ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

№4
2025

ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

4 (472)

JULY – AUGUST 2025

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, 2025

Clarivate Analytics

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ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: «Central Asian Academic research center» LLP (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, hydrogeology, geography, mining and chemical technologies of oil, gas and metals*
Periodicity: 6 times a year.
http://www.geolog-technical.kz/index.php/en/

N E W S OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Орталық Азия академиялық ғылыми орталығы» ЖШС (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *Геология, гидрогеология, география, тау-кен ісі, мұнай, газ және металдардың химиялық технологиялары*

Мерзімділігі: жылына 6 рет.

http://www.geolog-technical.kz/index.php/en/

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Собственник: ТОО «Центрально-азиатский академический научный центр» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, гидрогеология, география, горное дело и химические технологии нефти, газа и металлов*

Периодичность: 6 раз в год.

http://www.geolog-technical.kz/index.php/en/

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NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 4. Number 472 (2025), 27–45

https://doi.org/10.32014/2025.2518-170X.528

UDC 622.6
IRSTI 52.29.01

© T.M. Almenov[1], R.K. Zhanakova[1*], G.E. Askarova[1*], M.R. Shautenov[1], K. Amantayuly[2], 2025.
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COMPREHENSIVE ASSESSMENT OF ORE LOSSES AND DILUTION IMPACTING VASILKOVSKY GOLD DEPOSIT PROFITABILITY

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Abstract. The modern development of the Vasilkovsky gold ore deposit is accompanied by decreasing gold content in the ore, increasing mining depths, and shrinking available reserves, all of which significantly impact production economics. This article presents a comprehensive assessment of ore losses and dilution, as well as their influence on the profitability of mining and processing operations. The full production cycle from ore extraction in the open pit to processing at the beneficiation plant is examined, taking into account geological, structural, techno-economic, and technological parameters. Particular attention is paid to identifying interstage relationships that demonstrate how variations in loss and dilution levels affect cost structures. Taking into account the variability of the conditions for normalizing the completeness and quality of ore extraction during the mining of complex-structured gold deposits, as well as the labor intensity of computational work, a downhole optimization of the ratio between ore losses and dilution during extraction is carried out. An integrated assessment methodology has been developed, combining factor analysis and economic modeling, which enables the identification of critical control points for ore quality management. It has been established that process optimization and the use of internal production reserves can significantly reduce unit costs per ton of processed ore mass and enhance mining efficiency. The results can help develop strategies to improve enterprise profitability and competitiveness in challenging mining and economic conditions.

Keywords: rock mass, mineral resources, mining of mineral resources, ore loss, dilution, effect

Acknowledgement, funding: *This article is based on the results of research work under the project AP23489198 «Development of rational technology for conducting and fixing underground mine workings by means in-depth study of stress-strain state and stability» under the grant funding for 2024-2026, project leader Candidate of Technical Sciences, Professor Almenov T.M. The research was funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan.*

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ВАСИЛЬКОВСКИЙ КЕНОРНЫН ИГЕРУДІҢ ТИІМДІЛІГІНЕ ӘСЕР ЕТЕТІН КЕНДЕРДІҢ ЖОҒАЛЫМЫ МЕН ҚҰНАРСЫЗДАНУЫН КЕШЕНДІ БАҒАЛАУ

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Аннотация. Қазіргі уақытта құрамында алтыны бар кен орындарындағы кендегі алтынның құрамының төмендеуі, өндіру тереңдігінің артуы, сондай-ақ игерілмеген және толық зерттелмеген қорлардың азаюы карьерден бастап байыту фабрикасына дейінгі бүкіл өндіріс тізбегінде тиімді шешімдер әзірлеуді қажет етеді. Мұндай шешімдер әрбір нақты тау-кен кәсіпорнының геологиялық, технологиялық, техникалық және ұйымдастырушылық ерекшеліктеріне сәйкес бейімделіп, өндірістік шығындарды оңтайландыруға бағытталуы тиіс. Осы мақалада Васильков алтын кен орны мысалында жоғалымдар мен кеннің құнарсыздануы өндіріс циклі шығындарының тізбегіне қалай әсер ететіні кешенді түрде зерттелген. Күрделі құрылымды алтын кен орындарын өңдеу барысында толықтай қазып алу мен кен сапасын зерттеу кезіндегі кен жоғалымы мен құнарсыздық деңгейінің арақатынасын оңтайландыруды жүзеге асырылу қарастырылған. Ұсынылып отырған мақалада жоғалым мен кен құнарсыздығы бойынша жедел түрде нормалау әдісі кен орындарын игеретін тау-кен кәсіпорындарында қолдануға болады. Дайындалған алгоритмдер, жоғалтымдар мен кен құнарсыздығы деңгейінің оңтайландырылған арақатынасы минералдық шикізат сапасын басқарудың автоматтандырылған жүйелерін ендіріп жатқан тау-кен кәсіпорындарына қолданылады. Мақалада карьерден фабрикаға дейінгі шығындар тізбегін қалыптастыруға арналған, шығындарды бағалаудың түрлі әдістерін біріктіретін авторлық тәсіл ұсынылады. Ұсынылған әдістеме факторлық талдау мен шығындарды есептеу тәсілдерін қамтып, жоғалымдар мен құнарсыздандыру деңгейінің өзгеруіне байланысты шығындардың қалай ауытқитынын ескеруге мүмкіндік береді. Зерттеу нәтижелері кен сапасының көрсеткіштерін басқару, өндірістік процестерді жетілдіру және ішкі резервтерді тиімді пайдалану жалпы өндіріс тізбегі бойынша тау-кен массасының әр тоннасына шаққандағы шығындарды едәуір азайтуға жол ашатынын дәлелдей алды. Сонымен қатар, бұл тәсіл өндіру тиімділігін арттыруға, өнімнің өзіндік құнын төмендетуге және кәсіпорынның ұзақ мерзімді тұрақты дамуына ықпал етеді.

