FEATURES OF INTERACTION BETWEEN POTASSIUM SALTS MINING AND THE ENVIRONMENT

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ABSTRACT. Unlike the vast majority of minerals, the gangue in all types of halurgic raw materials is represented by a water-soluble material - rock salt, contaminated clay and other impurities insoluble in water. Thus, the storage of water-soluble waste from the enrichment of ground-based sylvinite enrichment plants out in the open air, in addition to the disfigurement of natural landscapes, is accompanied by the dissolution of waste congestions due to atmospheric precipitation, with the formation of gigantic volumes of excess brines, causing soil salinisation and contamination of drinking water sources. This paper proposes prevention of the harmful impact of the potassium salts industry on the environment, achieved by enriching the initial water-soluble raw materials in underground conditions based on new environmentally friendly technologies using fire- and explosion-proof non-aqueous heavy liquids with a given set of physical and physiologically inert properties with a full cycle of their energy-efficient regeneration.

Key words: mining of potash salts; underground processing minerals without harming to environment

Introduction

The Earth's population is growing steadily (Figure 1). According to UN projections, by 2050, more than 9.8 billion people will live on our planet which is an increase by 1.8 billion (United Nations, 2024).

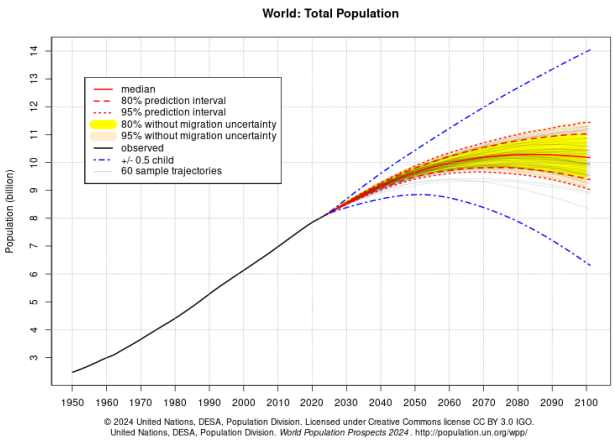


Fig. 1. Total world population grow
(https://population.un.org/wpp/graphs)

The growing global population requires, first and foremost, increased food production. Meanwhile, there is almost no additional available arable land suitable for agriculture in countries with suitable climate. Therefore, increasing crop yields is becoming the primary resource for increasing agricultural production. However, intensifying agricultural production is impossible without the use of mineral fertilizers, including potash.

Most countries in the world lack their own potash reserves, while 25.9% (almost 2 billion people) of the world's population already experience food shortages (United Nations, 2025). Potash fertilizers, along with phosphorus and nitrogen fertilizers, significantly increase the yields of major agricultural crops, leading to enlarged demand for potash products. However, the uneven distribution of potash deposits worldwide means that of the world's total potash fertilizer production 77% (for 2025) is accounted for by just four countries: Canada, Russia, China and Belarus – Figure 2 (Jasinski, 2026).

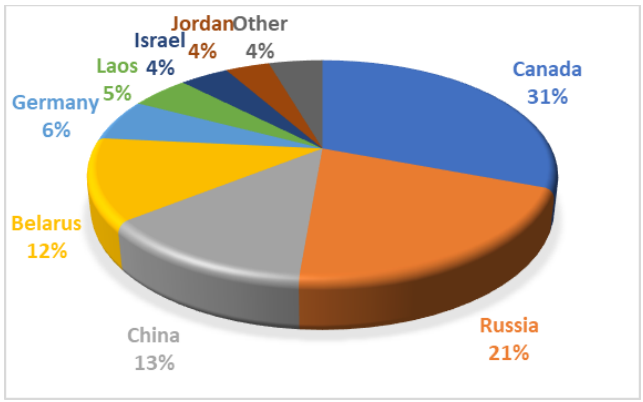


Fig. 2. Major world potash producers in 2025

Unlike most minerals, the waste rock in potash ores is primarily rock salt contaminated with clay impurities. For every ton of potassium salt obtained as a finished product, there are 3...4 tons of rock salt and 0.2...0.5 tons of clay-salt sludge stored on the surface in the form of waste heaps and sludge - Figure 3 (Ushakova et al., 2023).



