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Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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ШЕН Пин, PhD, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай), <https://www.scopus.com/authid/detail.uri?authorId=57202873965>, <https://www.webofscience.com/wos/author/record/1753209>

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НУРПЕЙСОВА Маржан Байсановна – доктор технических наук, профессор Казахского Национального исследовательского технического университета им. К.И. Сатпаева, (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=57202218883>, <https://www.webofscience.com/wos/author/record/AAD-1173-2019>

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AGABEKOV Vladimir Enokovich, Doctor of Chemical Sciences, Academician of NAS of Belarus, Honorary Director of the Institute of Chemistry of New Materials (Minsk, Belarus), <https://www.scopus.com/author/detail.uri?authorId=7004624845>

CATALIN Stefan, PhD, Associate Professor, Technical University of Dresden, Germany, <https://www.scopus.com/author/detail.uri?authorId=35203904500>, <https://www.webofscience.com/wos/author/record/1309251>

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FRATTINI Paolo, PhD, Associate Professor, University of Milano - Bicocca (Milan, Italy), <https://www.scopus.com/author/detail.uri?authorId=56538922400>

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MIRLAS Vladimir, Faculty chemical engineering and Oriental research center, Ariel University, (Israel), <https://www.scopus.com/author/detail.uri?authorId=8610969300>, <https://www.webofscience.com/wos/author/record/53680261>

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**O.G. Khayitov¹, L.S. Saidova², A.A. Umirzokov^{1,4},
M.A. Mutalova³, N.M. Askarova³, 2025.**

¹Tashkent State Technical University named after Islam Karimov,
Tashkent, Uzbekistan;

²Navoi branch of the Academy of Sciences of the Republic of Uzbekistan; Navoi,
Uzbekistan;

³Almalyk branch of the Tashkent State Technical University named after Islam
Karimov, Almalyk, Uzbekistan;

⁴Alfraganus University, Tashkent, Uzbekistan.
E-mail: o_hayitov@mail.ru

RATIONAL TECHNOLOGICAL SCHEME FOR TRANSPORTING ROCK MASS FROM DEEP QUARRY

Khayitov Odiljon Gafurovich – Doctor of geological-mineralogical sciences, academician of the Turan Academy of Sciences, head of the Mining Department, Tashkent State Technical University, Tashkent, Republic of Uzbekistan; o_hayitov@mail.ru; <https://orcid.org/0000-0002-7735-5980>;

Saidova Lola Shodieвна – PhD., senior researcher of the Navoi branch of the Academy of Sciences of the Republic of Uzbekistan, Navoi, Uzbekistan; navoiy@academy.uz; <https://orcid.org/0000-0001-6236-0288>;

Umirzokov Azamat Abdurashidovich – PhD, Associate Professor, Tashkent State Technical University named after Islam Karimov, Alfraganus University, Tashkent, Republic of Uzbekistan; a_umirzoqov@mail.ru; <https://orcid.org/0000-0002-9609-179X>;

Mutalova Markhamat Akramovna – Candidate of technical sciences, Associate Professor of the Mining Department, Almalyk Branch of Tashkent State Technical University Named After Islom Karimov; Almalyk, Uzbekistan, marxamat.mutalova@mail.ru; <https://orcid.org/0009-0007-5718-1104>;

Askarova Nilufar Musurmonovna – PhD, Associate Professor of the Metallurgy Department, Almalyk Branch of Tashkent State Technical University Named After Islom Karimov; Almalyk, Uzbekistan, nilu_shas@ru; <https://orcid.org/0000-0001-7730-4895>.

Abstract. Considering the possibility of changing the parameters of equipment for solving problems related to the cargo flow of mining enterprise in deep quarries, since the volume of work performed on extraction and opening increases due to increasing the productivity of the quarry. In addition, this contributes to the re-examination of existing equipment and technologies. In deep quarries with depth of up to 600 m, the development of minerals and their transportation are one of the

main tasks. When studying the development of mining operations in deep pits, there is tendency to change the scheme of transportation of rock mass. The main factors determining the development of quarry transport are systematically deteriorating mining-geological and mining-technical conditions of development.