Түйін сөздер: тау-кен массасы, пайдалы қазбалар, пайдалы қазбаларды игеру, кен жоғалымы, кен құнарсыздығы, тиімділік

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КОМПЛЕКСНАЯ ОЦЕНКА ПОТЕРЬ И РАЗУБОЖИВАНИЯ РУДЫ ПРИ РАЗРАБОТКЕ ВАСИЛЬКОВСКОГО ЗОЛОТОРУДНОГО МЕСТОРОЖДЕНИЯ

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Аннотация. Современная разработка Васильковского золоторудного месторождения характеризуется ухудшением горно-геологических условий, выражающимся в снижении содержания золота в руде, увеличении глубины горных работ, усложнении морфологии рудных тел и сокращении доступных запасов. Эти факторы существенно влияют на себестоимость и рентабельность добычи, требуя комплексного подхода к оптимизации производственного процесса и повышению эффективности управления ресурсами. В статье проведена всесторонняя оценка влияния потерь и разубоживания руды на эффективность разработки месторождения. Проанализирован полный производственный цикл от выемки горной массы в карьере до переработки на обогатительной фабрике с учётом геолого-структурных, технико-экономических и технологических параметров. Особое внимание уделено межстадийным взаимосвязям, демонстрирующим влияние уровня потерь и разубоживания на структуру затрат, производственные риски и конечные технико-экономические показатели. В условиях высокой изменчивости геологических характеристик и сложности нормирования полноты извлечения руды предложен подход оперативной скважинной оптимизации, основанный на моделировании взаимосвязей между технологическими параметрами и экономическими результатами. Разработанные алгоритмы интегрированы с современными системами автоматизированного управления качеством минерального сырья и могут быть использованы в реальном времени для поддержки оперативных решений. Представлена методология интегрированной оценки, включающая факторный анализ, технико-экономическое моделирование, сценарный подход и идентификацию критических точек управления качеством. Установлено, что использование предложенного подхода позволяет повысить точность прогнозирования производственных потерь, рационализировать загрузку перерабатывающих мощностей, улучшить управление операционными показателями, обеспечить адаптивность производственных решений и значительно снизить удельные издержки на тонну перерабатываемой массы. Полученные результаты могут быть использованы для стратегического планирования повышения рентабельности, устойчивости и конкурентоспособности горнодобывающего предприятия в условиях усложняющихся технико-экономических и природных ограничений.

Ключевые слова: горная масса, полезные ископаемые, добыча полезные ископаемые, потеря руды, разубоживание, эффект

Introduction. In modern conditions the main development of scientific and technical progress is a close connection between science and production. The solution of problems facing the mining industry is unthinkable without serious research into the physical processes of mining. Due to the constant degradation of mining-technological conditions in exploitation of Vasilkovsky deposit steadily increases unproductive costs for lost minerals that predetermines the importance and necessity of improving the methods of normalization and management of the level of qualitative and quantitative losses in mining (Nurpeissova, 2023:19).

The current regulatory documents concerning operational rationing of losses and dilution during extraction, do not exhaust the available opportunities to reduce losses of raw materials in situations where the formation of the extraction flow is carried out by a set of blocks differ from each other conditions of their development. The relevance of research on the development of methods of block-by-block rationing of losses and dilution in gross mining is increasing with the involvement in the development of complex mineral deposits characterized by the presence of a network of geological discontinuities of discontinuous nature of different orientation of amplitude and angle of incidence unevenness of contacts of the mineral with the host rocks, a wide range of variation of the elements of deposit occurrence, thickness and angle of their fall variability of the quality of extracted raw materials, etc. (Rakishev, 2022:116).

The purpose of the work is to develop a methodology for operational normalization of losses and dilution for a set of mining blocks that differ from each other by mining and geological and mining conditions of their mining. The idea of the work is to minimize the total losses and dilution of minerals through the formation of an optimization function that takes into account the relationship between the completeness and quality of excavation with the technological parameters of development of mining blocks (Moldabayev, 2020:30). Relevance of the research topic. Transition to a market economy faced mining companies in Kazakhstan with the problem of exhaustion and deterioration of the quality of mineral raw materials. As the costs of exploration, mining, processing and transportation of minerals increased, their reserves, estimated and put on the state balance 20 years ago, became economically inactive by 20-80% and more, which led to the crisis situation of the mineral resource base. At the same time, medium, large and unique deposits have changed the morphology of ore bodies beyond recognition, reducing the ore bearing capacity and increasing the discontinuity of conditioned mineralization (Almenov, 2025:1217) This is accompanied not so much by a decrease in reserves as a whole, but by an increase in the share of inactive reserves. This situation is especially pronounced in the mining regions of gold-bearing ores (Moldabayev, 2020:29; Blom, 2019:318). Nowadays, more variables have been added to the optimization process in the modern world due to advances in technology, making it more realistic and relevant to operational data. Among these improvements are simulated block models, i.e., multiple equal probability models that account for grade and geologic uncertainty. A method for capturing uncertainty is to create stochastic simulations of the resource model, where stochastic behavior expresses the uncertainty or variability of the model properties (Dimitrakopoulos, 2002:8; Dimitrakopoulos, 2011:138).

Accounting for uncertainties in mine planning is a necessary task to achieve the expected objectives, regardless of the planning stage considered. Splat stated in his paper that one of the key risks in a mining project is geologic uncertainty because an understanding of the geology, spatial distribution and variability of the qualities and host minerals of the ore can only be inferred from limited data that are not necessarily representative of the entire deposit.

