quartzite beneficiation is among the priority pressing problems. To address this problem, extensive researches have been being conducted throughout the world. Among the possible solutions, there is the development of new technologies for magnetization of nonmagnetic component of oxidized iron ores for the purpose of its further beneficiation by magnetic separation [1].

In this regard, a promising direction is the of study characteristics of structural transformation of iron oxides and oxy-hydroxides.

This research is aimed at studying the transformation of hematite and goethite into strong magnetic minerals under the influence of temperature, in the presence of starch.

MATERIALS AND RESEARCH METHODS

The main experiments were performed on two samples of materials: 1) rich hematite-containing ore and 2) synthetic goethite obtained using the method described in [2].

For studying the structural transformations and magnetic properties the original samples were

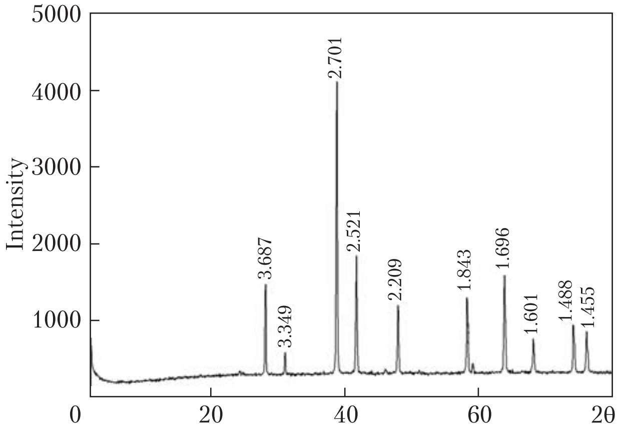

Fig.1. X-ray pattern of original hematite-containing ore sample

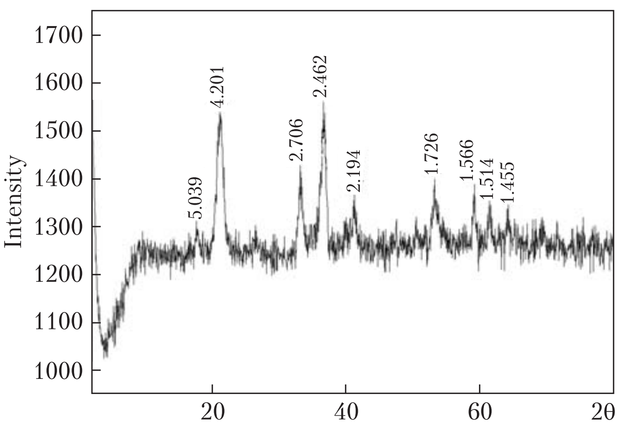

Fig. 2. X-ray pattern of original synthetic goethite sample

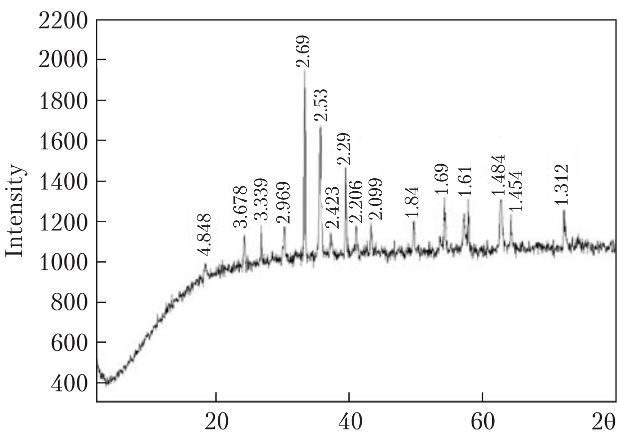

Fig. 3. X-ray pattern of hematite-containing ore after magnetization

thoroughly mixed with 3% starch and placed in quartz mini-reactor, then heated and cooled at a rate of about 60–70 °C per minute. The samples were heated up to a temperature of 650 °C.

The sample characteristics before and after magnetization have been studied using methods of magnetometry (a magnetometer with Hall sensors), X-ray diffraction (DRON-3M), and thermomagnetic analysis (a device for thermomagnetic research that enables automatic registration of sample magnetization depending on temperature).

RESULTS AND DISCUSSION

The analysis of X-ray diffractograms makes it possible to identify the phase composition of initial samples. The reflections in the diffraction pattern of the first sample (Fig. 1) indicate the presence of hematite and quartz traces in the sample. The corresponding values of d and indices of respective planes for hematite are as follows: 3.687 (012); 2.701 (104); 2.521 (110); 2.209 (113); 1.843 (024); 1.696 (116); 1.601 (122); 1.488 (214); and 1.455 (300) and for quartz: 3.349 (011).