A number of scientific and practical works have been carried out in the Republic on the development of methods and means of adaptation of cyclic-flow technology, the formation of transport system of deep quarries by technological modules when using modular crushing and transshipment point, new technological schemes and parameters of cyclic-flow technology have been developed. The performance of dump trucks largely depends on the distance of transportation, the average daily duration of work and the utilization factor of calendar time. Indicators of technological road transport development include the average number of cars (by brand), the load capacity of the dump truck fleet and the average load capacity of one average dump truck.

Key words: quarry, transport equipment, technological transport indicators, energy intensity, loading and unloading, period, mining.

**О.Г. Хантов¹, Л.Ш. Саидова², А.А. Өмірзақов^{1,4},
М.А. Муталова³, Н.М. Асқарова³, 2025.**

¹И. Каримов атындағы Ташкент мемлекеттік техникалық университеті,
Ташкент, Өзбекстан;

²Өзбекстан Республикасы Ғылым Академиясының Навои филиалы,
Навои, Өзбекстан;

³И. Каримов атындағы Ташкент мемлекеттік техникалық университетінің
Алмалық филиалы, Ташкент, Алмалық, Өзбекстан;

⁴Альфраганус Университеті, Ташкент, Өзбекстан.

E-mail: o_hayitov@mail.ru

ТАУ ЖЫНЫСТАРЫНЫҢ МАССАСЫН ТЕРЕҢ КАРЬЕРДЕН ТАСЫМАЛДАУДЫҢ ҰТЫМДЫ ТЕХНОЛОГИЯЛЫҚ СХЕМАСЫ

Хантов Одилжон Гафурович – Геология-минералогия ғылымдарының докторы, Тұран ғылым академиясының академигі, Тау-кен инженериясы кафедрасының меңгерушісі, И. Каримов атындағы Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан, E-mail: o_hayitov@mail.ru, ORCID: <https://orcid.org/0000-0002-7735-5980>;

Саидова Лола Шодиевна – Ph.D, Өзбекстан Республикасы Ғылым Академиясының Навои филиалының аға ғылыми қызметкері, Навои, Өзбекстан, navoiy@academy.uz б. <https://orcid.org/0000-0001-6236-0288>;

Өмірзақов Азамат Абдурашидұлы – Ph.D, Ислам Каримов атындағы Ташкент мемлекеттік техникалық Университеті & Альфраганус Университеті, Ташкент, Өзбекстан, a_umirzakov@mail.ru, <https://orcid.org/0000-0002-9609-179X>;

Муталова Мархамат Акромовна – Техника ғылымдарының кандидаты, Ислам Каримов атындағы Ташкент мемлекеттік техникалық Университеті, Алмалық филиалының Тау-Кен ісі кафедрасының доценті; marhamat.mutalova@mail.ru б. <https://orcid.org/0009-0007-5718-1104>;

Асқарова Нилуфар Мусурмоновна – PhD Докторы, Ислам Каримов атындағы Ташкент

мемлекеттік техникалық университетінің Алмалық филиалының Металлургия кафедрасының доценті; nilu_shas@ru; <https://orcid.org/0000-0001-7730-4895>.

Аннотация. Терең карьерлердегі тау-кен кәсіпорнының жүк ағынымен байланысты мәселелерін шешуге арналған жабдықтың параметрлерін өзгерту мүмкіндігін қарастыру аса маңызды. Өйткені карьердің өнімділігін арттыруға байланысты өндіру және ашу бойынша орындалатын жұмыстардың көлемі артады. Сонымен қатар, бұл қолданыстағы жабдықтар мен технологияларды қайта тексеруге ықпал етеді. Тереңдігі 600 м-ге дейінгі терең карьерлерде пайдалы қазбаларды игеру және оларды тасымалдау негізгі міндеттердің бірі. Терең шұңқырлардағы тау-кен жұмыстарының дамуын зерделеу кезінде тау жыныстарының массасын тасымалдау схемасын өзгерту үрдісі байқалады. Карьерлік көліктің дамуын анықтайтын негізгі факторлар тау-кен-геологиялық және тау-кен-техникалық даму жағдайларының жүйелі түрде нашарлауы болып табылады.

