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Justification of the Need for Selective Development of the Phosphorite Reservoir by Horizontal Milling Combines

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Abstract: *Based on the development of the Dzheroy-Sardarinsky reservoir Deposit of granular phosphorites, technological features of the use of horizontal milling combines of various types and manufacturers are revealed. The selective development and implementation of the scheme of mining operations, which allows to increase production efficiency by intensifying the use of mining and transport equipment, is justified. The areas of application of the developed schemes are determined taking into account the mining and geological conditions of the field development and the design and technical parameters of the equipment used.*

Keywords: Quarry, Deposit, phosphorites, milling conveyor, mining operations, rock, formation, drilling equipment, rock mass.

Reservoir deposits of sedimentary origin are characterized by significant size in plan and a thick layer of loose sand and clay rocks covering relatively low-power layers of minerals, which predetermined the construction of high-capacity quarries using in-line technological schemes for mining operations. At the same time, rotary excavators with a low digging force were used as the main excavation and loading equipment in such schemes.

The practice of developing such deposits has shown that the use of in-line technological schemes in a number of quarries is difficult due to the presence in loose rocks of inclusions of dense clays, marls, gravelites, limestones and sandstones, the strength properties of which differ sharply (up to 8-15 times) from the properties of the host rocks. These inclusions are distributed unevenly and randomly not only in the thickness of loose overburden rocks, but also in the layers of minerals. In addition, they, as a rule, do not lend themselves to direct destruction by the working body of the dredging machine, since the resistance of such inclusions to digging exceeds the digging force of excavators not only continuous, but even cyclical action. The creation of rotary excavators with increased digging force has expanded the scope of in-line technological schemes, but the problem has not been solved. Therefore, research has been intensified to improve the efficiency of developing multi-strength rock massifs based on the explosive method of preparing them for excavation and transportation. At the same time, it became necessary to solve a set of scientific and technical problems, since traditional engineering methods for controlling the explosion energy, based on the principle of proportionality of the specific explosive consumption to the volume of exploding rocks, do not allow to ensure the necessary quality of explosive loosening in the conditions of exploding multi-strength massifs.

The use of explosive loosening of multi-strength rock massifs required the study of the distribution patterns of strong inclusions in the rock mass, as well as the development of methods and tools for quickly determining their spatial position and geometric parameters. The situation was complicated by the fact that during the geological exploration of the field, such inclusions were not recorded in the overburden, so information about them before the start of mining operations was almost completely absent.

The uncertainty of the spatial position of strong inclusions in the thickness of loose or relatively low-strength rocks, combined with the variability of their geometric dimensions, required the development of new methods for calculating the parameters of drilling and blasting operations aimed at creating maximum explosive stresses exactly where such inclusions occur.

Explosive loosening of strong inclusions in mineral layers inevitably leads to mixing of different types of rock mass and an increase in losses and dilution of conditioned raw materials. Therefore, it became necessary to develop methods for conducting blasting operations while preserving the geological structure of the destroyed massif.

The use of high-performance rotary excavators is associated with the development of massifs with high (up to 30-40 m or more) ledges. Explosive loosening of rocks in such ledges required drilling explosive wells of large (more than 300 mm) diameters, and drilling rigs for this task were not produced by the industry. Therefore, there was a need to develop a method for drilling and blasting operations based on the use of common drilling equipment that provides high efficiency of explosive loosening of rocks with high ledges.

The developed methods and tools required practical testing in operating quarries with a variety of mining and geological conditions. At the same time, the experience of explosive loosening of rocks for cyclic flow technology was also used. This is due

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to the fact that in some cases, when developing reservoir deposits with diverse rocks, it became necessary to transform the flow technology into a cyclic flow technology.

In accordance with the programme of industrial development geroy-Sardaryinsky phosphorite Deposit was provided by the bring capacity of the mining and processing complexes up to annual capacity for ore is at least 3.6 million tonnes mining in Tashkura area of the field is accepted as a matter of priority for production. The development of the site is provided for by nine quarry fields (sections), which are put into operation as they are developed. The advance of the mining front is projected from South to North. The priority areas of mining operations are quarry fields 1, 2 and 3, since this part of the field has the most favorable development conditions in terms of the smallest volumes of overburden, and 47% of the reserves of the Tashkent section are also concentrated here.

The main ore mineral at the Tashkent site is francolite, which is an appatite-like calcium fluoride phosphate. Associated elements are fluorine and uranium. Uranium is present as an isomorphic impurity, its content in ores is insignificant (0.002-0.006%). The thickness of phosphorite layers is almost the same-0.5±0.85 m. The average content of phosphoric anhydride P_2O_5 in ore of the first fastplant is 14,83%, the second Festplatte – 17,43%. The following patterns can be traced in the structure of layers. The roof of the formation is a layer of marl phosphorites with a thickness of about 0.15 m with an average P_2O_5 content of 15.2±3%. The middle part of the formation is represented by loose granular phosphorites (20.9±2.7% P_2O_5) of variable thickness, on average 0.3±0.4 m, in which a layer of marl phosphorites with an average thickness of 0.15±0.05 m is almost everywhere present. The plantar part of the formation is composed of strong phosphorites with 15.2±3% P_2O_5, sometimes up to 24% and a thickness of up to 0.35 m (on average, 0.15 m). When working out the upper and lower parts of the phosphoplasts, the ore is diluted with host phosphotized marls and clay, and its quality becomes even lower.

