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ASSESSMENTS OF THE SYLVINITE ORE DRESSABILITY AT THE STAROBIN POTASSIUM SALT DEPOSIT

Ocena możliwości wzbogacenia rudy sylwinitowej ze starobińskiego złoża soli potasowej

Natalia S. PETROVA[1], Ludmila V. BAKHMUTSKAYA[2] & Alesja M. ZHURAVSKAYA[2]

[1] Belarusian Research Geological Exploration Institute; Kuprevich str., 7, Minsk, Belarus; e-mail: petrova@geology.org.by
[2] JSC "Belgorkhimprom"; Masherov str., 17, Minsk, Belarus; e-mail: flotest@rambler.ru

Abstract: Determination of basic quality parameters of sylvinite ores qualifies them as economic mineral material only, but does not account for the properties necessary to be considered to classify their dressability. A saturation exploration of the Nezhin mining site involved for the first time a forecast and technological assessment of sylvinite ores in three minable potash horizons, which was made along with estimates of geological fields and was based on a comprehensive study of the mineralogical and technological features of ores in the rock massif and crushed samples.

Key word: potash deposits, sylvine ore dreassability, Nezhin mine, Belarus

Treść: Określenie podstawowych parametrów jakościowych złóż sylwinitu umożliwia ustalenie ich użyteczności ekonomicznej, lecz nie pozwala ocenić własności niezbędnych do oceny możliwości wzbogacenia rudy. Badania geologiczne prowadzone w kopalni Nezhin umożliwiły po raz pierwszy prognozowanie i techniczne oszacowanie mineralizacji sylwinitowej w trzech eksploatowanych horyzontach potasonośnych dzięki zastosowaniu kompleksowej analizy cech mineralogicznych i technologicznych mineralizacji w litych i pokruszonych próbkach ze złoża. Przemysłowe złoża potasowe kopalni Nezhin zawierają kopalinę o wysokiej zawartości sylwinu, ich główne ciało rudne zakwalifikowano jako obiekt o średniej możliwości wzbogacenia. Jako sylwinitowe serie eksploatacyjne wyodrębnia się warstwy kopaliny reprezentujące jeden typ technologiczny kopaliny. Mineralizacja potasowa wykazuje nieznaczne różnice w eksploatowanych warstwach II poziomu, jest obfita w warstwach sylwinitowych nr 2, 3 i 4 III poziomu oraz w warstwach I poziomu potasonośnego. Udział we frakcji rudy powyżej 0.5 mm sięga ponad 70%. Właściwości technologiczne sylwinitowej rudy z głównych poziomów eksploatacyjnych kopalni Nezhin wskazują, że instalacja wzbogacająca rudę do wymaganego poziomu przemysłowego może być użyteczna dla rudy pokruszonej do frakcji 3.15 mm.

Słowa kluczowe: złoża soli potasowej, wzbogacanie rudy sylwinowej, kopalnia Nezhin, Białoruś

The development of salt deposits in the Pripyat potassium-bearing basin depends in many respects on the accepted standards of the mineral raw material quality assessment, those of mineral and petrographic studies and technological investigations included.

Sites prepared for mining (such as Krasnaya Sloboda, Nezhin, Darasin, Smolov ones, etc. (Fig. 1) at the Starobin, Petrikov and Oktiabr deposits need a technological evaluation to be made in the light of the new metallurgical and technical approaches. Ores mined at the deposit flanks in the marginal parts of potassium-bearing horizons of the Starobin deposit are often described by the changed structure of productive beds; therefore concentrating mills operate at present under process charts modified against those designed along conventional lines.

