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# Improvement of the backfilling characteristics by activation of halite waste for non-waste geotechnology

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**Abstract.** To reduce the frequency of man-made disasters it is recommended to use development of deposits systems with backfilling of working space at potash mines. The use of halite enrichment waste in the filing mixture is proposed in order to improve the technical and economic indicators of the mine and the environmental situation in the mining area. The factors influencing the choice of development technology with artificial maintaining of winning area are considered. The advantages and disadvantages of using the technology of the backfilling are indicated. Aspects of preparation of hardening backfill and questions of improvement of its quality by disintegration activation of components are revealed. The possibility of activation of halite enrichment waste used as an inert aggregate in disintegrators is considered.

## 1. Introduction
The frequency of geotechnogenic disasters during the extracting minerals from the depths of the earth increases. In 1986 - surface failure BKPRU-3 Uralkali, Perm Territory; 1999 - a rock blow at the Umbozero mine in the Murmansk region; 2007 - surface failure at BKRP-1 Uralkali, Perm Territory; 2014 - water breakthrough at the Solikamsk-2 mine, Perm Territory; 2017 - water breakthrough from a spent quarry into an underground mine at the Mir enterprise in Yakutia; 2019 - the collapse of the Korbalikhinsky mines in the Altai Territory, Sarylakh in Yakutia, Novo-Kalinskaya in the Sverdlovsk Region, etc. Many of these disasters led to the cessation of work at the mines, and accordingly entailed the loss ofreserves for mineral deposits [1].

The catastrophe, including the geotechnological one, arises as a result of the appearance of several causes and with the combination of a number of adverse factors. The most common causes leading to a geotechnological disaster are: errors made during design; errors made during construction, and they are often compounded by incorrect exploitation and an attempt to make design changes during exploitation.

All this indicates the need for a more detailed approach to the selection of development technology at the time of mine design and careful monitoring at the time of construction and exploitation.

## 2. Geotechnology with artificial maintenance of natural space
One of the ways to minimize geotechnogenic disasters is the use of technology with backfilling of working space [1], [2].

Analyzing the world experience, it can be concluded that about 35% of mines use systems with backfilling of working space when extracting minerals [3].

Factors that influence the choice of technology with backfilling:
• increasing the depth of mining;
• improving the completeness of the extraction of minerals;
• increase the service life of enterprises;
• mining under protected objects (the need to preserve the earth's surface);

Development systems with a hardening backfilling based on the cement binder component are used in deposits with a high value of the extracted raw materials [4], [5]. In coal deposits, due to the low value of the mineral, dry or hydraulic backfilling are used by coarse-ground rocks from sinking, finely crushed coal waste, ash and slag waste of thermal power plants or specially mined sand. Hardening backfilling in coal deposits is used only in exceptional cases:

- when extracting powerful, steeply dipping layers
- when it is necessary to reduce endogenous fire hazard
- when mining layers under protected objects

The use of backfilling of working space in underground geotechnology allows:

- manage rock pressure;
- improve the safety of mining operations;
- conduct simultaneous development of the deposits by underground and open pit methods;
- increase the rate of extraction;
- minimize losses;
- improve the quality of extracted ores;
- reduce the negative impact of mining on the environment;
- preserve the earth's surface;
- extract reserves previously considered off-balance or left in pillars;
- increase the life of the mine, which in addition to the economic aspect, solves the social issue in the regions where the mining enterprise is a city-forming.

Despite the large number of advantages of underground geotechnology with the backfilling of working space, it is not always implemented in a sufficient way and requires improvement of the filling mixture itself, its constituent parts and related processes, since it increases the cost of mining

A filling mixture is used, which is a composite material that can harden in underground conditions, when applying technology with the backfilling of working space. This mixture has in its composition: astringent; inert aggregate; mixing water and chemical additives. As an inert aggregate for the preparation of filling mixtures, both traditional building materials (sand, gravel, etc.) and production waste (slag of metallurgical processing, tailings of concentration plants, ash and ash and slag of thermal power plants, etc.) are used. The use of waste materials in the filling mixture obliges to take into account a number of environmental, economic and other restrictions when choosing the composition [6], [7].

The choice of the composition of the hardening mixture for various development systems is carried out taking into account [8], [9]:

- specified strength;
- method of transportation and good mobility for a given time (the filling mortar must remain in a fluid state for the entire time necessary for its transportation to the chamber to be laid);
- the cost of building an artificial array (to minimize the cost of backfilling works);
- the time to achieve the specified strength characteristics of the material, which determine the possible intensity of the actual mining (i.e., a rapid increase in the value of the elastic modulus E and the ultimate shear value $T_0$ are required);
- minimal water loss and segregation at rest;
- good adhesion to rocks.

Determination of the optimal rheological properties of the hardening mixture is provided by [10]:

- sustainable transportation along the route of the backfilling pipeline;
- lack of stratification at all stages of backfilling works;
- uniform spreading over the chamber;
- the required depth of penetration into the rock when using the combined method of laying cameras.

The use of various activation properties of the backfilling mixture and its individual components can improve the strength properties and uniformity of the artificial array, the use of new materials in the composition of the filling mixture, including production waste materials [11], [12].

## 3. Activation as a way to improve the quality of the filling mixture

By activation, it is necessary to understand one of the methods for processing the components of the filling mixture separately or the finished filling mixture, as a result of which the properties of the components are used to the fullest extent [12].

Purposesofactivation:

- increase the mechanical strength of cement stone;
- intensificationofitshardening;
- increase the mobility of mixtures;
- reducing binder costs without reducing strength;
- improving the quality of the inert aggregate, etc.