Fig. 3. "Potash ore processing waste disposal facilities on the Verkhnekamskoe deposit's territory:
(a) potash tailings pile; (b) potash tailing slurry" (Ushakova et al., 2023)

As a result, open-air storage of water-soluble waste from potash ore processing not only consumes vast areas of arable land but also leads to the accumulation of excess brines, which

form as a result of atmospheric precipitation. Halite dumps and clay-salt sludge storage facilities are underlain by polyethylene waterproofing, which is susceptible to chemical destruction, leading to seepage of saltwater into underground horizons (Latipov et al., 2023).

Such anthropogenic processes lead not only to soil salinisation and loss of fertility, but also to the irreversible mineralisation of local drinking water sources.

The accumulation of water-soluble waste as a result of the enrichment of potassium salts is reaching alarming proportions in all major potash-producing countries. Suffice it to say that in the south of Belarus alone, in four waste dumps belonging to the Belaruskali mining company, approximately one billion tons of rock salt, contaminated with clay impurities saturated with the remains of flotation reagents, have already accumulated (Andrejchuk and Rózkowski, 2000; Liskova, 2017). In addition to rock salt, sylvinite contains a high clay content. This clay must be removed from the beneficiation process before potassium chloride (KCl) flotation. Special basins are being constructed to receive clay sludge, which leads to the withdrawal of thousands of hectares of fertile land from agricultural use (Eminov et al., 2026).

The waste rock accounts for 65 to 75% of the ore's mass (Ushakova et al., 2023) making mine hoisting clearly inefficient, as three-quarters of the energy expended is spent transporting the waste rock, not to mention the environmental damage caused by warehousing of waste products on the surface.

Extracting such poor raw materials from the mine, in addition to the obviously inefficient energy consumption for vertical transportation of the ballast component of the extracted ore, leads to the formation of enormous volumes of mined-out empty space in the subsoil.

However, nature abhors a vacuum. Over time, this leads to irreversible, uncontrolled development of geomechanical processes of displacement of the overlying rock mass, which leads to irreparable damage to all natural and anthropogenic surface objects due to soil subsidence, up to the destruction of above-ground buildings and a rupture of the continuity of the earth's surface with the formation of giant sinkholes (Florkowska and Bryt-Nitarska, 2025). In addition, when the occurrence groundwater level is high enough, subsidence of the earth's surface leads to waterlogging of the soil, flooding of basements of houses and salinisation of water in village wells.

The above-described leads to the conclusion that the only radical way out of this situation, capable of resolving this fundamental technological contradiction of the modern potash industry, is to abandon the delivery of the entire volume of mined ore onto the earth's surface, and to process the rock mass underground, with subsequent prompt placement of enrichment waste in the underground mined space.

The current paper aims to present such a technology.

Materials and methods

The underground enrichment of potash salts must be based on the differences in the properties of the minerals that make up sylvinite. The universal parameter for the state of any mineral is its density. Potash ores contain three main components:

- sylvine (KCl, density 1.98 g/cm^3);
- halite (NaCl, density 2.17 g/cm^3);
- clay impurities (Al_2O_3 .2SiO_2.2H_2O, density 2.60 g/cm^3).

Therefore, if we prepare a non-aqueous, fire- and explosion-proof liquid with a density of 2.05 g/cm³, with a given set of all the main physical, chemical, and physiologically inert properties, in which mineral salts are devoid of solubility, then, after immersing a mechanical mixture of the minerals that make up sylvinite in such a natural liquid medium, only KCl will float to the surface of such a liquid medium, while all other components will sink (Wills and Napier-Munn, 2006).

Preliminary laboratory experiments on the stratification of sylvinite ore of varying sizes in a natural heavy liquid yielded results that fully confirm the feasibility of producing beneficiated products of acceptable quality.

However, after hydromechanical separation of such a system into concentrate and waste, the beneficiated products remain wet, carrying residual non-aqueous liquid phase on their surface. To avoid spending thermal energy to remove them in a dry state from such a beneficiation cycle, the liquid impregnating them must have a boiling point lower than the ambient medium mine air temperature. Then, by arranging heat exchange between such a wet material and the surrounding environment, the beneficiated products automatically become dry, and their further use is no longer impeded.