The reflections in the diffraction pattern of the second sample (Fig. 2) correspond to pure goethite. The respective values of d and plane indices are as follows: 5.039 (020); 4.201 (110); 2.706 (130); 2.462 (111); 2.194 (140); 1.726 (221); 1.566 (231); 1.514 (151); and 1.455 (241). The widened diffraction peaks for sample 2 mean that synthetic goethite particles are finely dispersed.

The saturation magnetization of both initial samples is $M_s < 1\ A \cdot m^2/kg$.

Having been heated in the presence of starch to a temperature of 650 °C and cooled subsequently the original samples change their properties significantly. Their color changes from brown to black.

According to X-ray phase analysis (Fig. 3) it has been established that after transformation of hematite-containing ore sample, in addition to quartz (3.349 (011)) and hematite (3.678 (012); 2.69 (104); 2.29 (006); 2.206 (113); 1.84 (024); 1.484 (214); and 1.454 (300)) a new phase of magnetite appears (4.848 (111); 2.969 (220); 2.53 (311); 2.42

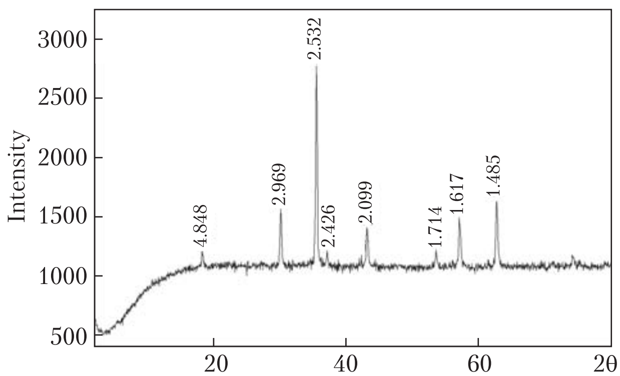

Fig. 4. X-ray pattern of synthetic goethite after magnetization

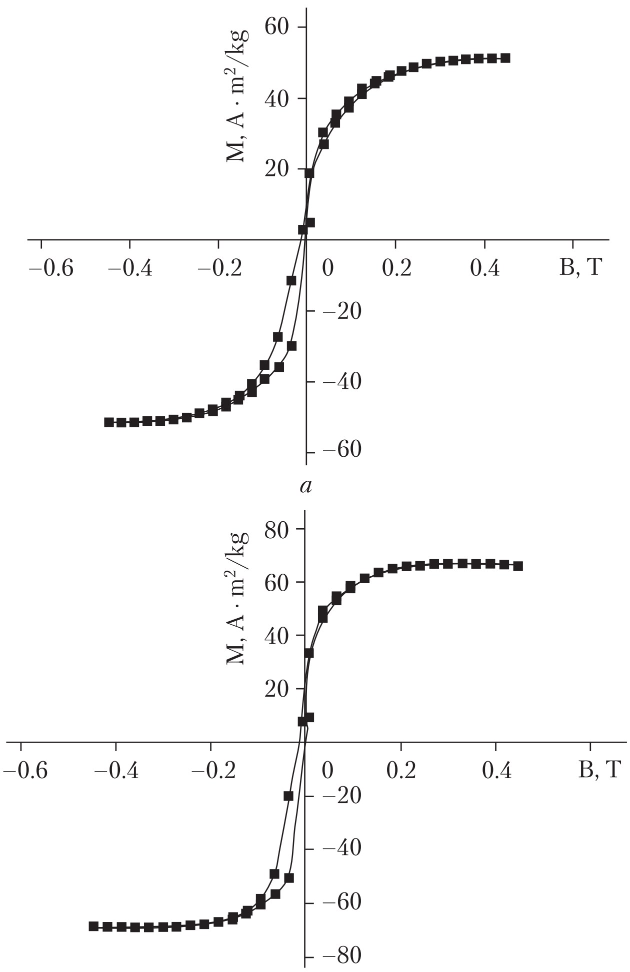

Fig. 5. The magnetization curves of magnetized hematite ore (*a*) and goethite (*b*). *M* is magnetization of the sample; *B* is magnetic field

(222); 2.099 (400); 1.69 (422)); and 1.61 (511)). After processing the synthetic goethite sample by the above described method, the goethite reflections disappear, with new reflections typical for magnetite coming out (4.848 (111); 2.969 (220); 2.532 (311); 2.426 (222); 2.099 (400); 1.714 (422); 1.617 (511); and 1.485 (440)) (Fig. 4).