The ore field is located within the Kokchetavsky median massif. There are four systems of discontinuities (submeridional, sublatitudinal, north-east and north-west directions). The most developed is the system of north-west faults, to which the regional Donguliagash zone is confined.

The Vasilkovskoye ore field is localized within the Altybai synclinal structure and is confined to the zone of intersection of the Donguliagash fault with the north-east strike-slip fault and to the contact zone of the Donghulagash zone. It is bounded on three sides by faults, two of which, of north-east strike, intersect in the area of the Dalneye ore occurrence. In the south-west direction they diverge and adjoin the north-west strike of the Donguliagash zone. faults of the Donguliagash zone. All faults are well recorded by magnetometer survey. Along the faults at all stages of activation there were smaller faults with inherited elements of occurrence, often accompanied by crushing zones (Bekbergenov, 2025:49). The most intensive development of higher-order faults and crushing zones occurred in the block bounded by large faults above the diorite bodies. In the southwestern part of the ore field they are disjointed, and in the north-eastern direction they merge. These faults are usually accompanied by smaller zones of disturbance. The Vasilkovskoye deposit is confined to the junction of one of such zones with a similar zone of north-east strike, where the rocks were fragmented over a large area. This object is characterized both by a very intense degree of rock disturbance, manifested in pre-metallic, ore and post-metallic times, and by the multidirectional of faults.

Figure 1. Location of the Kokshetau (gold deposit)

Figure 1 shows a diagram of the generation of losses and dilution due to complex shaped deposits. This is what determined the general structural pattern (system of small blocks) of the deposit, the type of ore bodies and their location in space. From the north, north-west and south-west the ore field is framed by stratified Riphean and Ordovician formations. The oldest formations within the ore field are the Early-Middle Riphean formations located in the form of two bands in the north-west and south-west parts of the field, which are represented by green and greenish-gray phyllite-like rocks of chloritesericite, epidote-albite-actinolite, chlorite-sericite-siliceous composition, often carbonatized. Vasilkovsky deposit is one of the largest in the gold mining industry of Kazakhstan, and in the world it is one of the 20 largest in all parameters. The deposit is located in Akmola region, Republic of Kazakhstan, 17 km north of Kokshetau. The region has well developed infrastructure including roads, railroads, electricity and water supply facilities. The design parameters of the open pit are: width - 1,210m, length - 1,290m, depth - 450m. A gold extraction plant has been built at the deposit in accordance with the best international standards. The plant is capable of processing up to 8 million tons of ore and producing up to 500 thousand troy ounces of gold per year. The current production level is on average 8 million tons of ore or about 400 thousand troy ounces of gold per year (Torres, 2018:189).

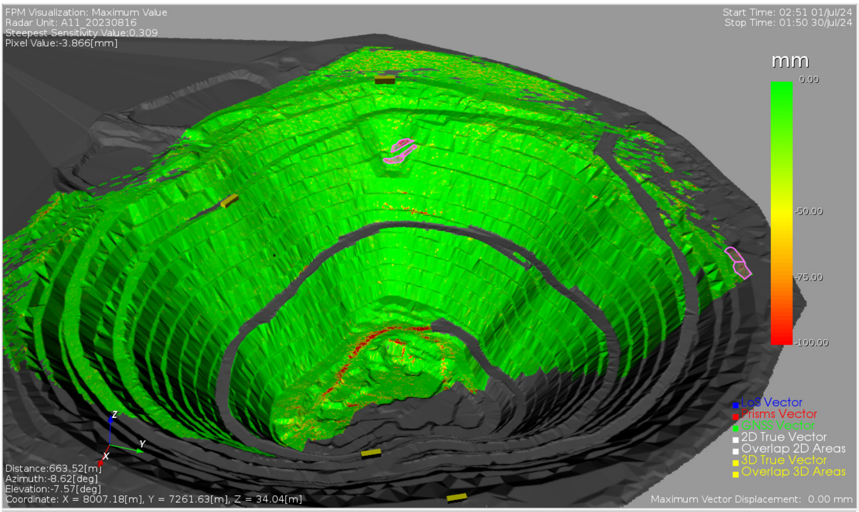

Figure 2. Overview scheme of the Vasilkovskoye field

Norming and planning of ore losses and dilution is one of the most difficult tasks of the problem of rational and efficient utilization of reserves of mineral deposits. Norms are set for the correct, cultural, passport execution of the development system as a whole and in details, taking into account strict and accurate compliance with all the requirements of safety rules, current technical and technological instructions, as well as accepted for implementation recommendations of research organizations (Birge, 2011:12).

Materials and methods of research. Research methods include technical and economic analysis, calculation-analytical, numerical, mathematical modeling. The relationship between the values of losses and dilution in the development of near-contact zones with different nature of contact with the need and sufficient accuracy is expressed analytically, which allows to set and solve optimization problems on rationing the completeness and quality of the explosion and transportation of minerals.

Modern mining and processing of minerals is impossible without losses and dilution, so to ensure rational subsoil use it is necessary to establish their normative values. Norming and planning of ore losses and dilution is one of the most difficult tasks of the problem of rational and efficient use of mineral deposits reserves. Norms are set for correct, passport execution of the development system as a whole and in details, taking into account strict and accurate compliance with all requirements of safety rules, current technical and technological instructions, as well as accepted for implementation recommendations of research organizations. At present, when assessing the completeness of subsoil reserves utilization, first of all (and not rarely exclusively) the emphasis is placed on the indicator of mineral losses. At gross development of complex-structured deposits or a group of deposits of simple structure with different mining-geological and mining-technical conditions of their working out losses and dilution is expedient and possible to rationize by slaughter providing thus a minimum of total losses at an optimum level of quality of the general mining flow content of harmful or useful components (Dare-Bryan, 2004:19).