The non-aqueous vapours released from these processes can be compressed, condensed under elevated pressure, and thus the regenerated working heavy fluid can be returned to the head of the process. Consequently, the working fluid cycle is virtually completely closed, eliminating the need for thermal energy to dry the enrichment products.

The lower the boiling point of such a liquid, the easier it is to dry the enrichment products through heat exchange with the surrounding environment. In other words, the challenge of this technological process lies in the problem of loading the feedstock ore into such a low-boiling liquid, as the crushed rock leaves the face hot, not to mention the ambient air temperature. If this heated material is immersed in a liquid whose boiling point is lower than the ambient temperature, it will immediately boil.

To overcome this technological obstacle, an original solution is proposed in this paper. The working fluid must be at least two-component, consisting of a high-boiling and a low-boiling component. Moreover, the regeneration cycle of such a fluid must also include continuous rectification of the mixture into its two original components.

Then, by pre-loading the initial mechanical mixture of minerals into the high-boiling component of the fluid (which has not only a higher boiling point but also a higher density), it is possible to prevent the boiling of this less volatile liquid.

After this, the low-boiling component of the working fluid is added to the resulting suspension, bringing the density of the liquid mixture not only to an intermediate value between the minerals being separated but also lowering its boiling point to a level lower than the ambient mine air temperature.

Moreover, the milling of the feedstock ore can be carried out in the liquid itself, to avoid reducing the finished product's particle size below the threshold required by agricultural consumers.

Three pilot plants in total were used in the experiments.

The majority of the ore being mined from the face is represented by halite (NaCl) in an open form. Some reduction in the harmful impact of potash production on the environment is possible by increasing the selectivity of extracting sylvinite ore from layers of complex structure, separated from each other by a layer of rock salt. By sawing this monolith into blocks, pre-prepared building material is obtained that is ready for the construction of artificial pillars from it, to control rock pressure

instead of supporting the roof on expensive hydraulic supports, which are characterised by increased metal consumption.

These goals are achieved by a cutting machine equipped with a system for an advance preparation of rock salt blocks using saws for longitudinal and transverse cutting of the rock salt layer into monolithic blocks, followed by the assembly of stacks from them (with preliminary assembly of sets of such supports in the receiving unit of the cutting machine), with the subsequent construction of artificial pillars from them. The construction of artificial pillars from blocks of rock salt, prepared by sawing the monolithic balk remaining in the chest of the working face after the removal of the upper and lower layers of sylvinite, can be carried out using a forklift, available in the complex of mining equipment. The cutting machine can be equipped with a screening surface for preliminary removal of coarse halite with the subsequent use of halite tailings discharged as a damping bed during the construction of artificial pillars, thereby imparting a certain flexibility to them for a smoother absorption of rock pressure.

The harmful impact of potash production on the environment can be reduced not only by increasing the selectivity of sylvinite ore extraction from layers of complex structure separated from each other by a layer of rock salt, but also by organising the underground processing of initial raw material, using for this purpose a mobile enrichment plant equipped with a crusher and designed to continue the processing of potassium ore (Figure 4).