Magnetization curves of transformed samples are showed in Fig. 5. The saturation magnetization of hematite-containing ore and synthetic goethite samples has been showed to reach 51 A × × m^2/kg (Fig. 5, *a*) and 68 A · m^2/kg (Fig. 5, *b*), respectively, after incubation with starch. One can see that having been heated in the presence of starch the samples transform from weak into strong magnetic materials. It is likely that the rate of increase in sample magnetization depends on the initial content of weak magnetic minerals.

CONCLUSIONS

1. A relatively simple and cost-effective way to transform the weak magnetic minerals (goethite, hematite) into the strong magnetic one (magnetite) has been developed.

2. The structure and magnetic properties of hematite ore and finely-dispersed goethite are transformed by heat treatment in the presence of bio-reducing agent (starch) within the range of temperature from 300 to 600 °C. Having been treated in this way the weak goethite and hematite phases have been showed to transform into the strong magnetic magnetite phase.

3. The new data on transformation of the structure and magnetic properties of weak magnetic oxides and hydroxides into strong magnetic oxides can be used for addressing problems related to processing of oxidized iron ores in Kryvyi Rih region and disposal of man-made iron ore deposits (waste dumps, tailing pits) and environmental problems caused by the contamination of the Kryvyi Rih region by superfine oxides and hydroxides of iron.

The research was implemented within the framework of R&D project of the NAS of Ukraine no.11, in 2013.

REFERENCES

1. Ponomarenko A.N., Bryk A.B., Dudchenko N.A., Yushyn A.A. Novye enerho- i materyalosberehaiuschye tekhnolohii sozdanyia zhelezorudnykh kontsentratov iz okyslennykh y dyspersnykh zheleznykh rud. *Materialy druhoi mizhnarodnoi naukovo-tekhnichnoi konferentsii «Heomekhanichni aspekty ta ekolohichni naslidky vidpratsiuvannia rudnykh pokladiv»*. Vydavnychyi tsentr Kryvorizkoho nats. un-tu, 2012, pp. 197-198 [in Ukrainian].
2. *Rukovodstvo po neorhanycheskomu syntezu*. M.: Myr, 1985, T.5, p. 1751 [in Russian].

О.М. Пономаренко, О.Б. Брик, Н.О. Дудченко, О.О. Юшин

Інститут геохімії, мінералогії та рудоутворення
ім. М.П. Семененка НАН України, Київ

СПОСІБ ПЕРЕТВОРЕННЯ СЛАБОМАГНІТНИХ МІНЕРАЛІВ (ГЕМАТИТ, ГЕТИТ) У СИЛЬНОМАГНІТНИЙ МІНЕРАЛ (МАГНЕТИТ) ДЛЯ ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ТЕХНОЛОГІЙ ЗБАГАЧЕННЯ ОКИСЛЕНИХ ЗАЛІЗНИХ РУД

Розроблено нову відносно просту методику перетворення слабомагнітних мінералів (гетит та гематит) в сильно-магнітний (магнетит). Показано, що перетворення структури та магнітних характеристик гетиту та гематиту реалізуються в присутності крохмалю за відносно низьких температур (в діапазоні 300—600 °С). Отримані результати надають нові можливості для розробки ефективних технологій збагачення окислених залізних руд.

Ключові слова: магнетит, гематит, гетит, перетворення структури.

А.Н. Пономаренко, А.Б. Брик, Н.А. Дудченко, А.А. Юшин

Институт геохимии, минералогии и рудообразования
им. М.П. Семененка НАН Украины, Киев

СПОСОБ ПРЕВРАЩЕНИЯ СЛАБОМАГНИТНЫХ МИНЕРАЛОВ (ГЕМАТИТ, ГЕТИТ) В СИЛЬНОМАГНИТНЫЙ МИНЕРАЛ (МАГНЕТИТ) ДЛЯ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ТЕХНОЛОГИЙ ОБОГАЩЕНИЯ ОКИСЛЕННЫХ ЖЕЛЕЗНЫХ РУД

Разработана новая относительно простая методика превращения слабомагнитных минералов (гетит и гематит) в сильномагнитный (магнетит). Показано, что превращения структуры и магнитных характеристик гетита и гематита реализуются в присутствии крахмала при относительно низких температурах (в диапазоне 300—600 °С).

Полученные результаты открывают новые возможности для разработки эффективных технологий обогащения окисленных железных руд.

Ключевые слова: магнетит, гематит, гетит, преобразования структуры.

Received 25.06.14