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Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

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CONTENTS

Abdullaev A.U., Kamberov I.M.
Possibilities of mercury studies in seismic hazard assessment and earthquake forecasting........8

Agzamova I.A., Abdurakhmanov B.M., Normatova N.R., Ermatova Ya.S., Agzamova N.Sh.
Forecast assessment of disturbances and fracturing during development of solid mineral deposits........18

Arystanov M.B., Zhandiyar A.G., Kaipbayev Y.T., Sultanbekova A., Nikam B.R.
A geospatial approach to managing irrigation water resources of the big almaty canal.....32

Babii K., Kiriia R., Smirnov A., Kuttybayev A., Mishchenko T.
Justification of parameters of a steeply inclined tubular conveyor of cyclic-flow technology at a deep open pit in Kryvbas........55

Bryukhanova N.N., Gladkikh V.A., Idigova L.M., Lepekhina Yu.A., Kondratiev V.V.
Engineering control of blast-induced seismicity and environmental safety in underground ore mining under complex geodynamic conditions........74

Evsyukov D.Yu., Pchelintseva S.V., Vakhrusheva I.A., Ermolaeva O.S., Modina M.A.
Geophysical investigation of technogenically disturbed areas for environmental assessment in Southern Russia........90

Galiyev S.Zh., Axanaliyev N.E., Sarsenbayev Y.Ye.
Justification of technological parameters and energy consumption of quarry excavators taking into account the quality of rock preparation for excavation........109

Hryhoriev Y., Lutsenko S., Hryhoriev I., Kuttybayev A., Kuantayev N.
Adaptive modeling of mining schedule using genetic algorithm in a dynamic environment........120

Ismailov V.A., Aktamov B.U., Yodgorov Sh.I., Yadigarov E.M., Avazov Sh.B.
Assessment of the possible seismic risk of residential buildings in the Samarkand region based on a scenario earthquake........135

Ismayilov S.Z., Aliyev I.N., Karimov I.C.
Real-time monitoring and statistical analysis: optimizing sand detection in oil wells.....155

Kazakov A.N., Khakberdiyev M.R., Qurbonov H.A., Turgunov Sh.Sh., Obidov M.I.
Effect of rock mass discontinuities on underground mine stability (Uzbekistan)............170

Kukartsev V.V., Stupina A.A., Khudyakova E.V., Stepantsevich M.N., Matasova I.Yu.
Diagnostics of the structure of crystalline materials of rock formations by the method of thermally stimulated depolarization........182

Medetov Sh.M., Zaidemova Zh.K., Suyungariev G.E.
Oscillatory dynamics of rigging operations in the development of exploration wells......196

Mustapayeva S., Nikolaeva S., Kabanov P., Omarova G., Assambayeva A.
New ammonoid records and gamma-spectrometry in the stratotype of the Beleutian regional substage (Central Kazakhstan) 215

Nurpeissova M., Menayakov K., Aitkazinova Sh., Nukarbekova Zh., Bakyt N.K.
Environmental and industrial safety of subsurface development near a nuclear power plant...231

Obeidat M.A., Shmoncheva Y.Y., Jabbarova G.V.
Immiscible displacement of Herschel–Bulkley fluids in porous media: a modified Buckley–Leverett approach...247

Sakhmetova G.E., Uralov B.K., Brener A.M., Turymbetova G.D., Absamatova Z.
System analysis of scaling problems while designing biogas plants in the context of energy..274

Salikhov T.K., Issayeva Zh.B., Onal H., Akhmetzhanov Zh.B., Atasoy E.
Using GIS technologies and traditional ground-based methods to analyze the vegetation cover of ecosystems in the West Kazakhstan Region...286

Satybaldina D., Teshebayev N., Shmitov N., Kissikova N., Zakarina A.
Methods for improving oil production efficiency using pumping units...........................303

Shalabaeva G.S., Abdimutalip N.A., Koishiyeva G.Zh., Ozler M.A., Toychibekova G.B.
Study of hydrological and geostructural changes in the koskorgan reservoir due to climatic changes...318

Suiintayeva S.Ye., Bakhtybayev N.B., Imangazin M.K., Andagulov D.T., Atageldiyev K.T.
Experience in the use of self-propelled drilling rigs to increase the efficiency of drilling and blasting operations with sublevel mining systems..................................332

Tolesh A.B., Mamitova A.D., Karlykhanov O.K., Tazhieva T.Ch., Kalmakhanova M.S.
Flow regulation of the Syrdarya River at Shardara under energy releases.......................345

Torekhanova M.T., Tleuzhanova G.B., Yeserkegenova B.Zh., Kadyrov Zh.N., Kadyrova B.B.
Innovative technical approaches to the development of automatic control systems for bitumen-chip spreading...362

Tynchenko V.S., Krasovskaya L.V., Ashmarina T.I., Kononenko R.V., Shtyrkhunova N.A.
Geomechanical justification of underground mining technologies for ore deposits in complex rock massifs from the standpoint of nature and resource conservation.............382

Zholtayev G.Zh., Rassadkin V.V., Umarbekova Z.T., Mashrapova M.A., Miniskul S.D.
Formation and development prospects of placer gold deposits in Southern Junggar.......396

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FORECAST ASSESSMENT OF DISTURBANCES AND FRACTURING DURING DEVELOPMENT OF SOLID MINERAL DEPOSITS

