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STUDY OF PHYSICOCHEMICAL PROCESSES OCCURRING IN CHROME CONCENTRATE UNDER MICROWAVE RADIATION

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The mechanism of chromate ores destruction under microwave radiation is studied by optical polarizing microscope and X-ray method. The obtained results of optical studies have been analyzed by computer simulation. It is established that under microwave radiation occurring not only local heating and mechanical splitting of chromate concentrates but also structural and chemical transformations. As a result, products of destruction are enriched with the basic substance – chromite.

***Keywords*:** chromate ores destruction, chemical and phase transformations.

Introduction. Microwave radiation (MWR) is widely used in mining industry for sample preparation [1–10], while the mechanism of ore destruction under MWR has not been studied sufficiently. In the literature uneven heating of sample is particularly discussed, in consequence of this process mechanical destruction of ores occurs [11–13]. But under MWR chemical and phase transformations can also occur, about which there are not any explanations in literature. Elucidation of MWR influence mechanism on studied samples makes it possible to evaluate the nature of general process of sample preparation and MWR effective application. For this aim the processes occurring at ores destruction under MWR have been studied by optical polarizing microscope and X-ray method.

Experimental Part. The chemical composition of studied chrome concentrate is given in Tab. 1. The samples have been prepared in aqueous medium. The studies have been performed by using microwave oven SK10-Milestone, optical polarizing microscope MEL-5 and X-ray diffractometer DRON-2.

Table 1

Data of chemical and silicate analysis of chrome concentrate

Compounds	Cr_2O_3	Na_2O	K_2O	Al_2O_3	NiO	SiO_2	P_2O_5	CaO	MgO	Fe_2O_3	TiO_2	MnO	Losses**	S
Content, %	41.10	0.001	–	5.69	0.095	28.0	–	0.41	10.07	10.06	0.27	0.000*	4.46	0.15

* Trace quantities; ** losses due to firing + humidity.

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Results and Discussion.

Optical Studies. The data received by optical polarizing microscope (OPM) at different temperatures (Fig. 1) have been analyzed by computer simulation programs NOVA and LabVIEW. This makes possible to set direct analysis of histograms of sizes and perimeter of separate particles of the sample. The obtained histograms of sizes and perimeter of separate particles are presented in Fig. 2–4. The use of computer simulation also makes it possible to determine the number of combined particles. From the analysis of obtained histograms it follows that there are no significant differences between histograms of unheated and at 100º*C* heated samples. The difference is only in the number of combined particles, which decrease at 100º*C*. Significant different parameters have been obtained when sample was heated at 200º*C*: in that condition both the surface and the perimeter of particles increase and at the same time the number of combined particles increases.

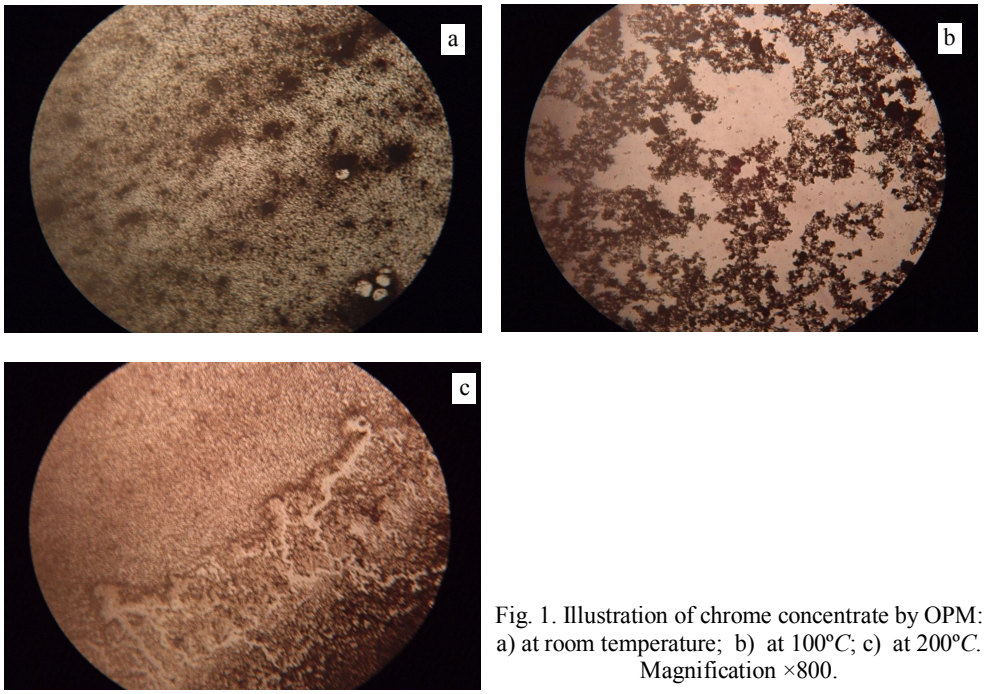

Fig. 1. Illustration of chrome concentrate by OPM: a) at room temperature; b) at 100º*C*; c) at 200º*C*. Magnification ×800.