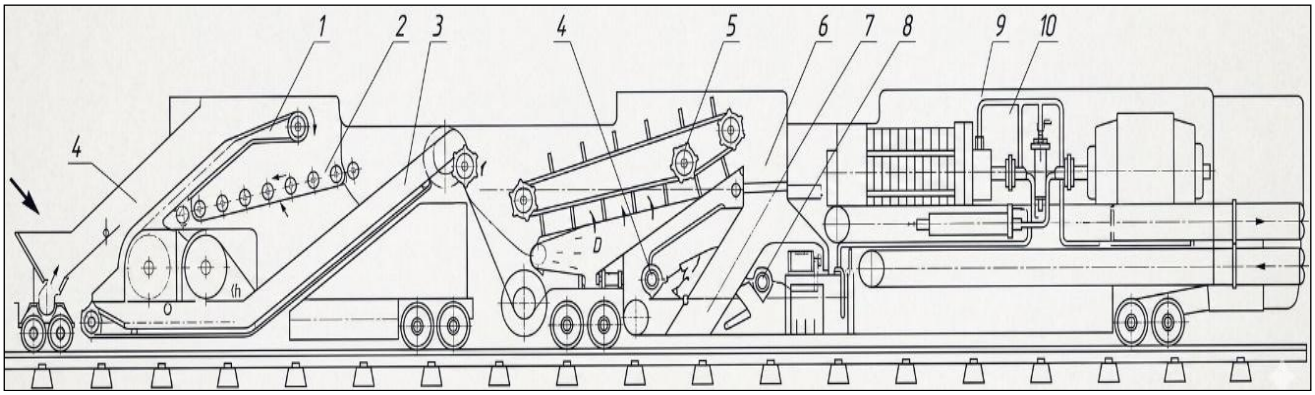


Fig. 4. Mobile pilot plant for separation of sylvinite in the field of gravitational forces:1. Feeder, 2. Classifier, 3. Loader, 4. Heavy liquid tank, 5. Scraper conveyor, 6. Concentrate receiver, 7. Waste product receiver, 8. Cover, 9. Regeneration system shown, 10. A conditional connection of the regeneration system with process pipelines

In this regard, the refined sylvinite coming from the shearer is loaded into the preparatory compartment 4, equipped with a roller crusher, after which, via conveyor 3, this material enters bath 6 for stratification of the mixture of salt minerals in a quiescent liquid medium.

To justify the optimal parameters of such a multi-stage enrichment process, modelling of the separation of sylvinite of various sizes was carried out on a pilot plant equipped with a separator with an internal scraper conveyor, the bath of which was flooded by a heavy liquid (Figure 5). Product of each preceding stage supplies for further processing to the next stage as its size decreases. This multi-stage beneficiation approach is designed to remove waste rock in its largest form, helping to save energy during grinding.

The upper branch of the internal scraper conveyor is designed to unload the floating concentrate, while the lower branch scrapes out the waste rock from the bottom of such a separator. The ore was first crushed in a hammer mill, and three ore classes of varying sizes were separated from it. Sylvinite with initial particles size of -30...+3 mm and KCl content of 25.5 % is used in the experiments.

The process flow diagram of the final stage of finishing the intermediate product to its final state using additional grinding and a centrifugal field is shown in Figure 6 (description of the equipment designation is given in the text). Rough concentrate obtained by enriching sylvinite concentrate with a size of -1...+0 mm in a bath with a stationary heavy liquid of a static separator (Figure 5) is used for the process in Figure 6. This process diagram shows a sylvinite enrichment system using a centrifugal field to separate the finest ore fractions (less than 1 mm) to intensify their stratification.

The material is loaded from bin 1 via feeder 2 through rotary valve 3 into mixer 4, where this material is pre-mixed with the heavy component of the working fluid, dibromo(difluoro)methane - CBr_2F_2 - a colourless non-flammable liquid with density 2.28 g/cm³, boiling point 24.5 degrees Celsius (Morachevskii and Sladkov, 1996) and NIOSH REL of 860 mg/m³ (https://www.cdc.gov/niosh/npg/npgd0214.html).

The resulting suspension is diluted in mixer 5 with the light component of the working fluid, difluorochlorobromomethane $CBrClF_2$ - a colourless non-flammable liquid at low temperatures with density 1.83 g/cm³ and boiling point - 3.4 degrees Celsius (Morachevskii and Sladkov, 1996; https://pubchem.ncbi.nlm.nih.gov/compound/Bromochlorodifluoromethane) until the liquid phase of this system reaches a density of 2.05 g/cm³. This substance is used to extinguish fires because it is not hazardous (the maximum permissible concentration in the atmosphere of the working area is 1000 mg/m³ (Tryon et al., 1969).

Wet milling of the ore is carried out in drum mill 6. The mill drum is half-filled with a liquid medium whose density is between that of the minerals being separated. The opened sylvinite minerals, which do not require grinding, remain afloat, while the intergrown KCl and NaCl crystals sink into the grinding media. As a result, as they are released from the intergrown crystals, the valuable minerals escape the impact of the balls, preventing further unnecessary destruction.

