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GOLD IN POTASH ORES OF THE STAROBIN DEPOSIT

Preliminary investigations were conducted to evaluate gold content in the potash ores of the Starobin deposit in Belarus. The composition of potash ores is: KCl (22–27%); NaCl (63–74%) and insoluble residue (ir), (4–10%). Reserves of salt ores in Belarus are approximately equal to a few billion tons. Samples of ores and various products including undersize of arch screens, over- and underflow of hydrocyclones, mill discharges, concentrates and tailings of flotation, and products from a slime pond of three flotation plants were analyzed. Also samples from a hallurgic (saline) plant processing including raw ore, pile tailings, product from a slime pond, and residua of thickeners were examined. The samples were screened with a 2 or 0.8 mm sieve and processed using a Knelson-7.5 centrifugal concentrator and hand pans. The light and heavy fractions were separated in bromoform. Free gold in the heavy fraction was analyzed with a microscope. The size of gold particles was determined and the microprobe analysis was carried out. The gold content was determined in all products of the processing of the potash ores and their salt solutions by means of the fire assay and combined fire assay-emission analysis. It was shown that the free gold particles size is from 25 to 250 microns and the shape of the particles is plate-like. The fineness of gold was very high and silver, copper and palladium represented the main admixtures. These complex investigations permitted to detect gold in potash ores. Its concentration was considerably higher than the content of gold in the Earth's crust (clarke) and directly depended on the volume of insoluble residue in ores. Similarly to gold, increased concentration of silver were detected in the ores.

INTRODUCTION

Prospecting of mineral deposits containing precious metals represents an important task for Belarus. During estimation of the mineralogical potential of Belarus, specialists of the BelGEO (Belarus State Geological Company) company found mineralogical indicators of gold presence in potash ores in the Starobin deposit. In this paper results of mineralogical, technological, and analytical investigations of gold present in the potash ores and products of their processing are described.

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MATERIAL AND METHODS

Flotation and hallurgy are used to process potash ores of the Starobin deposit. Hallurgy is a processing method based on different solubility of potassium chlorine (KCl) and sodium chlorine (NaCl) with temperature. The flotation process consists of crushing, preliminary classification, grinding, several steps of slime removal, flotation, dehydration, drying, while hallurgy process includes crushing, dissolving, slime removal, clarifying, vacuum crystallisation, and drying of a concentrate. The raw potash ores and all main products of their processing such as undersize of arch screen of preliminary and control classification, mill discharge, over- and underflows of a hydrocyclone, concentrate and tailings of the flotation, slime thickener discharge, as well as the material taken from a slime pond, were investigated. The first stage of investigation was extraction of free gold and determination of its content by the gravity separation of all processing products listed above. Forty one samples were selected with a volume ranging from 20 to 400 dm^3. They were classified by means of 10, 2 or 0.8 mm screens in the water medium with partially dissolved material.

A laboratory centrifugal concentrator (Knelson-7.5) and pan gravity trap manufactured by Knelson (Canada) were used for quantitative determination of free gold. Concentrates produced by 157 runs were separated into light and heavy fractions in bromoform. Then, the samples of heavy fractions were investigated by quantitative mineralogical analysis under a microscope to determine the presence of free gold particles. A second step of investigations included a quantitative determination of gold in 104 samples of raw ores and products of their processing using th fire assay method and combined fire assay-emission analyses.

DISCUSSION

Table 1 shows that free gold was recovered practically from all samples taken from potash ores and the products of their processing. Its highest concentration was found at the flotation plants in the raw ore, hydrocyclone overflow and underflow, product from the slime pond, and hydroseparator discharge. In the samples taken from the hallurgic plant a great number of gold particles was recover from the raw ore, product from the slime pond, salt slime, and dissolver residuum.

The size of recovered gold particles was from 25 to 250 micrometer. If we divide particles into three sizes (in micrometer): very small (100–250), fine (50–100), and dust-like (10–50), then we can say that fine gold occurred most frequently. The gold particles were in the form of plate, wire, fibre, and wad-shaped flattened crystals. They were yellow, light-yellow, and brown-yellowish in color. Thin layers and spots of hydrous ferric oxides and carbonate rims were visible on the surface of gold particles. The gold particles were not in the form of nodules because their nodule form was poorly developed. Gold particles with glossy surface were seldom encountered. To check the chemical composition of individual particles of gold, selected grains were subjected to a microprobe analysis and the results are given in Table 2.