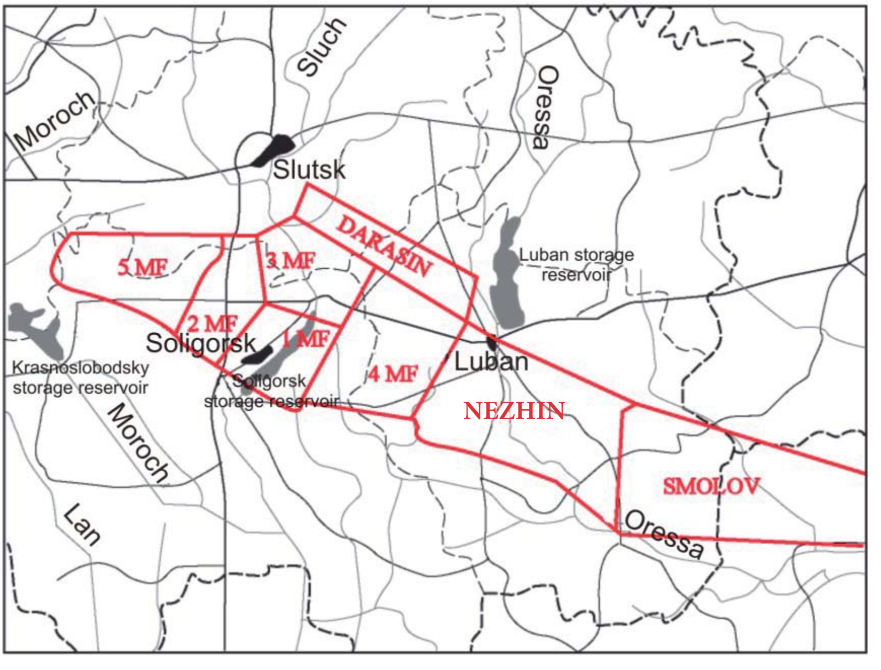

Fig. 1. Sketch map of the location of mining sites of the Starobin potassium salt deposit. MF – mining fields

Fig. 1. Mapa lokalizacji terenów górniczych na obszarze starobińskiego złoża soli potasowych. MF – pole górnicze

An efficient control over the ore concentration procedure decreasing the useful component extraction from ores of inferior quality depends in many respects on an algorithm developed for the forecast technological evaluation of ore, i.e. methods used for investigations of the ore structural and material composition, determination of the sylvinite opening both in a rock massif, and in the ore processing products at every stage of ore development, especially at the floatation supply.

Table (Tabela) 1

KCl and insoluble residue (IR) distribution in different density fractions of ore of size 3.15 + 0.25 mm from the third potash horizon of the Nezhin mining site

Zawartość KCl i IR we frakcjach mineralnych o różnej gęstości dla kopaliny o frakcji 3.15 + 0.25 mm pochodzącej z trzeciego horyzontu potasonośnego w kopalni Nezhin

Ore fraction density [kg/m^3]	Yields from particular ore fractions					Summed yields from “plus”					Summed yields from “minus”				
	Yield [%]	Proportion [%]		Extraction [%]		Yield [%]	Proportion [%]		Extraction [%]		Yield [%]	Proportion [%]		Extraction [%]	
		KCl	IR	KCl	IR		KCl	IR	KCl	IR		KCl	IR	KCl	IR
< 2000	19.31	96.67	0.10	56.98	0.43	19.31	96.67	0.10	56.98	0.43	82.64	34.42	0.42	86.84	7.40
2000–2030	5.13	80.31	0.30	12.59	0.32	24.45	93.24	0.14	69.57	0.76	63.33	15.43	0.52	29.86	6.97
2030–2050	2.20	63.85	0.50	4.29	0.23	26.64	90.82	0.17	73.85	0.99	58.19	9.71	0.53	17.27	6.64
2050–2100	5.19	45.40	0.52	7,21	0.57	31.83	83.41	0.23	81.06	1.55	56.00	7.59	0.54	12.99	6.41
2100–2150	16.87	9.08	0.44	4.68	1.62	48.70	57.67	0.30	85.74	3.17	50.81	3.73	0.54	5.78	5.84
2150–2200	33.63	1.01	0.35	1.04	2.56	82.33	34.52	0.32	86.78	5.74	33.94	1.06	0.59	1.11	4.23
> 2200	0.31	6.52	25.73	0.06	1.66	82.64	34.42	0.42	86.84	7.40	0.31	6.52	25.73	0.06	1.66
Total for particle size +0.25 mm	82.64	34.42	0.42	86.84	7.40										
Total for particle size –0.25 mm	17.36	24.69	22.96	13.16	92.60										
Initial ore	100.00	32.57	4.30	100.00	100.00										

Table (Tabela) 2

KCl and insoluble residue (IR) distribution in minerals and products separated by fractionation of ore of size 3.15 + 0.25 mm from the third potash horizon of the Nezhin mining site in heavy liquids at different ore crushing size

Zawartość KCl i IR w minerałach i produktach frakcjonalnej separacji w cieczach ciężkich kopaliny o frakcji 3.15 + 0.25 mm, pochodzącej z trzeciego horyzontu potasonośnego w kopalni Nezhin