Depending on the specific conditions of comprehensive development of mining faces, the use of face standardisation methods can reduce mineral losses in the subsoil by up to 30% compared to the standards established by current industry guidelines. Significant research in the field of economic assessment of mineral extraction from the subsoil, as well as in the methodology for standardising qualitative and quantitative losses in the extraction process, has been carried out by scientists such as A.S. Astakhov, M.I. Agoshkov, Yu.M. Adigamov, B.N. Baikov, P.P. Bastian, M.I. Glazer, G.G. Lomonosov, A.N. Omelene, V.P. Ryzhov, N.V. Melnikov, A.A. Sergeev, G.V. Sekisov, V.N. Zaraysky, V.P. Nurpeisova, M.B. Rakishev, B.R. Begalinov, S.K. Moldabaev, K.A. Yusupov and others. Under the guidance of Academician M.I. Agoshkov, standard methodological recommendations were developed for the standardisation, accounting and economic assessment of losses of solid minerals during their extraction. Were the basis for the development and implementation of relevant guidance documents in all sectors of the mining industry (Splate, 2014:13). At the same time at gross development of complex-structured fields or a group of fields of simple structure differing from each other conditions of development of near-contact zones and formation of the general flow of extracted raw materials of regulated quality, the use of available methods does not allow to establish the optimal values of excavation parameters in the faces providing the minimum possible level of total losses in the subsurface (Zaršenas, 2016).

Results. Therefore, to achieve the above research goal the following tasks were solved:

1) Strict analytical expressions of the relationship between the values of dilution losses and technological parameters of excavation for various mining-geological and mining-technical conditions of bulk mining of mining blocks characterized by the presence of aged contacts, and for the conditions of mining contacts of unaged character algorithms of numerical calculations to determine the corresponding functional relationships in approximate form have been developed.

2)The methodology of downhole operational normalization of quality of excavation for a set of mining faces developed by the gross method is developed (Matthews, 2015:4). In the paper, drilling operations were provided for profiles 0, 1 and -1. It is planned to drill a total of 6 inclined core holes, parallel to each profile on each side of the ore stockwork. Project wells are laid at drilling angle 75-800 (from the horizon) with further curvature up to 40-450 by analogy with previously drilled wells at the deposits. The well information is summarized in Table 1.

Table 1-Information on project blocks

Binding	Design depth, m
1 bloc	230
2 bloc	320
3 bloc	380

These profiles were chosen because they pass through the most productive and deep part of the deposit. Next, we examine the sensitivity map, which can be used to analyze how well the GPR line of sight corresponds to the expected offset direction. This map is very important when selecting alarm thresholds.

The range of the sensitivity map is [0 ÷ 1]

- Sensitivity map value = 0: this is the lowest sensitivity (slope direction is mutually perpendicular to the GPR line of sight).

- Sensitivity map value = 1: this is the highest sensitivity (slope direction is parallel to the GPR line of sight).

The use of this map allows to promptly assess the conditions of GPR equipment operation and adjust the monitoring parameters depending on the geomechanical situation in the quarry (Figures 3).

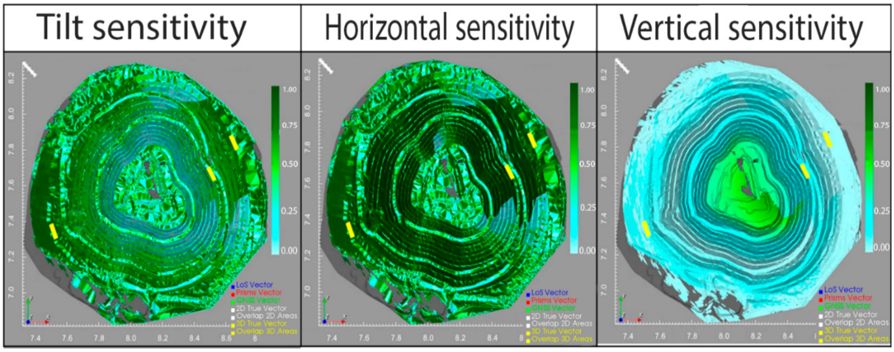

Figure 3. IBIS ArcSAR sensitivity map (FPM configuration)

Development of complex deposits of valuable multi-grade gold-bearing ores is associated with the difficulty of not only choosing a development system, but also to establish the relationship between the main parameters of the systems of technical and economic indicators of various mining and geological conditions. An example of special complexity of development of valuable multigrade ores is Vasilkovskoye gold-bearing deposit, represented by a thick declivity of solid sulfide, oxidized and differently disseminated ores. The complexity of the deposit development is determined by the fact that the richest continuous sulfide ores mined primarily by open pit in this deposit are faulted, confined to the bottom part of the intrusion, disturbed by tectonic fractures and have complex hypsometry of ore body contacts in combination with extremely unstable rocks. The thickness of rich ores within the deposit is constant varying from 1.0 to 45 m, disseminated ores reach a thickness of 90 m (Xingwana, 2016:149).

Table -2 Results of sieve analysis and distribution of gold by size class of open pit ore sample crushed to 2.5 mm.