The results of analysis, shown is the Table 2, confirm the presence of free gold in the processing products of all plants and show that gold is very pure because its fineness is very high. Silver, copper and palladium apparently form intermetallic compounds with gold while other elements probably come from impurities on gold surface and reflect, to some extent, the surrounding rocks composition. According to the results of investigations, liberated gold in the samples is present mainly as fine (dust) particles which are flattened or plate-like. This is probably the reason why gold is difficult to recover by traditional methods and therefore it requires special equipment and beneficiation methods.

Table 1. Results of mineralogical analysis of gold in potash ores and products of their processing

Hallurgy

No.	Product name	Number of gold particles in the sample		
		Flotation		
		min.	max.	
1	Raw ore	70	517	460
2	Mill discharge	120	138	–
3	Hydrocyclone overflows	200	640	–
4	Hydrocyclone underflows	18	458	–
5	Undersize of arch screens	26	319	–
6	Flotation concentrate	50	250	–
7	Waste pile tailings	45	94	10
8	Hydroseparator discharge	450	538	–
9	Slime thickener discharge	125	433	320
10	Product from a slime pit	253	524	800
11	Dissolver residuum	–	–	675
12	Salt slime	–	–	588

Table 2. Composition of free gold according to the microprobe analysis data

Number of determinations	Standard of fineness (‰)	Content of chemical elements, %								
		Au	Ag	Cu	Pd	Fe	Ti	Mg	Al	Ca
16	973.4	97.2	3.28	0.088	0.066	0.03	0.049	0.048	0.036	0.034

The results of the fire assay and combined fire assay-emission analyses show that gold was present practically in all processing products of potash ores (Table 3). Its content in ores follows the logarithmic-normal law of the distribution with the average value of 0.08 ppm and mean error equal to ±0.023 ppm. The gold content in the processing products is approximately at the same level, which indicates an absence of the metal concentration at the individual stages of the potash ores beneficiation.

Table 3. Average gold content in potash ores and processing products at different stages of the Belaruskalii Industrial Company

No.	Product name	Number of analysis	Average content (the numerator), the contents interval (the denominator), ppm
1	Raw ore	18	0.08/(0.02–0.0340)
2	Products of the ore classification		
	including:	15	0.052/(0,02–0.14)
	undersize of arch screens	10	0.056/(0.02–0.14)
	mill discharges	5	0.044/(0.02–0.06)
3	Products of desliming including:	25	0.068/(0.02–0.22)
	underflow of hydrocyclone	9	0.065/(0.03–0.14)
	overflow of hydrocyclone	5	0.052/(0.04–0.08)
	discharge of hydroseparators	3	0.12/(0.02–0.22)
	overflow of hydroseparators	2	0.03/(0.02–0.04)
	discharge of slime thickener	6	0.77/(0.020–0.2)
4	Products from a slime pond	6	0.083/(0.04–0.14)

According to the data of different authors (Zvereva,1997; Nekrasov,1991) the clarke and average gold contents in sedimentary rocks range from 0.001 to 0.057 ppm and in halogen compounds from 0.00162 to 0.024 ppm. Investigations of gold content in the potash ores of the Verkhnekamskoye deposit, carried out by specialists of the „Giredmet" Institute (Moscow, Russia) showed that the mean gold content is in the range from 0.062 to 0.105 ppm. A comparison of received average content of gold with the values given above shows that the gold content in potash ores of the Starobin deposit (Belarus) exceeds the gold clarke and is comparable with the gold content in the Verkhnekamskoye deposit in Russia. A comparison of the average gold contents and the insoluble residue (ir) in ores of four Starobin enterprises permitted to reveal a direct correlation between them (Fig. 1). Namely, the gold concentration in ores increases with the increase of ir. Taking into account the accumulation of the main mass of the insoluble residue (up to 65%) in slimes and the data mentioned above, it can be concluded that a considerable part of the liberated gold enters the slime pit.

An increased content of silver and the presence of platinum and palladium were also detected by the combined fire assay-emission analysis. It considerably increases perspective of recovery of gold and other precious metals from the potash ore of the

Starobin deposit. According to the data of Smetannikov and Kudryashov (1995), the Verkhnekamskoye deposit also contains increased concentrations of silver and metals of the platinum group.

Technological investigations on potash ores of the Verkhnekamskoye and Starobin deposits, carried out by Matyushev and Zubinin („Giredmet", Moscow, 1997) confirmed the existence of non-liberated form of gold. Results of experiments with saline solutions showed that gold is present in the potash ores in Belarus, and that gold easily passes into aqueous solutions from evaporation residues.