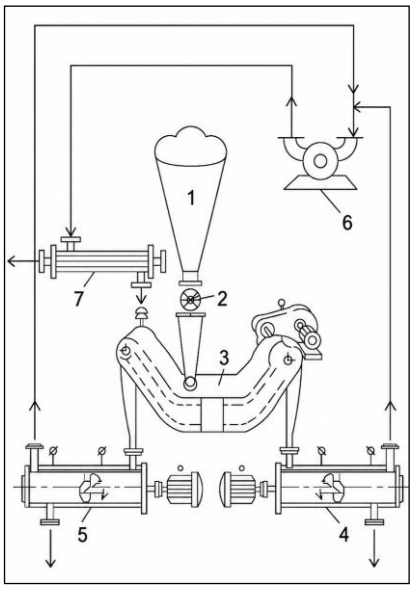
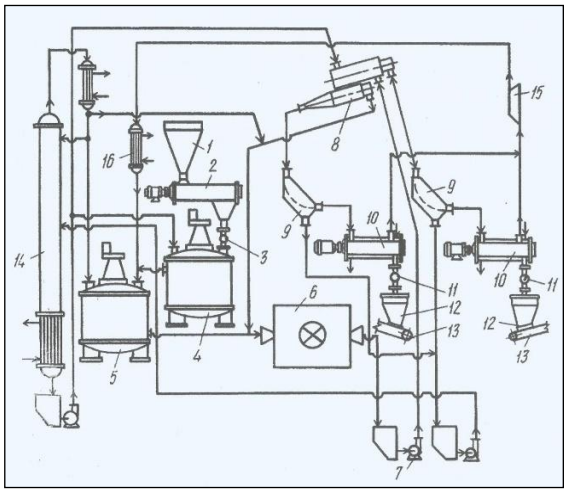




Fig. 5. Separator for separation of sylvinite in a gravitational field (a) Chart of a pilot plant with a bath-type separator: 1. Loading hopper, 2. Rotating shutter, 3. Separator, 4. Concentrate dryer, 5. Gangue minerals dryer, 6. Compressor, 7. Condenser; (b) Photo of the pilot installation working underground

The overflow from mill 6 is directed by pump 7 to centrifugal separation in a three-product hydrocyclone 8. The conditioned products of gravity enrichment, separated by means of a centrifugal field, are wringed from the liquid phase on arc screens 9, after which they are dried in evaporators 10, operating under a vacuum created at the suction of compressor 15. The intermediate product of centrifugal enrichment of sylvinite ore, represented by still under-opened intergrowths, is returned from the three-product hydro cyclone 8 to the mill 6. To intensify the evaporation of the liquid impregnating the enrichment products, warm mine air is blown into the jackets of evaporators 10.

Dry enrichment products are discharged through rotary valves 11, accumulated in storage tanks 12, and then sent for further transportation on belt conveyors 13. A portion of the working fluid, freed from its solid phase, is sent for distillation to the distillation column 14, where it is separated into a heavy component (dibromo(difluoro)methane) and a light component (difluorochlorobromomethane).



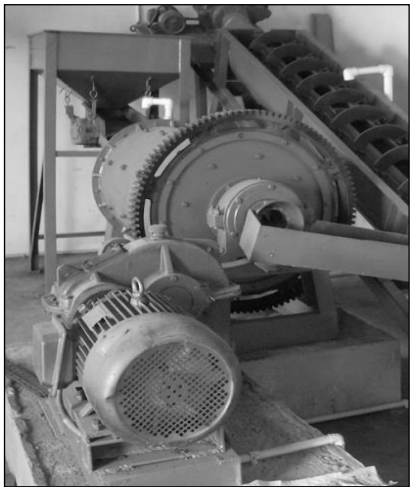


Fig. 6. Process flow diagram (a) and a picture of the pilot plant used in the final series of experiments (b)

Dibromo(difluoro)methane is fed to the feedstock ore and to weight the liquid phase of the system entering the cylindrical-conical section of hydrocyclone 8, while difluorochlorobromomethane is used to dilute the sylvinite suspension to a lower density prior to centrifugal separation of the ore's constituent mineral mixture.

The non-aqueous vapours released from the evaporators are sucked in by compressor 15. They are liquefied in condenser 16, after which the regenerated working fluid returns to mixer 5, thereby completely closing the circuit of its internal circulation.

However, the set of underground mining operations in this case does not end with the receipt of the finished product, since this material must be raised to the earth's surface and loaded into railway cars.