Coarseness classes, mm	Output		Gold content, g/t	Distribution, %
	g	%		
-2.5+1.25	78.3	4.04	10.8	7.49
-1.25+0.8	600	30.02	7.2	37.11
-0.8+0.56	230	11.86	5.6	11.41
-0.56+0.40	166.8	8.0	7.6	10.50
-0.40+0.30	112.7	5.81	5.6	5.570
-0.30+0.20	126.8	6.54	5.2	5.88
-0.20+0.15	51.8	2.99	6.2	3.18
-0.15+0.1	84.0	4.38	4	2.99
-0.1+0.074	56.1	2.89	5.4	2.68
-0.074 seeded	73.4	3.78	4.8	3.14
-0.074washed	353	18.9	3.1	10.15
Total	1940	100	5.8	100

The level of losses and dilution of multigrade ores at advanced development is largely determined by the complexity of the hypsometry of the soil and the roof of the ore body and the adopted mining technology (Ebrahimi, 2013:4). The sieve and chemical analysis of open pit ore and dump ore was carried out and the results obtained are shown in Table 1 and 2.

Table 3 - Results of sieve analysis and distribution of gold by size class of ore sample from dumps, from crushed to -2.5 mm

Coarseness classes, mm	Output		Gold content, g/t	Distribution, %
	g	%		
-2.5+1.25	92.0	4.6	4.2	9.15
-1.25+0.8	409.8	20.49	2.8	27.4
-0.8+0.56	204	10.2	2.4	11.65
-0.56+0.40	183.2	9.16	2.5	10.9
-0.4+0.20	92.0	4.6	4.2	9.15
-0.20+0.15	70	3.5	2.0	3.28
-0.15+0.1	79	3.95	1.7	3.15
-0.1+0.074	52.6	2.63	2.2	2.8
-0.074 seeded	83	4.15	1.7	3.4
-0.074washed	576	28.8	1.2	16.85
Total	2000	100	2.1	100

In Table 1 and 2 the same value of ore grade was obtained in different grades. In the conditions of the deposit under consideration, the excavation of rich ores in each block is started with the sinking of cuttings located in the soil of the ore body. We examined it for testing under an optical microscope. The electron microscope results are shown in Figure 4.

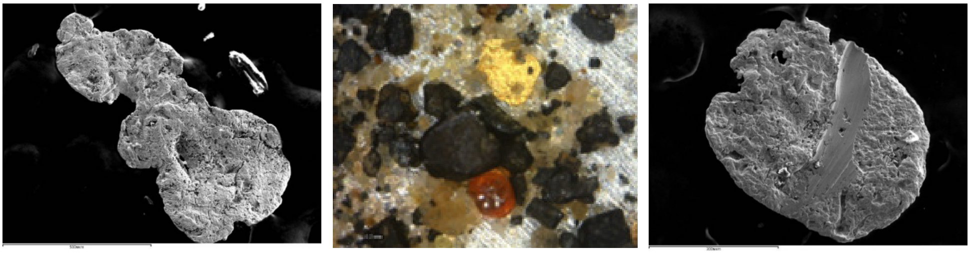

Figure 4. Clastogenic free native gold (size class -0.5+0.25 mm). The surface of gold particles in back-scattered electrons

Due to the variability of elements of occurrence of the lower contact of the ore body, during sinking there are inevitable deviations of the sub-base of the workings from the soil of the ore body. The magnitudes of such deviations and their frequencies are not constant. The most frequent deviations are up to 1.0 m. As an example, let us consider the distribution of deviations of the footings from the soil. In the section with length of 172m of horizon - 175m of the ore body.

Table 4. Static characteristics of ore body soil block deviations

Deviations, m	Empirical		Theoretical	
	Frequencies	Probability, %	Frequencies	Probability, %
0-1	100	68	117	68
1-2	65	48	48	28
2-3	7	4	7	4

Comparison of the empirical and theoretical distributions allows us to consider that the deviations under consideration obey the normal distribution law. Some discrepancy between empirical and theoretical frequencies is explained by the fact that in any statistical series there are always elements of randomness, violations of the smoothness of the function under consideration. Smoothing the influence of random deviations can be achieved only by increasing the number of observations. To analyze and calculate the permissible theoretical level of ore losses and dilution, which are of important economic importance for each mining enterprise, it is proposed to allocate a conditional near-contact zone at the contacts of the ore body, one boundary of which would exclude dilution, and the other - ore losses. Depending on the complexity of ore body contacts and cleaning technology, the capacity of the near-contact zone, and therefore ore losses and dilution, will vary.

Together with technical and economic indicators, the probability of controlling the contact of the ore body also changes. Such probability is the highest in exploration workings, therefore, depending on the purpose of workings, the estimated boundary of workings can be set and according to economic indicators to the required probability of control of ore contact.

To enhance blast planning accuracy, OrePro 3D software was employed. Integrated into production workflows, it offers functionality for evaluating financial outcomes of various mining scenarios, particularly useful for structurally complex deposits. Developed in cooperation with major mining companies, OrePro 3D provides detailed modeling of rock mass displacement after blasting. It uses initial data such as blast designs, block models, and post-blast survey results to simulate ore redistribution and calculate displacement vectors, enabling accurate prediction of ore content in the post-blast rock mass.

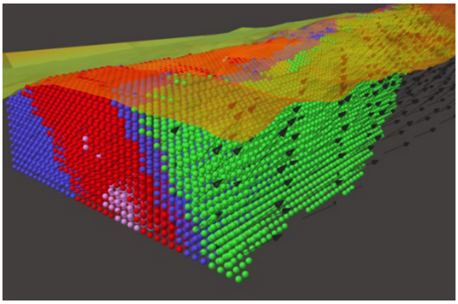

Figure 5. General position of the rock mass on the 3D image

For effective separation of ore mass and waste rocks, as well as improving the effectiveness of subsequent mining and processing operations, an accurate understanding of the direction and nature of the displacement of the rock mass after blasting is of fundamental importance. This information is of significant value to the mining company, allowing it to minimize losses and dilution of ore.