It can be suggested from the obtained data that when the sample is heated at 200º*C*, mechanical separation of individual granules (grains) of sample occurs. This can be explained by local heating of some parts of the sample, and as a result high gradients of temperature both at the border of granules and in micro voids of samples are formed. This leads to the formation of mechanical tension, which causes mechanical separation of the sample.

The samples studies have been done both for chrome ores and for wastes. Optical method does not make it possible to understand only mechanical changes of samples have taken place under MWR but also structural and chemical changes have occurred. To explain of these aspects the method of X-ray analysis has been used.

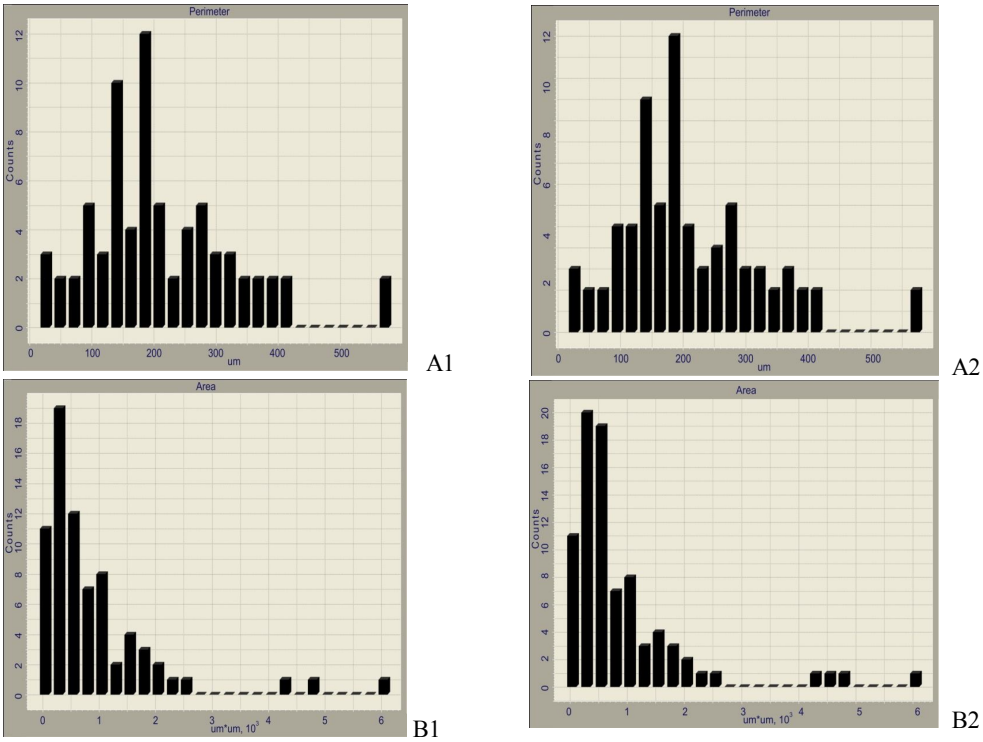

Fig. 2. Histogram of chrome concentrate at room temperature:
A) particles perimeter; B) particles surface – 1) separate particles; 2) combined particles.