Yield from ore [%]	Proportion [%]		Extraction [%]		Yield from ore [%]	Proportion [%]		Extraction [%]		Yield from ore [%]	Proportion [%]		Extraction [%]		Yield from ore [%]	Proportion [%]		Extraction [%]	
	KC1	IR	KC1	IR		KC1	IR	KC1	IR		KC1	IR	KC1	IR		KC1	IR	KC1	IR.
In minerals																			
Sylvine < 2000 kg/m^3					Intergrowths 2000–2150 kg/m^3					Halite 2150–2200 kg/m^3					Halopelite IR > 2200 kg/m^3				
19.31	96.67	0.10	56.98	0.43	29.39	27.70	0.77	28.77	2.74	33.63	1.01	0.35	1.04	2.56	0.31	6.52	25.73	0.06	1.66
In products																			
Concentrate fraction < 2000 kg/m^3					Intermediate fraction 2000–2150 kg/m^3					Waste fraction >2150 kg/m^3					Size –0.25 mm				
19.31	96.67	0.10	56.98	0.43	29.39	27.70	0.77	28.77	2.74	33.94	1.06	0.59	1.11	4.23	17.36	24.69	22.96	13.16	92.60

The most important indications of the sylvinite ores dressability are their chemical and mineralogical composition, the main structural and morphological features of salt minerals, textural and structural characteristics of salt rocks, grain size distribution of free sylvine in the rocks and in the process of ore preparation; size of sylvine inclusions in mineral intergrowths with halite and halopelite material in crushed and grinded ore; general mass fraction, as well as chemical-mineralogical and aggregate composition of the insoluble residue; the degree of the ore mineralogical composition variability in the mining area. When the rock is transformed into the ore, the natural grain size range is changed even in the process of ore productive development.

Some portion of the mined mineral component is extracted as sylvine and halite mineral associations (poor and rich, double and triple mineral interpenetrations, contact intergrowths).

Sylvinites of the main commercial beds of the Starobin deposit are represented by assorted granular or assorted crystalline (in the case idiomorphic grains) minerals. Sylvine and halite differ in the degree of idiomorphism: sylvine grains are xenomorphic almost without exception, those of halite are distinctly idiomorphic. Sylvinites from the Starobin deposit are mainly red in colour, though light-coloured (pale-orange, whity-pink, milky-white, or colourless) varieties occur sometimes; these are mainly fine or microcrystalline in texture.

Sylvinite layers are distinguished by bedded macrostructure and homogenous, banded, or disordered microstructures. Banded microstructures show a fine- to medium-granular lower band and fine-granular (aligned with the bedding plane) upper band. The size of sylvine grains decreases as the amount of banded sylvinites increases. The upper bounds increase in thickness with increasing the clay content of the layer. The upper boundaries of sylvinite interlayers are even and clear, slightly "powdered" with anhydrite-carbonate-clayey material, the lower boundaries are uneven and sinuous. Such interlayers are similar to those of potassium deposits in the Upper Rhine graben.

The study of crystal intergrowth coefficients in sections and of the composition of contact intergrowths in crushed samples has shown that differences in the structural and textural features of sylvinite interlayers can change the yield of free (open) sylvine grains even with the similar granulometric composition of natural sylvine. The crustal intergrowth coefficients determined in thin sections classify the ore as moderately interpenetrated that is the opening of 75% might be reached. A degree of sylvine opening in crushed samples of some sizes was determined by the mineralogical analysis and as an average value (integral opening degree) of unevenly grained broken rock.

To identify better the mineralogical composition and to make a forecast evaluation of ore dressing products the fractional analysis in heavy liquids with calibrated density values was made (Tabs 1, 2). The particle-size fractionation of sylvinite ore together with the density fractionation enabled the operation with quantitative ratios of particle mineral types. The sylvine fraction which density is less than 2000 kg/m^3, or less than 2030 kg/m^3 (depending on the ore processing technique) is considered to be economic ore concentrate at the KCl proportion of at least 95%. The free sylvine and halite grains density variations depend on the gas-liquid minor inclusions and minor interpenetrations. A fraction floating at a liquid density of 2000–2150 kg/m^3, or 2030–2150 kg/m^3 (according to which ore fraction was considered to be economic) is represented by sylvine contact intergrowths with the other minerals (with KCl mass value decreasing) and is considered to be commercial (intermediate product fraction). A fraction floating at a liquid density of 2200 kg/m^3 is considered to be halitic. A fraction sinking at a liquid density of 2200 kg/m^3 is halopelitic (Fig. 2). The halitic and halopelitic fractions compose the waste rock.