Traditional mine hoisting systems suffer from an inherent technological drawback, such as high cyclic operation and, associated with this circumstance, a sharp drop in the productivity of rope-and-skip hoisting installations with increasing depth of the extracted raw material (Ilin et al., 2019).

This disadvantage is overcome by switching to a continuous process of delivering the finished product by its continuous floating vertically in a stationary liquid with a density exceeding its own. Tests of this process were carried out on a pilot plant, using the same liquid that filled the separator for enriching sylvinite (Figure 7). The purpose of testing the lifting pilot plant shown in Figure 7 was to determine the competitiveness of hydrostatic hoisting by continuously moving product up a vertical

borehole with the cyclic operation of a conventional vertical mine mechanical haulage system using a skip hoist. The experiments were conducted with concentrate sizes of 0.707-0.841 mm and 0.841-1.000 mm. This pilot unit was installed in two configurations, depending on the size of the material being loaded. When handling lower-size material, the loading unit was designed as an auger (position 2). To load larger material, a rotary valve (position 3) was used. The vertical pipeline 4 was made collapsible, which allowed testing such a system with different heights of material floatation (Figure 8).

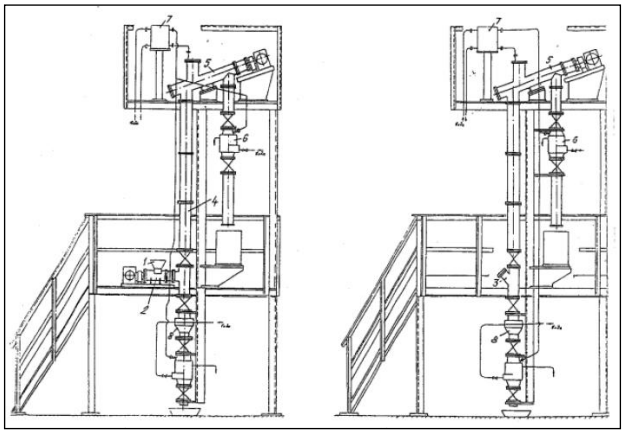


Fig. 7. Installation of hydrostatic lifting of the finished product by its buoyancy: 1. Loading hopper, 2. Screw feeder, 3. Airlock loader, 4. Pipeline, 5. Unloading auger, 6. Dryer with electric heating, 7. Condenser, 8. A trap for substandard products

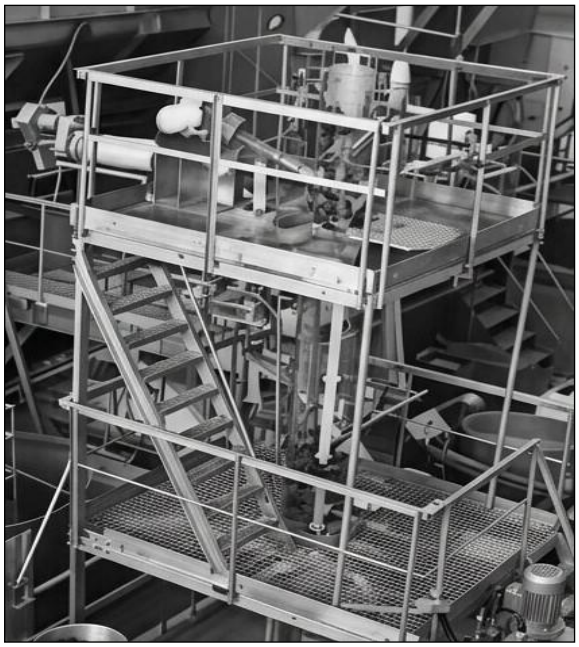


Fig. 8. General view of the pilot hydrostatic lift unit

Results and discussion

The obtained results of testing the step-by-step enrichment process through implementing each stage of such a process in a continuous mode (with a reduction in particle size as it is ground and the majority of the ballast rock salt is removed in the largest possible form) - obtained during testing with the setup shown in Figure 5 - confirmed the full validity of the multi-stage enrichment of potassium salts in underground conditions, since after each stage of separation it is possible to separate the waste rock with the least energy consumption for its grinding. Results are presented in Tables 1 - 3.