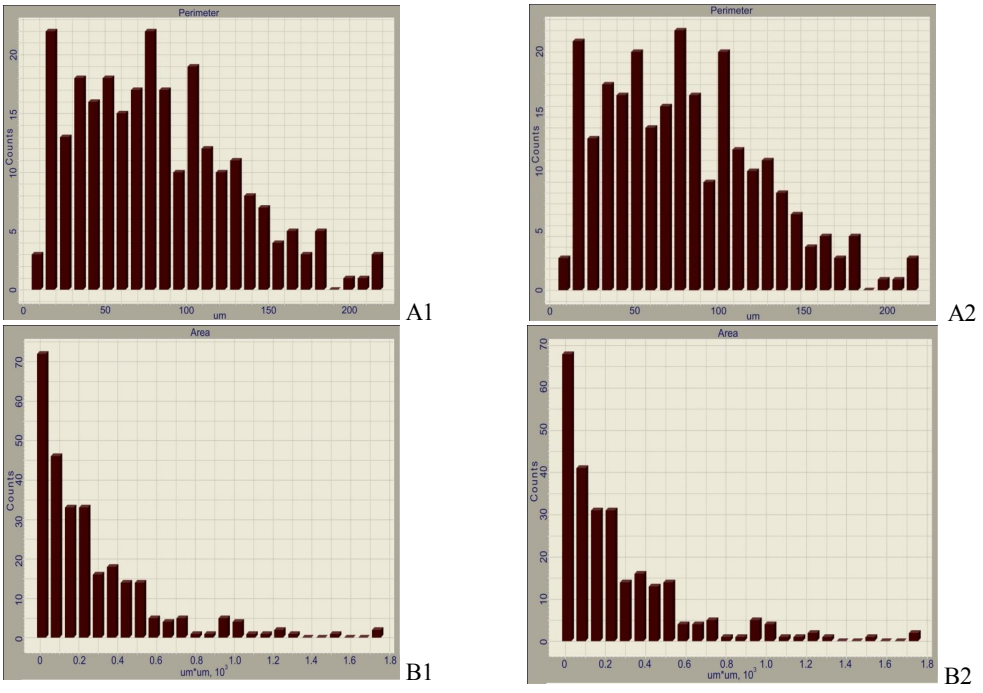

Fig. 3. Histogram of chrome concentrate at 100ºC:
A) particles perimeter; B) particles surface – 1) separate particles; 2) combined particles.

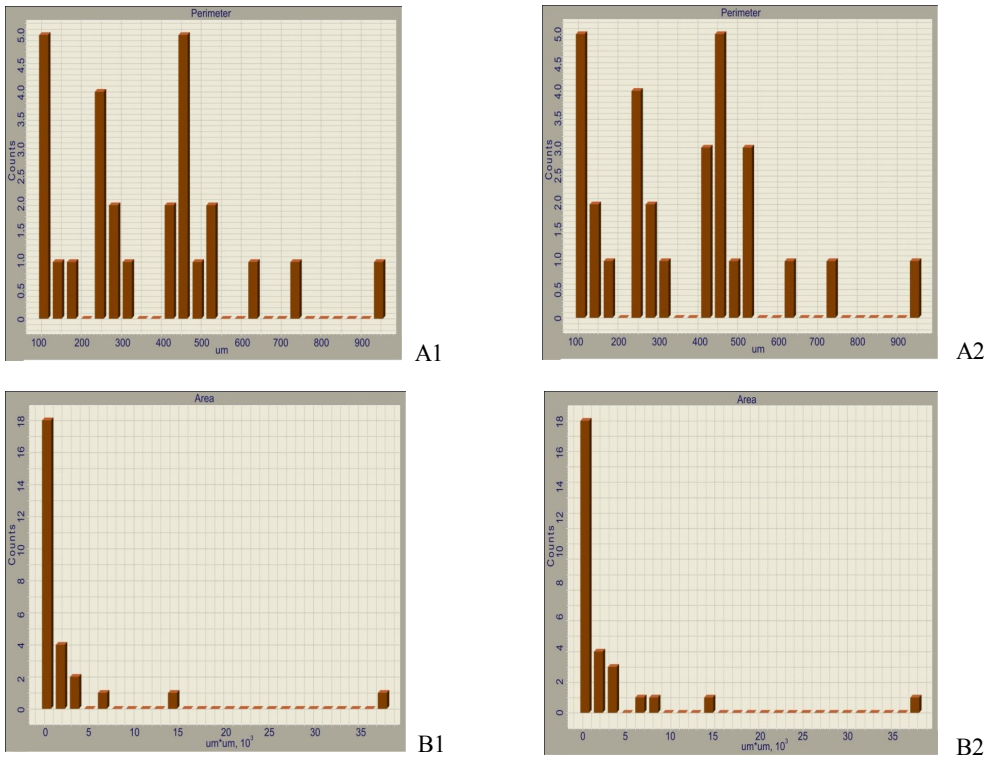

Fig. 4. Histogram of chrome concentrate at 200ºC:
A) particles perimeter; B) particles surface – 1) separate particles; 2) combined particles.

X-ray Analysis. The same samples, which have been studied by optical method, have been studied also by the method of X-ray analysis. From X-ray diagram (Fig. 5, a) the reflexes of different intensities can be seen: 2.52 Å is the period of complex of chrompicotit, antigorite and magnetite; 2.57 and 7.2 Å are periods of antigorite; 2.93 and 4.79 Å are periods of chrompicotit; 8.0 Å is period of chromite.

In Fig. 5, b the X-ray diagram of the same sample treated at 100ºC is presented, from which reflex of complex of chrompicotit, antigorite and magnetite turn to chrompicotit at 2.07 Å follows. The intensity of antigorite with 2.60 Å period increases, and at the same time 3.01 Å magnetite reflex forms, which is absent in Fig. 5,a the intensity of 4.79 Å chrompicotit increases, and the reflex peak with 8.0 Å period disappears.

From data comparison of Fig. 5, a,b it follows, that complex of chrompicotit, antigorite and magnetite decompose forms and the quantity of antigorite and chrompicotit increases.