The thickness of the near-contact zone for determining theoretical indicators of ore loss and dilution in the development of complex deposits is established by the formula

$$M = 6\sqrt{\delta_{К}^{2} + \delta_{С}^{2}}, м$$

where $\delta_{К}^{2}$— standard deviation of ore body contact, m

$\delta_{С}^{2}$— RMS deviation of the direction of the borehole or hole, m.

Due to the fact that the deviations of boreholes as a rule are small and do not exceed their diameter, the value of borehole stripping can be neglected. Then the power of the contact zone is determined by the following formula.

$$M_0 = 6\delta_{К}, m$$

Table 3 summarizes the thicknesses of the near-contact zone in the ore body soil in several worked-out stripping faces. The thickness of the near-contact zone reached the highest values of 1.5-1.9 and 2.5-2.9 where there are significant tectonic disturbances with displacement amplitude up to 6 meters.

The cutting ledges in the blocks under consideration were cut by shallow borehole method and strictly followed the soil of the ore body. The movement of the ledge per cycle was about 1.6-1.8 m. With the increase in the length of the rectilinear section of sinking and at ore stripping by boreholes, the estimated thickness of the contact zone, as well as losses and dilution of ore, all other things being equal, increase (Camara, 2018:8).

Table 5- Change in the thickness of the contact zone on the cleaning ledges

Design depth, m	Sum of squared deviation m^2	Number of measurements m^2	Mean square deviation, m	Capacity of the near-contact zone M,m
100	12.4	12	1.02	6.1
150	4.71	12	0.75	4.3
200	14.8	14	1.05	6.3
250	24.6	17	1.3	7.4
300	4.13	17	0.52	3.1
350	3.8	22	0.43	2.6
400	0.13	17	0.03	0.2
410	1.8	23	0.35	1.4
420	3.2	24	0.26	2.3
450	3.04	26	0.22	2.1

The data of table 5 show that in the conditions of the considered deposit at small borehole stripping and bottom-hole movement about 10 m the average thickness of the contact zone is 3.6 m and at stripping by wells of 16 m length it increases up to 12.6 m. But in the case if the contact of the ore body is maintained the thickness of the contact zone is determined by formula 2 and for the conditions of ore stripping by wells of 16 m length it would be necessary to take it equal to 3.8 m

Table 6-Variation of the contact zone power depending on the length of the rectilinear section

Length of rectilinear section, m	Standard deviation, m			Contact zone thickness, m
	Contact of the ore body	Direction of borehole or hole	Total	
1	0.32	0.02	0.354	1.7
2	0.61	0.04	0.705	3.2
4	1.16	0.08	1.17	4.1
8	1.33	0.16	1.40	5.6
16	2.01	0.32	2.21	7.1
32	2.68	0.64	2.81	8.3

After establishing the thickness of the near-contact zone, the permissible theoretical values of ore loss and rock blasting are determined based on the condition of the normal law of deviation distribution and the accepted probability of controlling the contact of the ore body. For this purpose, Table 5 is drawn up, where the values of ore losses and undermining of rocks are given in the values of standard deviation. In addition to Table 5, a graph of the dependence of ore losses and rock blasting on the thickness of the near-contact zone and the probability of controlling the contact of the ore body was plotted.

Comparison of theoretical and actual values of rock undermining in blocks is given in table 5, according to which the actual value of undermining reaches on average 0.95 m with a probability of control of the ore body contact of 90%, and the theoretical one with the same probability should be 0.8m (Figure 5), i.e. slightly less. For calculations of theoretical indicators of losses and dilution take the probability of control of the ore body contact about 98%, then the value of undermining of soil rocks will reach 1.2 m. When calculating the permissible indicators of ore loss and dilution for the conditions of Vasilkovskoye deposit, the shape of the bottom of blocks depending on the method of ore delivery was taken into account.

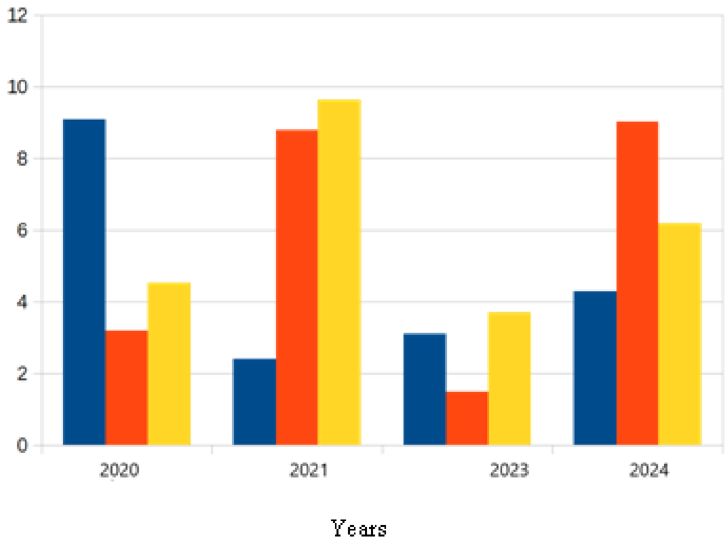

Figure 6-Definitions of the amount of losses, dilution and profit of ore

Discussion. Similarly, it is possible to determine the permissible amount of ore loss and rock blasting in the mine; however, in the conditions of the Vasilkovskoye deposit, with unstable rocks on the immediate side of the quarry, the use of this technique is difficult due to significant self-collapses of rocks from the sides of the ledge during mining operations.