Table 1. *Stage 1: Enrichment of sylvinite with a size of -30...+3 mm*

Parameter/ Product name	Yield, %	Content, % KCl	Recovery, % KCl
Initial sylvinite	100	25.5	
Concentrate	34	72.4	96.5
Final tailings	66	1.34	3.5

Table 2. *Stage 2: Enrichment of pre-enriched sylvinite with a size of -3...+ 1 mm*

Parameter/ Product name	Yield, %	Content, % KCl	Recovery, % KCl
Pre-cleaned sylvinite	100	72.4	
Concentrate	78	92.4	99.6
Final tailings	22	1.28	0.4

Table 3. *Stage 3: Refinement of rough concentrate to a final product with a particle size of -1...+0 mm*

Parameter/ Product name	Yield, %	Content, % KCl	Recovery, % KCl
Pre-cleaned sylvinite	100	92.4	
Concentrate	95.8	96.4	99.95
Final tailings	4.2	1.02	0.05

As it can be seen from Tables 1 – 3 decreasing the particles size by additional grinding increases sylvinite recovery and grade.

However, the separation capacity of fine material in a stationary heavy liquid does not allow for high process throughput. Therefore, unlike the three previous enrichment stages, the final refinement of the concentrate to a high-quality end product was carried out in a centrifugal field using hydrocyclones (see Figure 6).

The results of processing rough concentrate in a beneficiation system with additional grinding in a drum mill and the use of a centrifugal field to intensify separation (the equipment shown in Figure 6) are not much different from the beneficiation of such an intermediate product in a stationary heavy liquid – Table 4. However, although separation in a centrifugal field is not as precise as in a bath, in a hydrocyclone the process is incomparably faster than in a stationary liquid. The grade of the product obtained (Table 4) is comparable with that of the market available fertilizers (Wakeel and Ishfaq, 2022).

The success of the entire process of producing the final product with minimal environmental impact is largely determined by the mining technology. Therefore, the higher the selectivity of sylvinite seam extraction without rock salt contamination, the more economical and environmentally friendly the production will be.

Table 4. *Stage 3: Final refinement of rough concentrate to a finished product with a particle size of -1...+0 mm in centrifugal field*

Parameter/ Product name	Yield, %	Content, % KCl	Recovery, % KCl
Pre-cleaned sylvinite	100	92.4	
Concentrate	94.2	97.9	99.78
Final tailings	5.8	3.1	0.22

A mixture of halogenated organic compounds based on dibromomethane is proposed as the working fluid in an attempt to beneficiate high-clay potash ores using continuous heavy liquid concentration (Liles et l., 1973). In this case, a mixture of halogenated organic compounds based on dibromomethane is used as the working fluid. The density of this base liquid is 2.48 g/cm³ while the boiling point is 99 degrees Celsius. Therefore, all components of the sylvinite ore float up within it, and mechanical separation of the mineral mixture does not occur. To reduce the density of such a working fluid, trichloroethylene is used. This solvent has a density of 1.46 g/cm^3 and a boiling point of 86.5 degrees Celsius. Hence, the boiling point of the working mixture of these two liquids is at a level of approximately 95 degrees Celsius.

However, after the separation of the minerals that make up the initial raw material into concentrate and tailings, both of these enrichment products will remain impregnated with such a high-boiling liquid. In order to remove the enriched products from such an enrichment process in dry form, they will have to be heated to high temperatures directly in the mine (in the case of underground enrichment).

On the other hand, as the depth of potash ore increases, the temperature of the atmosphere in the mine also increases in proportion to the size of the geothermal step. Assuming a geothermal gradient of 35 meters per degree Celsius (https://www.icgc.cat/en/Thematic-areas/Territori-sostenible/Potencial-solar-i-geotermic/Geothermics/Geothermics-Gradient-flow-and-propagation), we can determine the depth of a mine where the host rock temperature is at least 100 degrees Celsius. We'll also assume the ground temperature at the Earth's surface is 25 degrees Celsius. A temperature increase of 75 degrees Celsius would occur if we descended to a depth of 75 x 35 = 2625 meters. In this case, if the enrichment products are impregnated by a liquid with a boiling point of 95 degrees Celsius, then such a liquid can be distilled off from them with hot air and the concentrate and waste can be dried directly in the mine.

However, there are no deposits of potassium salts at such great depths, while at a depth of 800 meters the ambient temperature is clearly insufficient to evaporate the remains of the non-aqueous working fluid prepared on the basis of high-boiling brominated organic compounds from the surface of the enrichment products.