Республикада циклдік-ағынды технологияны бейімдеу әдістері мен құралдарын жасау, модульдік ұсақтау және ауыстырып тиеу пунктін пайдалану кезінде технологиялық модульдер бойынша терең карьерлердің көлік жүйесін қалыптастыру бойынша бірқатар ғылыми-практикалық жұмыстар жүргізілді, циклдік-ағынды технологияның жаңа технологиялық схемалары мен параметрлері әзірленді. Самосвалдардың өнімділігі көбінесе тасымалдау қашықтығына, жұмыстың орташа тәуліктік ұзақтығына және күнтізбелік уақытты пайдалану коэффициентіне байланысты. Автомобиль көлігінің технологиялық даму көрсеткіштеріне автомобильдердің орташа саны (маркасы бойынша), самосвалдар паркінің жүк көтергіштігі және бір орташа самосвалдың орташа жүк көтергіштігі жатады.

Түйін сөздер: карьер, көлік техникасы, технологиялық көлік көрсеткіштері, энергия сыйымдылығы, тиеу-түсіру, кезең, тау-кен өндірісі.

**О.Г. Хайитов¹, Л.Ш. Саидова², А.А. Умирзоков^{1,4},
М.А. Муталова³, Н.М. Аскарова³, 2025.**

¹Ташкентский государственный технический университет имени Ислама Каримова, Ташкент, Узбекистан;

²Навоийское отделение Академии Наук РУз, Навои, Узбекистан;

³Алмалыкский филиал Ташкентского государственного технического университета имени Ислама Каримова, Алмалык, Узбекистан;

⁴Alfraganus University, Ташкент, Узбекистан.

E-mail: o_hayitov@mail.ru

РАЦИОНАЛЬНАЯ ТЕХНОЛОГИЧЕСКАЯ СХЕМА ТРАНСПОРТИРОВКИ ГОРНОЙ МАССЫ ГЛУБОКИХ КАРЬЕР

Хайитов Одилжон Гафурович – доктор геолого-минералогических наук, академик Академии наук Туран, заведующий кафедрой горного дела Ташкентского государственного технического

университета им. И. Каримова, Ташкент, Узбекистан, E-mail: o_hayitov@mail.ru, ORCID: <https://orcid.org/0000-0002-7735-5980>;

Саидова Лола Шодиевна – PhD, доцент, старший научный сотрудник Навоийского филиала Академии наук Республики Узбекистан, Навои, Узбекистан, E-mail: navoiy@academy.uz, <https://orcid.org/0000-0001-6236-0288>;

Умирзоков Азамат Абдурашидович – PhD, доцент, Ташкентский государственный технический университет имени Ислама Каримова & Университет Альфраганус, Ташкент, Республика Узбекистан, E-mail: a_umirzoqov@mail.ru, <https://orcid.org/0000-0002-9609-179X>;

Муталова Мархамат Акромовна – кандидат технических наук, доцент кафедры горного дела Алмалыкского филиала Ташкентского государственного технического университета имени Ислама Каримова, E-mail: marhamat.mutalova@mail.ru, <https://orcid.org/0009-0007-5718-1104>;

Аскарова Нилуфар Мусурмоновна – PhD, доцент кафедры металлургии Алмалыкского филиала Ташкентского государственного технического университета имени Ислама Каримова, E-mail: nilu_shas@ru, <https://orcid.org/0000-0001-7730-4895>.

Аннотация. Рассмотрение возможности изменения параметров оборудования для решения задач, связанных с грузопотоком горного предприятия в глубоких карьерах, так как объем выполняемых работ по добыче и вскрытию увеличивается за счет увеличения производительности карьера. Кроме того, это способствует повторному изучению существующего оборудования и технологий. В глубоких карьерах глубиной до 600 м разработка полезных ископаемых и их транспортировка являются одной из основных задач. При изучении развития горных работ в глубоких карьерах отмечается тенденция к изменению схемы транспортировки горной массы. Основными факторами, определяющими развитие карьерного транспорта, являются систематически ухудшающиеся горно-геологические и горнотехнические условия разработки. Поддержание непрерывности горных работ в транспортной части может дать логистическое управление грузопотоком глубокого карьера. На сегодняшний день мировые различия технологических транспортных схем действующими предприятиями в основном будут продолжать использовать существующие виды транспорта с внедрением новых транспортных систем на отдельных участках карьера, в основном на глубоких горизонтах, а во-вторых, используются более современные.