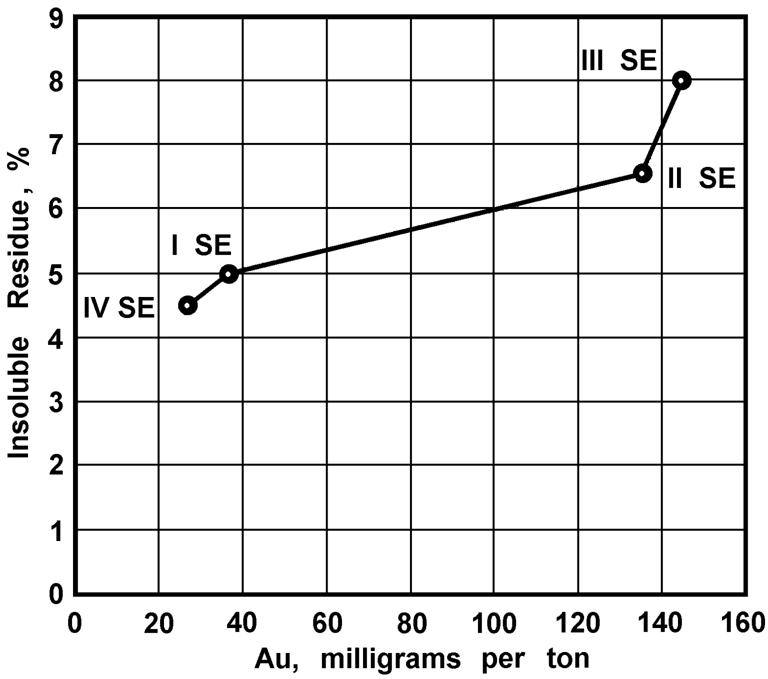

Fig. 1. Relationship between insoluble residue and gold content for potash ore of the Soligorsk Enterprises (I–IV SE), Belarus

Approximate calculations of the metal balance indicate that the content of other forms of gold considerably prevails over the content of the gold which can be processed by gravity separation. Situation with silver is similar. The concentration of silver in the evaporated residues reaches a few grams per ton.

CONCLUSIONS

The investigation of the potash ores of Belarus and products of their processing showed that the gold and silver are present there in increased quantities. The results point to a new non-traditional source of precious metals in the Pripyat Salt Basin. However, the presence of the precious metals as fine particle requires a development of special technological schemes for the estimates of the commercial value of gold- and silver-bearing content of the potash ores of Belarus.

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Głównymi składnikami surowca solnego ze złoża Starobin na Białorusi są KCl (22–27%), NaCl (63–74%) oraz składniki nierozpuszczalne (4–10%). Zasoby tego typu złóż na Białorusi oceniane są na kilka mld Mg soli. W pracy przebadano szereg produktów zakładu wzbogacania rudy solnej, takich jak: produkt podsitowy sita łukowego, przelew i wylew hydrocyklonu, wylew młyna, koncentrat i odpad flotacji oraz osady ze stawu osadowego, w którym deponowane są muły z trzech zakładów flotacyjnych. Przebadano także próbki produktów z zakładu warzelniczego: nadawę (sól surową), odpady ze składowiska, muły z osadnika i wylew zgęszczacza. Próbki do badań przesiewano przez sita o oczkach 2.0
i 0.8 mm i poddawano wzbogacaniu na wzbogacalniku odśrodkowym Knelson-7.5 oraz na ręcznej misce do płukania złota. Otrzymane frakcje lekkie i ciężkie rozdzielano w bromoformie. W wydzielonych frakcjach minerałów ciężkich oznaczano ziarna złota metodą mikroskopowo. Ich skład chemiczny określano przy pomocy mikrosondy. Ponadto we wszystkich produktach przeróbki rudy potasowej a także w ich roztworach solnych określano zawartość złota metodą kupelacyjną oraz kombinacją metody kupelacyjnej i spektrometrii emisyjnej. Stwierdzono, że wolne ziarna złota występują w postaci płaskich łuseczek o rozmiarach 25–250 μm. Ziarna złota były wysokiej czystości choć stwierdzano w nich domieszki srebra, miedzi i palladu. Przeprowadzone badania pozwoliły oszacować zawartość złota w złożu soli potasowej. Jest ona znacząco wyższa od przeciętnego rozproszenia tego metalu w skorupie ziemskiej i ściśle zależy od zawartości nierozpuszczalnych składników w surowcu solnym. Stwierdzono także podwyższoną zawartość srebra w badanym surowcu.