The fire- and explosion-proof heavy liquid system proposed here overcomes the shortcomings pointed. Using the natural heat exchange between wet beneficiation streams and the surrounding environment, the beneficiated products automatically become dry in the nowadays potassium salts mines.

When comparing the proposed method with classical flotation, it should be emphasized that before sending the potassium ore to flotation, it must first be completely crushed to a particle size of less than 1 mm, whereas 75% of the composition of such raw material consists of waste rock.

Three-quarters of potash ore is ballast. The energy consumption for lifting ore is directly related to the volume of rock mass lifted (Mine Hoist Equipment Electrical Calculations – 911 Metallurgist). Therefore, energy costs, regardless of the method used to lift the finished concentrate instead of the original ore, will be four times lower.

Unlike lifting installations cyclic action, the level of energy perfection of hydrostatic lifting is several times higher, since it does not require lifting vessels, whose mass is almost equal to the weight of the portion of ore being lifted.

Besides the lack of energy required to lift the skips, the working fluid remains stationary. Therefore, only material that has to be moved vertically moves. Everything else remains stationary. It is also necessary to take into account the absence of dusting during the operation of hydrostatic lifting, while losses of transported cargo due to dust carried away from the delivery of mined ore by mine hoisting units can reach 0.5...1.5%. (Cecala et al., 2019).

From an economic point of view, the costs of constructing a hydrostatic lifting system are incomparably lower. Sinking a large diameter shaft takes several years, while drilling a borehole to the same depth takes several months (Bołoz, 2019).

To illustrate the advantages of hydrostatic lifting over the use of rope-and-skip devices, we present the results of measurements of the floating up to the surface rate of sylvine grains (using the pilot plant shown in Figures 7 and 8) and the calculations of the productivity of this method based on them of delivering finished products to the earth's surface – Table 5:

Table 5. *Productivity of hydrostatic lifting achieved in continuous operation mode*

Concentrate size, mm; Parameter	0.707-0.841	0.841-1.000
Concentrate density, kg/m^3	1980	1980
Density stationary liquid, kg/m^3	2270	2270
Buoyancy rate, m/sec	0.21	0.38
Transverse diameter of the well, m	0.3	0.3
Efficiency, kg/sec	29.1	52.7
Productivity, t/h	104.8	189.6

Potash ore is typically mined at a productivity rate of 350-400 tons per hour. However, no more than a quarter of this mass is extracted from the ore as finished products, or 90-100 tons per hour. Therefore, a hydrostatic lift is fully capable of handling this load.

So, as a result of the tests on delivering the finished products to the surface by floating them up in a vertical well, it was proven that a mine shaft with a diameter of 6...8 m can be replaced by a borehole with a diameter of 250...300 mm, filled with a liquid with a density superior to the floating material, which will ensure the same lifting performance due to the continuity of the transport process.

There is not a single mineral deposit in the world that can be mined indefinitely. The only question is the environmental consequences after the closure of such a mine. Only potash deposits, once their reserves are depleted, will pose a threat to

the environment, since the waste rock remaining on the earth's surface is water-soluble material.

The only way to prevent such a dramatic scenario is to abandon the processing of potash ore on the surface and instead produce the finished product in underground conditions.

Conclusions

The processing of potassium salts in underground conditions based on the use of gravitational enrichment of sylvinite in a fire- and explosion-proof liquid with a given set of physical properties, followed by a full cycle of its energy-efficient regeneration solves the following problems: (i) occupation of arable land by waste heaps of clay-salt sludge, (ii) salinisation of groundwater and (iii) unsuitability of adjacent soils for agricultural use.

The finished product (high-grade sylvine concentrate) can be delivered to the surface by floating it in a vertical well in the proper inflammable liquid with a density that exceeds the concentrate density. This way the productivity of the hoisting systems is increased at decreased energy use.

Laboratory studies and pilot tests have confirmed the direct economic feasibility of applying the enriching of the initial halurgical raw materials in underground conditions by using fire- and explosion-proof non-aqueous heavy liquids with a given set of physical properties.

The proposed technology is environmentally friendly with a full cycle of energy-efficient regeneration of reagents.

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