В республике проведен ряд научно-практических работ по разработке методов и средств адаптации циклично-поточной технологии, формирования транспортной системы глубоких карьеров технологическими модулями при использовании модульного дробильно-перегрузочного пункта, разработаны новые технологические схемы и параметры циклично-поточной технологии. Производительность самосвалов во многом зависит от дальности перевозки, среднесуточной продолжительности работы и коэффициента использования календарного времени. Показатели технологического развития автомобильного транспорта включают среднее количество автомобилей (по маркам), грузоподъемность парка самосвалов и среднюю грузоподъемность одного среднего самосвала.

Ключевые слова: карьер, транспортное оборудование, показатели

технологического транспорта, энергоёмкость, погрузка и разгрузка, период, добыча полезных ископаемых

Introduction. With increasing depth of works, reduce the options career in terms of having difficulty, geological conditions; the road transport career acquires a number of specific features. The main stages of development, such as opening and preparing new horizons in the deep parts of the quarry, are carried out in cramped working space conditions with a large concentration of excavation and loading equipment, with high rates of deepening (Bolatova, et al., 2022; Imashev, et al, 2022; Saidova, et al., 2023).

According to the design decisions “Working out of the pit” Muruntau V turn “working out of the pit is provided from the center to the flanks, which determines the placement of ore sites in the excavation units mainly from the side of the worked out space of the pit (Fig. 1).



Fig. 1 Muruntau Deep Pit

Findings. Accordingly, this significantly restricts maneuvers in the spatial organization of mining development, creating technological unevenness and heterogeneity of the ore flow from the quarry production (stochastic flow of the mining process). To compensate for the constantly occurring specified heterogeneity and uneven production volumes from the quarry, it will be necessary to carry out technological intensification of the edge part of the quarry, followed by putting the sides of the quarry in the design position (Saidova, et al., 2023; Khayitov, et al., 2023).

An intensive increase in the depth of open-pit mining required a study of the influence of mining conditions in quarries on the performance of technological vehicles. In this case, the indicator of the depth of open pits is decisive (Khayitov, et al., 2023; Li, et al., 2024; Mussin, et al., 2023; Askarova, et al., 2022; Snitka, et al., 2018). The given actual indicators of the mining conditions of the Muruntau open pit made it possible to obtain a graphical interpretation of the indicators of technological transport with the depth of the open pit.

Methods and materials. The processing of the obtained data made it possible to obtain dependencies that indicate a constant deterioration in the mining technical conditions for the operation of technological transport, accompanied by an increase in the distance of transportation and an increase in the height of the rock mass from the lower zones of the quarry.

An analysis of the increase in the depth of open pits showed that as they develop, the distance of transportation and the height of the rock mass rise increase. At the same time, the situation is complicated by the fact that mineral deposits that are complex in terms of their qualitative composition and geological structure are involved in the development. It should be noted that the growth in ore mining and the decline in the volume of mined rock mass led to the complication of mining conditions in the quarry. When ore is mined from deep open pits (the open pit is more than 600 meters deep) and the largest possible volumes of rock mass movement per year of mining, the work on their transportation increases significantly (Naimova, et al., 2020; Zairov, et al., 2018; Sładkowski, et al., 2024; Korobiichuk, et al., 2024; Dai, et al., 2024).

The profitability of the open pit mining in its lower zones is ensured with the right choice of mining and transport equipment, opening, as well as the stability parameters of the open pit walls. During the development of the Muruntau quarry, several rational innovations were implemented that were aimed at optimizing mining operations and reducing costs: the use of cyclic-flow technology; use of dump trucks with a carrying capacity from 27 tons to 40, 75, 130, 180, 220 tons for moving quarry cargo; with electric excavators with buckets with a capacity of 4 to 12 m³, as well as hydraulic excavators with a capacity of 15 to 20 m³; application of steeply inclined KNK conveyors.

For the conditions of the Muruntau quarry, the tracks of dump trucks with an average transportation distance of 3.73 km are characterized by a high weighted average slope of 6.1%, high complexity up to 3-4 turns per 1 km with a radius of 30m.

When using dump trucks as an independent (main) mode of transport, an important direction of energy saving is to increase the slopes of roads. In the technological aspect, the use of elevated gradients allows to reduce the additional spacing of pit from placing transport and communications, in energy — increase of slope in a certain range reduces the consumption of diesel fuel for the transport cycle.