Ways to activate filling mixtures are divided:

a) for the intended purpose:
  - increased mobility of mixtures (transportability, spreadability);
  - increase in strength properties;
  - regulation of the hardening time.

b) on the technological stages of backfilling operations:
  - preparations;
  - transportation;
  - filling.

c) by objects of influence:
  - processing of individual components (binder, mixing water, inert aggregate, chemical additives);
  - processing of their combinations.

d) by methods of influence:
  - exposure to vibration;
  - electromagnetic processing;
  - heat treatment (firing) of components;
  - the introduction of chemical additives

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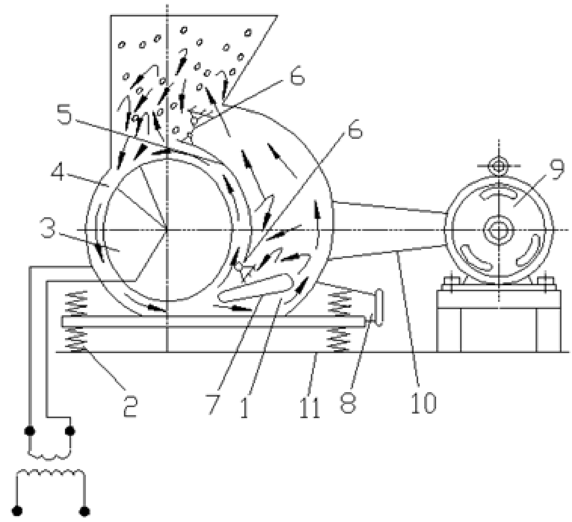


**Figure 1.** Disintegrator
1 – body; 2 – elastic supports; 3 – rotor; 4 – unbalance; 5 – hinged flap; 6 – hinges; 7 – divider; 8 –unloading device; 9 – electronic motor; 10 –V-belt transmission; 11 – frame [8].

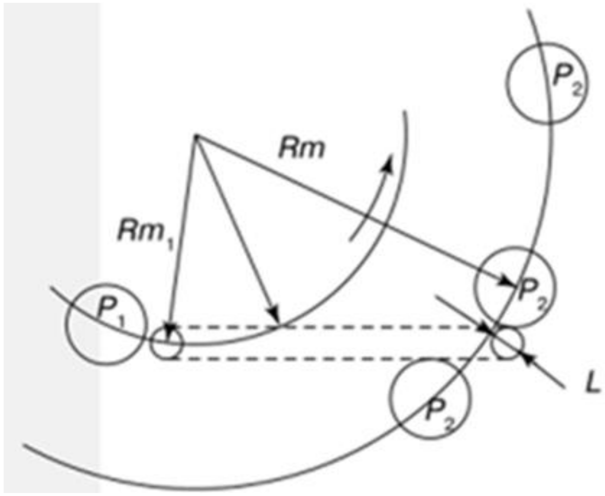


**Figure 2.** The movement of material in the working body
Rm, $Rm_1$ – radii of a circle of fingers; L – particle diameter of material; $P_1P_2$ – centers of adjacent fingers of a circle [Tyulyaeva Y.S].

Treatment of halite waste is performed before mixing it with other components. In the working body of the disintegrator, large internal stresses occur, which are caused by an uneven redistribution of speeds. In this case, the hydrate bonds on the surface of the inert aggregate are destroyed. The filling mixture obtained on the basis of activated halite waste is less prone to delamination, since it is more difficult to "give" water, is more mobile and uniform in composition (figure 3). The use of a disintegrating activation method allows to increase the strength by 25-30 % while reducing the cement by 40%.

Humanity faces a huge problem: the deterioration of the environment as a result of human activity, especially in the extraction of minerals [13], [14]. Recycling of mining waste is almost impossible due to its large volume and specific features. The main task of modern mining production is to create an effective environmentally balanced extraction and processing of minerals [18]. The use of industrial waste [15], [16], [17] along with mining waste [1], [4], [5], [6], [8], [9], [13], [18] is the most important environmental aspect in the world.

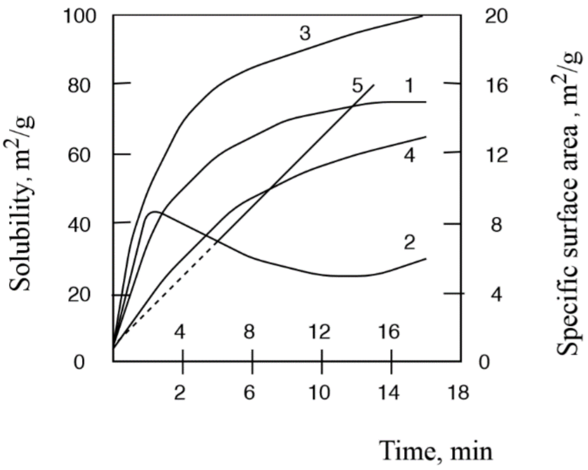


**Figure 3.** The effect of the duration of activation of halite enrichment waste
1 - solubility; 2–specific surface area of non-aggregated powders; 3 – specific surface area of aggregated powders; 4 – amorphization; 5 – comparison of specific surface growth and solubility [Tyulyaeva Y.S].

The use of disintegration activation of halite enrichment waste in disintegrators allows the use of enrichment waste in the filling mixture, improves the transportable properties of the filling mixture, increases the strength of the artificial array. This makes it possible to implement the principle of organizing mining, eliminating the generation of waste and calculating the use of intermediate products in cyclic production.

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