Thus, for the specified average thickness of phosphoplasts inside them, the average thickness of layers of different technological types and grades of phosphorite ores is a multiple of 15±5 cm. In this regard, for layer-by-layer development of the reservoir, a 15 cm sub-step was adopted as the optimal one.

The described geological features of phosphoplasts predetermined the technology of mining operations by milling combines, the operating experience of which showed their effectiveness in the excavation of thin ore layers.

The average thickness of the I and II phosphoplasts is 0.63 and 0.66 m, and the P_2O_5 content in the layers varies from 13 to 26%. The mining and geological conditions of the Deposit and the accepted technology of enrichment and processing predetermined the choice of technology for working out layers with milling combines with radiometric control of selective extraction of different grades of phosphorite ore.

The first two Wirtgen-2100SM milling combines were developed in thin layers of 15-25 cm, depending on the technological layer of the formation being worked, with ore loading into MoAZ-74051 and BelAZ-540 dump trucks. The first years of operation of the Wirtgen-2100SM combines confirmed the effectiveness of the chosen mining technology. Their application allowed us to provide: the necessary output of phosphorite ore with improved quality; minimizing losses and dilution; increase the efficiency of development by performing the main processes of mining production by one mechanism (breaking rocks from the massif, obtaining a piece of rock mass that does not require subsequent large and partially medium crushing, loading into a vehicle, with appropriate work schemes, crushed rock mass).

Further development of the new technology for open-pit mining of reservoir deposits using milling combines was carried out within the framework of the state program to increase the output of phosphorite products, which ensured the involvement of poor phosphorite ores in processing, which allowed switching to selective gross ore production using more powerful combines and heavy-duty dump trucks. The set of measures taken included both increasing the volume of processing and introducing new methods of processing phosphorite ore. This required the mining complex to perform a large amount of work to adapt the technological schemes of the combines: to the changing mining and geological conditions of the ore layers, taking into account the design features of the equipment used; to increase the production capacity of the quarry for ore extraction; to the requirements of the processing plant for the initial raw materials.

To increase the productivity of the quarry for production, it was necessary to develop technological schemes that allow to intensify the work of existing mining and transport equipment by optimizing the parameters of the blocks being worked out, determining the scope of Shuttle and loop milling schemes for rock mass, combining a continuous mining and loading cycle and work with stacking rock mass in piles or "rolls". As well as the use of more powerful equipment – milling combines of the next standard-size range and dump trucks with a higher load capacity.

More powerful milling combines MTS-250 (MAN TAKRAF)were used to comprehensively address the issues of increasing the completeness of mining the edge parts of phosphorite formations and increasing the productivity of mining and ore transportation. The first harvester was purchased in 2002 and the second in 2006. This made it possible, due to the increased height of the unloading console relative to the Wirtgen 2100, to use heavy-duty dump trucks manufactured by CATERPILLAR in conjunction with them (see Fig.). MoAZ-74051 (20t) and BelAZ-540 (27t) dump trucks were replaced with SAT-777 (90 t) and SAT-785V (136 t). The location of the milling drum in front of the combine at MTS-250 allowed us to reach the standard indicators of loss and dilution of ore during the development of the marginal parts of the field.

The effectiveness of the use of combines in the extraction of phosphoplastics depends on a clear organization of work, the parameters of the treatment face, the scheme of operation of the combine. The development of phosphoplasts is carried out in blocks with a length of up to 300 m and a width of 50-200 m. Milling on the block is carried out in parallel runs, while using Shuttle and loop patterns of movement of combines.

Fig. mining of ore by MTS-250 combine with loading into a SAT-777D dump truck

An analysis of the experience of using milling combines at the Dzheroy-Sardarinsky and similar mining and geological conditions fields with their stacking of rock mass in stacks or" rolls " allows us to distinguish two main schemes for conducting excavation and loading and subsequent transport operations:

• side filling of milled rock mass by MTS-250 and Wirtgen 2100 combines in a stack, which can be carried out when the combine works out several parallel lanes with the placement of raw materials for averaging purposes in one stack. Subsequent shipment of raw materials from the stack by the "loading facility - dump truck" complex»;

• release of material from the rear in the direction of movement of the Wirtgen 2100 combine from the working chamber of the milling drum with the formation of"rolls". Subsequent stacking of the material by a bulldozer and shipment of raw materials by the "loading vehicle - dump truck" complex.

When conducting mining operations according to the first or second schemes, it is possible to create a warehouse in the quarry for the purpose of charging and effective quality management of raw materials before submitting for processing. In addition, the use of these schemes does not exclude the possibility of conducting selective excavation, or combining it with gross excavation, since the collection of ore from the "rolls" into the stack and direct dumping of the stacks are carried out according to the grade of the ore within the processed block. The principle of operation of the equipment according to the second scheme is most clearly seen when developing deposits with color contrast of ores in the formation.

The effectiveness of the first or second schemes is determined by the design features of the combines used. So the angle of rotation of the unloading console from the axis of the Wirtgen 2100 combine is 36o, which allows you to work out ore on a stack from no more than 3 working passes. The angle of rotation of the unloading console MTS-250-100o, which allows, varying the angles of rotation and the height of the unloading console, to stack ore from 7 working passes. In this case, the height of the stack of 3.5-4 m ensures normal bucket filling and productive operation of the loader, and the width and distance between the stacks turn the loader and dump trucks. When a three-lane stack is formed by a Wirtgen 2100 combine, the resulting stack parameters do not ensure the productive operation of the "loading vehicle - dump truck" complex, which requires the use of a bulldozer to combine the stacks.

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