It should be noted that the main problems and limitations of ore reserves completion within the boundaries of the fourth stage of the quarry are the narrowed working space (20-30m) in the mining areas of the quarry (Nasirov, et al., 2023; Nasirov, et al., 2022; Burmistrov, et al., 2017; Androsov, et al., 2020). In the period 2020-2023, the use of heavy-duty dump trucks with a load capacity of more than 213-220t and with a width of at least 7.6 m will be required to work out these sections with a given rate of deepening(table).

It is known that the volume of the quarry, the current and average stripping ratio directly depend on the selected dump truck. In this regard, in order to select mining and transport equipment for the conditions of the deposit, studies and calculations of the volumes of extracted rock mass were carried out; dependences of the influence on certain sections of the wall of the Muruntau quarry were established (Saidova, et al., 2023; Khayitov, et al., 2023).

The increase in the volume of the open pit with a change in the carrying capacity used when moving the rock mass by a dump truck depends on the angle of slope of the sides of the open pit (Fig. 3)

Table 1. Parameters of heavy-duty dump trucks on the lower horizons

No	Parameters	Unit of meas.	By brands of dump trucks with a load capacity of 218-227 tons:							
			CAT 793D	Liebherr T-262	БелАЗ -75307	БелАЗ-75310	XCMG XEG220 (SF33901D)	XCMG XDE240	Komatsu HD830E	CAT 793F
1	Load capacity	ton	218,0	218,0	220,0	220,0	220,0	220,0	221,6	227,0
2	The capacity of the body loosened g/mass	m ³	129,0	119,0	130,0	141,1	136,0	148,0	147,0	130,0
3	The fill factor		0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9
4	Degree of fragmentation at Muruntau open pit		1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
5	Capacity g / mass per vehicle body in the rear	m ³	77,4	71,4	78,0	84,7	81,6	88,8	88,2	78,0
6	Capacity g / mass per vehicle body in the rear	ton	201,2	185,6	202,8	220,1	212,2	230,9	229,3	202,8
7	Percentage of capacity from the passport load capacity, %		92,3	85,2	92,2	100,1	96,4	104,9	103,5	89,3
8	The overall width of the a/s	mm	7680	7400	8400	8450	8330	7990	7320	7605
9	Loading height a / s	mm	5871	5900	6650	6030	6400	6490	6710	6533
10	Engine power	kWt/ h.f.	1801/ 2450	1492- 1864	1716	1864	1864-2500	1864- 2500	1865	1976/ 2650
11	Average technical lifting speed g / m to a height of 150-200 meters	km/ hour	17,8	17,5	17,7	18,1	18,1	17,5	19,2	19,0

For the conditions of the Muruntau quarry during its development in plan and depth, it is established that with an increase in depth, the transition and introduction of dump trucks with a lifting capacity of 180-220 tons during the technical re-equipment of the excavator-automobile complex will improve its management system (Androsov, et al., 2020; Nasirov, et al., 2024; Zairov, et al., 2020; Fedorov, et al., 2017; Ratov, et al., 2021).

The meaning of this technology is the application of engineering technique, which is performed using only hydraulic excavators and dump trucks with an overall width of not more than 7.6 m for sinking time of congresses and split tranches requires only 20 m (at the base of the soles), and using dump trucks overall width of 8.4 m requires that the width of the bottom on the sole was not less than 35 m (Fig.2).

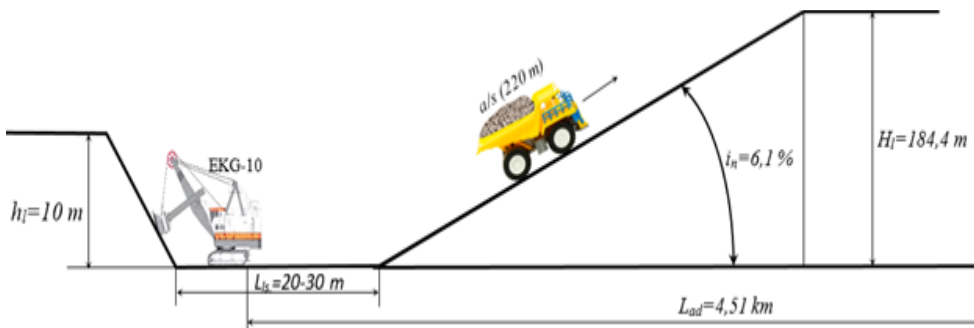


Fig. 2. Rational technological scheme of rock mass transportation during the development of deep quarries in plan and depth:

L_{ad} – average distance of transportation; L_{ls} – distance of the lower section of the mining face; i_n – weighted average slope; H_l – lifting height; h_l – height of the ledge.