In Fig. 5,c X-ray diagram of the studied sample treated in 200ºC is presented. From Fig. 5,c it is seen that the intensities of reflexes increase in comparison with intensities of reflexes in Fig. 5, a,b, which means that the quantity of complex of chrompicotit, antigorite and magnetite decreases. The chromite reflex with 4.63 Å period is clearly visible, which is the result of decomposition of chrompicotit.

Analysis of the obtained data makes it possible to confirm the occurrence of mechanical, structural and chemical separation, particularly formation of chromite from chrompicotit under MWR.

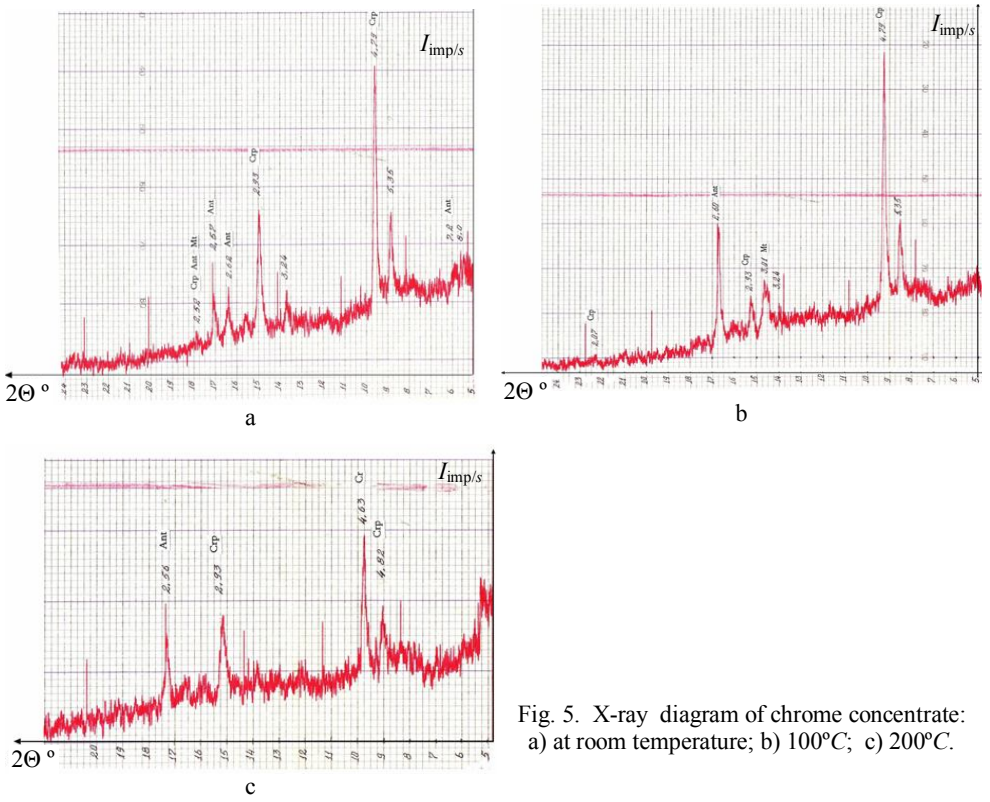

Fig. 5. X-ray diagram of chrome concentrate: a) at room temperature; b) 100°*C*; c) 200°*C*.

The X-ray data of chromite are compared with the data obtained from computer simulation and also with the database to make sure the reliability of the results. This comparison confirmed the obtained behaviors.

For the same aim the dielectric permittivity of samples has been studied using determined data of electrical capacity [13, 14]. The determined capacity for cylindrical sample is $c = 2\pi\varepsilon / \ln(a/b)$, where ε is average dielectric permittivity of the sample, a is the diameter of the sample, b is the length of the sample. The electrical capacity of samples was determined by using DM6013L technique and the obtained electrical capacity values at 100, 150 and 200°*C* are 24.1, 15.0 and 11.2 *nF* respectively. We choose samples with a/b=2.7 (ln2.7=1), therefore, $\varepsilon = c/2\pi$ and, so ε=3.8 at 100°*C*, ε=2.4 at 150°*C* and ε=1.9 at 200°*C* respectively. Thus, with heating sample ε decreases; this is the result of the number of hydrogen bonds decreasing and sample spelling, and it allows the decreasing of dipole moments direction.

The presented material helps to understand the mechanism and kinetics of destructive processes of difficult soluble chrome ores under MWR which were studied in [10, 15, 16].

Thus, it can be concluded that under MWR local heating and mechanical separation of chromate concentrate sample occurs, which promotes the chromate concentrate destruction and both structural and chemical transformations of minerals in the studied sample. As a result of the mentioned processes the products of the destruction are enriched with the basic substance – chromite. It must be noted that

the presented mechanism of MWR effect can be applied not only to chrome ores but also to other difficultly soluble ores.

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