Table 7—Change in ore losses and rock blasting depending on the probability of ore body contact

Probability of monitoring ore body contact, %	Ore loss	Rock blasting	Commercial ore mining
0.1	3.0	0.001	0.001
20	1.04	0.2	2.16
50	0.5	0.5	3.00
60	0.4	0.65	3.25
70	0.3	0.83	3.53
80	0.2	1.04	3.84
90	0.10	1.39	4.28
95	0.05	1.69	4.64
98	0.02	2.08	5.05

The application of the photometric method of shooting consists of photographing the track rim of the excavation contour with a rod with two light bulbs located at a distance of 50 cm from each other. The outer contour characterizes the profile, and the inner one is necessary to determine the scale of the survey and calculate the arch area.

Table 8 - The amount of soil rock blasting in the mining blocks depending on the probability of monitoring the contact of the ore body

Blocks	Thickness of the contact zone, m	Theoretical erosion of soil rocks at =0.98 m^3/m^2	Actual deviation of the base of the ore body, m	Actual probability of ore body contact control
1.5-1.9	6.0	2.1	0.7	0.91
2.0-2.4	4.2	1.5	1.55	1.01
2.5-2.9	6.2	2.2	2.4	1.02
3.0-3.9	7.2	2.5	2.1	0.81
4.0-5.5	3.0	1.05	0.81	0.82
6.0-8.0	2.5	0.9	0.55	0.72
8.5-11.0	0.2	0.1	0.45	0.62
11.5-13.0	1.5	0.5	0.81	1.02
13.5-16.0	2.2	0.8	0.61	0.82
16.5-21.0	2.0	0.6	0.55	0.85

Comparing the obtained cross-sectional profiles of blocks for rich (6) and disseminated (a) ores, one can see that rich ores are more suitable for mining in blocks 8 m wide, while unstable disseminated ores collapse and cause high dilution of rich ores (Camara, 2018:487). To reduce the dilution of rich ore and increase the safety of work, a temporary protective ore crust with a thickness of 0.5 to 2.5 m is often left in the working benches at the mine (Roldao, 2012:423).

During the experimental work, studies were carried out on the collapse of rocks of the immediate roof with bench widths of 4 and 8 m. In blocks 4 m wide, rock collapse averaged about 1.0-1.2 m, in blocks 8 m wide they reached 2.0-2.5 m with the formation of a vault with a height of 1/4 to 1/3 of the width of the blocks. When calculating the amount of losses and dilution, the theoretical area of the arch was taken

$$S = (0.196 - 0.26)B^2,$$

where B— ledge width.

Theoretical permissible indicators of dilution of rich ores during the development of the Vasilkovskoe deposit using a block system for an ore body with a thickness of 10 m were % for the extraction of benches 15, for the extraction between benches 21, for the system as a whole 18. Losses of rich ores should not exceed 2%.

The region groups indicators of ore dilution for various development system options; in area 2 - with mining systems with ore breaking from under block workings without leaving an ore crust in the quarry bench; in area 3 - with layered ore extraction and in area 4 - with systems with ore breaking from under bench workings and a temporary ore crust in the benches. Currently, when mining ore bodies with a thickness of 6 to 14 m in benches, the actual dilution of ore using the direct accounting method is 10-12%. When assessing the permissible level of losses and dilution of ore, it is very important to establish the maximum dilution at which the development of rich ores is still economically feasible.

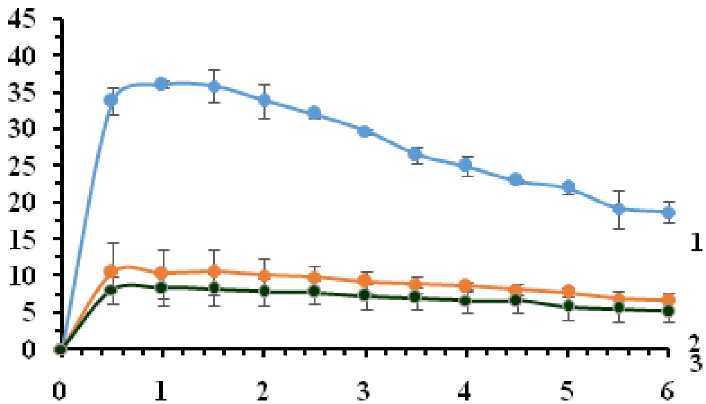

Figure 7- Determination of profit, dilution and losses in ore deposits where 1-ore profit 2 - ore dilution, 3- ore loss

Figure 7 shows profit dilution and ore loss. First of all, this relates to the excavation of a temporary ore crust at the base of the ledge. The maximum dilution of ore depends on the value of rich ores and diluting rocks, the thickness of the ore crust, and the additional production costs required for the extraction and processing of ores.

Conclusions. The purpose of this study was to develop a methodological approach to assess the impact that engineering factors have on the production cost chain from ore mining to processing. The study set the following objectives:

1)theoretical analysis and identification of the strengths and weaknesses of the “quarry-plant” concept, substantiation of the lack of a detailed methodological basis for assessing the effectiveness of monitoring ore mining parameters;

2) development of methodological recommendations for assessing the impact of losses and dilution indicators on the cost chain from ore mining to its processing;

3) practical assessment of the guidelines for the case of gold deposits. Based on the stated objectives, the study substantiates: the principle of economic evaluation based on continuous planning, analysis and control of the production process from the stage of ore mining to processing of the mineral product

Analytical and empirical dependences of the values of dilution losses and adjustable technological parameters of excavation on mining-geological and mining-technical parameters have been established development conditions that allow the formation of optimization functions, the use of which expands the capabilities of the methodological provisions existing in the mining industry for operational regulation of losses in the quality and quantity of raw materials during mining. A method has been developed for face-to-face optimization of the ratio of the level of losses and dilution, taking into account the effect of averaging quality indicators in the overall flow of extracted raw materials formed by the totality of the working faces.