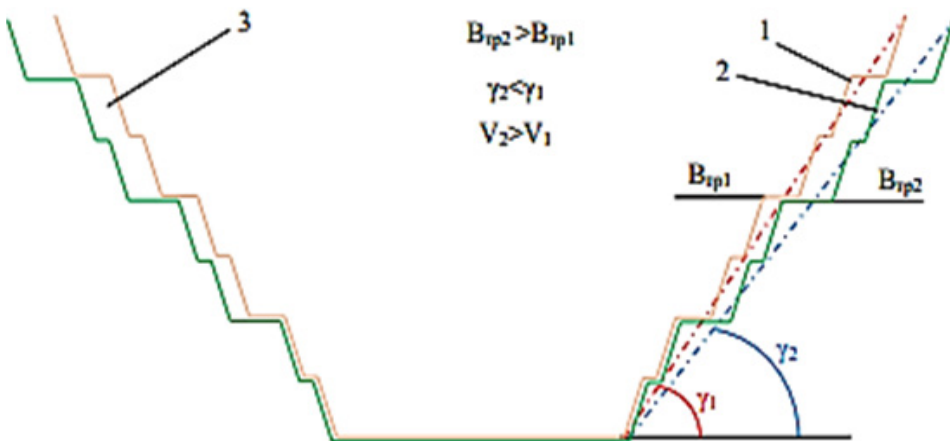


Fig.5. Deep pit boundary with transport berms of different widths

1 - quarry boundary with a narrow transport berm; 2- quarry fenders with a wide transport berm; 3 - additionally extracted volume of quarry rocks with an increase in the width of the berms.

According to its intended purpose, the transport berm serves to accommodate transport routes connecting the working platforms of ledges with capital trenches. The type of transport used, the intensity of the rock mass traffic along it, etc determine the width of the transport berm. A transport berm connecting several ledges is called a connecting berm (Saidova, et al., 2023; Khayitov, et al., 2023). Part of the upper platform of the ledge with a width equal to the base of the collapse prism is called a safety berm, while equipment, transport routes, power lines are placed outside the safety berm.

A safety berm is necessary to increase stability and reduce the angle of slope of the pit wall and to protect the located lower ledges from accidental falling of rock pieces. The safety berm is usually at least wide enough to accommodate equipment on the berm for loading and handling rolled rock.

Studies have established that such a factor as the overall dimensions of a dump truck is not taken into account well, and it is this factor that determines the width of the transport berm, which in turn affects the design of the side of a deep pit and, accordingly, the volume of extracted rock mass (Saidova, et al., 2023; Khayitov, et al., 2023).

Discussion and Results. This circumstance has the following explanation. The “Muruntau” quarry is unique in its mining, geological and climatic conditions; it is characterized by large volumes of rock mass production, which requires the operation of mountain transport in difficult and stressful conditions. According to the design decisions, the depth of the Muruntau quarry will reach 1000 meters, which in turn will increase the degree of slope of roads and increase the dynamic load on dump trucks by 2 times (Saidova, et al., 2023; Khayitov, et al., 2023). Further development of the V stage of the Muruntau quarry will be accompanied by its deepening and at the same time, it is possible to achieve efficiency in the operation of dump trucks only at the expense of dump trucks with electric-mechanical transmission.

Conclusions. The world analysis and experience of operation of dump trucks in the Muruntau quarry shows the efficiency of operation of dump trucks with hydro-mechanical transmission at an average lifting height of up to 130 meters. Their use at elevations of more than 130 meters leads to a decrease in the average technical speed of movement, which is expressed in a decrease in production. The electromechanical transmission has a higher efficiency of transferring power from the engine to the tires due to fewer rubbing and rotating parts, which lead to losses of transmitted power. Also, gear changes in the hydro-mechanical transmission lead to losses, since at the moment of switching there is a break in the power flow transmitted to the rear wheels, while in the electromechanical transmission there is no break in the power flow. On average, the efficiency of an electromechanical transmission when transmitting power is 97% compared to 90% for a hydro-mechanical one.

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