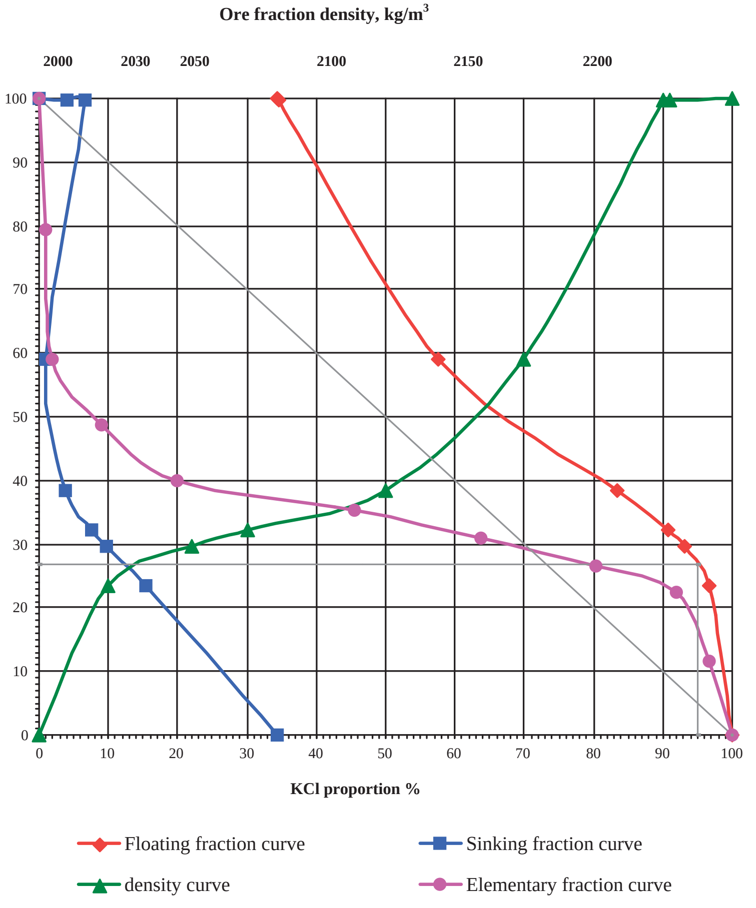

Fig. 2. Curves showing the dressability of ore of size 3.15 + 0.25 mm at the from the third potash horizon of the Nezhin mining site of the Starobin potassium salt deposit. Remark: yield of ore concentrate with KCl proportion of 95% (from ore of size +0.25 mm) is 26.7%; yield of ore concentrate with KCl proportion of 95% (from ore) is 22.06%

Fig. 2. Wykresy wzbogacenia kopaliny w przedziale frakcji 3.15 + 0.25 mm pochodzącej z trzeciego horyzontu potasonośnego w kopalni Nezhin na złożu starobińskim. Objaśnienia: czerwona krzywa – frakcja flotacyjna/zawiesinowa, niebieska krzywa – frakcja opadająca, zielona krzywa – krzywa gęstości cieczy ciężkich, fioletowa krzywa – krzywa frakcji podstawowej. Uwaga: uzysk dla koncentratu rudy o zawartości KCl 95% (dla frakcji rudy +0.25 mm) wynosi 26.7%, zaś dla całej rudy – 22.06%

The ore dressability assessment involves the study of the aggregate and chemical--mineralogical composition of halopelites, mainly, those forming a water insoluble ore residue. Halopelites are finely dispersed, silty, with particles less than 0.01 mm in size being dominate. Their aluminosilicate component is characterized by silty-pelitic composition. The microaggregate composition shows variations both in section, and over an area covered by potassium deposits.

Carbonate crystals and clayey-carbonate aggregates were identified in large classes. A fraction less than 0.001 mm is usually represented by illite with a high tetrahedral charge (Al^{1V} – 0.52) and considerable Mg amounts (Mg^{VI} – 0.80–0.95). Quartz and potassium feldspar are accumulated in the lighter part of the larger fractions (>0.01 mm). Feldspar is often dominant in halopelites of potassium horizons of the Starobin deposit. A relationship revealed between the halopelite composition and structural-textural properties of sylvinites is well logical, as the composition of all the halopelite complexes influences both the salt mineral crystallization, and the secondary processes pattern.

The potassium chloride is dominant in the chloride complex of halopelites from potash deposit. The $CaCl_2/MgCl_2$ ratio is normally more than 1. The indicator ratios of permanent components such as $CaSO_4/\Sigma$ (carbonates + aluminosilicate material) and Σ carbonates/aluminosilicate material are always less than 1. The only $CaSO_4/\Sigma$ carbonates ratio shows considerable variations over an area.

Commercial potash deposits of the Nezhin mining site include high-grade sylvinite ores, their main body being qualified as the medium dressability ore. The productive sylvinite beds were determined to be formed by one technological ore type. Ores show insignificant distinctions, are as-mined in beds of IInd horizon and rich in 2nd, 3rd, and 4th sylvinite beds of IIIrd horizon as well as in productive beds of Ist potash horizon The integral degree of sylvine opening within fractions larger than 0.5 mm is generally as high as 70% and more.

Technological features of sylvinite ore from major minable horizons of the Nezhin mining site suggest that with processing equipment available for the required commercial grades could be recovered from the ore crushed to a size of 3.15 mm.