References

Abenov A., Nurpeissova M., Dosetova A., Miletenko N. (2025). A Novel Approach to Selecting Rational Supports for Underground Mining Workings. Civil Engineering Journal, 11(3). — P. 1217–1241. https://doi.org/10.28991/CEJ-2025-011-03-022 (in English).

D.K. Bekbergenov, G.K. Jangulo, R.K. Zhanakova, B. Bektur, M., & Polat, E. (2024). Investigation of the block caving geotechnology at deep horisons. News of NAS RK. Series of Geology and Technical scieences, 6(468). — P. 49–66 (in English).

Almenov T., Begalinov A., Bakhramov B. (2015). Sposob razrabotki krutopadayuщih jilnyh mestorojdenii [Method of developing steep-slope formations]. İnnovatsionnyi patent №30460 na izobretenie. Ministerstvo yustitsii Respubliki Kazahstan, Astana. Data podachi zayavki: 08.12.2014g. Zaregistrirovano v Gosudarstvennom Reestre izobretenii RK 23.09.2015g. (in Russian).

Blom M., Pearce, A.R., Stuckey P.J. (2019). Short-term planning for open pit mines: a review: International Journal of Mining, Reclamation and the Environment, 33(5). — P.318–339. https://doi.org/10.1080/17480930.2018.1448248 (in English).

Camara T.R., Peroni R. de L. (2016). Quantitative assessment of dilution caused by work performance. REM: International Engineering Journal, 69(4), — P. 487–490. https://doi.org/10.1590/0370-44672014690006 (in English).

Camara T.R., и др. (2018). Operational management of quarry dilution. Mining Technology, 128(1). — P. 1–8. https://doi.org/10.1080/25726668.2018.1470275 (in English).

Dare-Bryan P. K., Dowd P.A. (2004). Estimating ore losses and dilution - quantifying geological and engineering uncertainties. B PACRIM 2004). — P.19–22 (in English).

Dimitrakopoulos R. (2011). Strategic planning of mining operations under conditions of uncertainty. Journal of Mining Science, 47(2), — P.138–150. https://doi.org/10.1134/S1062739147020018 (in English).

Dimitrakopoulos R., Farrelly K.T., Godoy M. (2002). Moving beyond traditional optimization: grade uncertainty and the impact of risk in quarry design. Mining Technology, 111(1). — P.82–88. https://doi.org/10.1179/mnt.2002.111.1.82 (in English).

Ebrahimi A. (2013). Importance of Dilution Factor for Open Pit Mining Projects [онлайн]. http://www.srk.com.au/files/File/papers/dilution_factor_openpit_a_ebrahimi.pdf (in English).

Matthews T. (2015). Forecasting ore dilution and losses: strategies and considerations. In SME Annual Meeting, — P. 1-4, Denver, Kolorado (in English).

Moldabayev S.K., Adamchuk A.A., Toktarov A.A., Aben Ye., Shustov O.O. (2020). Numerical modeling of quarry slope stability based on a probabilistic approach. Naukovyi Visnyk Natsional'noho Hirnychoho Universytetu, 4. — P. 30–38. https://doi.org/10.33271/nvngu/2020-4/030 (in English).

Moldabayev S.K., Sdvyzhkova O.O., Babets D.V., Kovrov O.S., Adil T.K. (2020). Testing the technology of efficient use of excavator-truck complexes in deep quarries. Naukovyi Visnyk Natsional'noho Hirnychoho Universytetu, 6. — P. 29–34. https://doi.org/10.33271/nvngu/2021-6/02 (in English).

Nurpeissova M., Avenov A., Miletenko N., Dosetova A. (2023). A highly efficient monitoring procedure for the prediction of formation in copper ore. Eurasian Mining, 1. — P. 19–24. https://doi.org/10.7580/em.2023.01.04 (in English).

Rakishev B.R. (2022). Tekhnologicheskie resursy povysheniya kachestva i polnoty ispol'zovaniya mineral'nogo syr'ya [Technological resources for improving the quality and completeness of the use of mineral raw materials]. Izvestiya NAN RK. Seriya Geologii i Tekhnicheskikh Nauk, 2(422). — P. 116–124 (in Russian).

Roldao D., i dr. (2012). Combined use of lithology and grade modeling for risk analysis in Brazilian iron ore deposits. In Geostatistics Oslo 2012. — P.423–434. https://doi.org/10.1007/978-94-007-4153-9 (in English).

Splate M. (2014) Stochastic Long-Term Mine Planning at the LabMag Iron Ore Mine in Labrador, Canada. Master's Thesis, McGill University, Montreal, Canada (in English).

Torres W.F.N., i dr. (2018 Classical and stochastic methods of mine planning, current status and trends. REM - International Journal of Engineering, 71(2). — P.289–297. https://doi.org/10.1590/0370-44672016710165 (in English).

Xingwana L. (2016). Monitoring ore losses and dilution for mine-to-mill integration in deep gold mines: a survey-based study. Journal of the South African Institute of Mining and Metallurgy, 116(2). P.149–160. https://doi.org/10.17159/2411-9717/2016/v116n2a6 (in English).

Zarsenas J., Saidi G. (2016). Assessment of the risk of dilution in quarries. Arabian Journal of Geosciences, 9(209). — P. 1–11. https://doi.org/10.1007/s12517-015-2214-8 (in English).

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ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
Редакторы: *Д.С. Аленов, Ж.Ш.Әден*
Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 15.08.2025.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
20,5 п.л. Заказ 4.

РОО «Национальная академия наук РК»
050010, Алматы, ул. Шевченко, 28, т. 272-13-19