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Abstract. One of the priority areas of economic aspects of the social life of the republic is natural resources, among which mineral deposits play the most important role. In recent years, one of the trends in the development of the mining industry throughout the world is the involvement in the exploration and development of mineral deposits characterized by more complex engineering-geological, hydrogeological conditions and located in the deepest horizons. In this regard, man-made complications on the geological environment increase, the consequence of which is the development of unforeseen engineering-geological processes (EGP), leading to technological difficulties in the exploration and development of deposits. There are many cases when, due to insufficient study of the assessment and forecast of fracturing and disturbance of the extracted rock mass and their impact on stability, accidents occurred in mine workings, sometimes human casualties and in some cases mining operations were mothballed. When developing solid mineral deposits, the increase in extractable volumes of rocks, depths and underground mine workings leads to an increase in the role of technogenic factors in the formation of hydrogeological processes. Due to the increase in drilling and blasting operations and changes in mining schemes, the tendencies of technogenic processes that complicate the development of deposits not only increase, but also provoke the development of various hydrogeological and engineering-geological processes. Natural hydrogeological conditions change: movements, formation of underground waters, natural infiltration, dynamics of fissure waters under certain conditions of underground mining and tunneling operations, the influx of water into the adit face increases.

Ensuring high efficiency and operational safety at modern mining enterprises is virtually impossible without a comprehensive study, assessment, and forecast of the engineering and geological conditions of field development at all stages of exploration and operation.

Keywords: fracture, process, stability, excavation, porogenesis, engineering geology, rock

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ҚАТТЫ ПАЙДАЛЫ ҚАЗБАЛАР КЕН ОРЫНДАРЫН ИГЕРУ КЕЗІНДЕГІ БҰЗЫЛУЛАРДЫ ЖӘНЕ ЖАРЫЛУЛАРДЫ БОЛЖАМДЫҚ БАҒАЛАУ

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Аннотация. Республиканың әлеуметтік-экономикалық дамуының басым бағыттарының бірі табиғи ресурстарды тиімді пайдалану болып табылады, ал олардың ішінде пайдалы қазбалар кен орындары ерекше маңызды рөл атқарады. Соңғы жылдары әлемдік тау-кен өнеркәсібінде күрделі инженерлік-геологиялық және гидрогеологиялық жағдайлармен сипатталатын, терең көкжиектерде орналасқан пайдалы қазбалар кен орындарын барлау және игеру үрдісі кеңінен таралуда. Осыған байланысты геологиялық ортаға техногендік әсердің күшеюі байқалады, оның салдары ретінде күтпеген инженерлік-геологиялық процестердің (ЭГП) дамуы орын алады. Бұл жағдайлар кен орындарын барлау мен игеру барысында елеулі технологиялық қиындықтарға әкеледі. Өндірілетін тау-кен массасының жарылуы мен бұзылу үдерістерінің тұрақтылыққа әсерін бағалау және болжау мәселелерінің жеткіліксіз зерттелуі тау-кен жұмыстарында апаттық жағдайлардың туындауына себеп болады. Мұндай апаттар кей жағдайда адам шығынына, ал кейбір жағдайларда тау-кен жұмыстарының толық немесе ішінара тоқтауына әкеліп соғады. Қатты пайдалы қазбалар кен орындарын игеру кезінде тау жыныстарының көлемінің, игеру тереңдігінің және жерасты қазбаларының өндірістік ауқымының артуы гидрогеологиялық процестердің қалыптасуында техногендік факторлардың рөлін едәуір күшейтеді. Бұрғылау-жару жұмыстарының көлемінің ұлғаюы және тау-кен қазбаларының сұлбаларының өзгеруі кен орындарын игеруді күрделендіретін техногендік үдерістердің қарқын алуына ғана емес, сондай-ақ әртүрлі гидрогеологиялық және инженерлік-геологиялық процестердің дамуына да ықпал етеді. Нәтижесінде табиғи гидрогеологиялық жағдайлар елеулі өзгерістерге ұшырайды: жер асты суларының қозғалыс режимі мен қалыптасуы өзгереді, табиғи инфильтрация үдерістері күшейеді, жерасты тау-кен және туннельдік қазбалар жағдайында жарықшақ суларының динамикасы артады, сондай-ақ адиттік беттерге су келуі жиілейді.

Қазіргі заманғы тау-кен өндіруші кәсіпорындардың жоғары тиімділігі мен қауіпсіздігін қамтамасыз ету кен орындарын барлау мен пайдаланудың барлық кезеңдерінде олардың инженерлік-геологиялық жағдайларын кешенді түрде зерттеусіз, бағалаусыз және болжаусыз іс жүзінде мүмкін емес.

Түйін сөздер: жарықшақ, процесс, тұрақтылық, қазба, порогенез, инженерлік геология, тау жынысы

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ПРОГНОЗНАЯ ОЦЕНКА НАРУШЕННОСТИ И ТРЕЩИНОВАТОСТИ ПРИ ОСВОЕНИИ МЕСТОРОЖДЕНИЙ ТВЕРДЫХ ПОЛЕЗНЫХ ИСКОПАЕМЫХ

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Аннотация. Одним из приоритетных направлений экономического развития и социальной сферы республики является рациональное использование природных ресурсов, среди которых важнейшую роль играют месторождения полезных ископаемых. В последние годы одной из ключевых тенденций развития горнорудной промышленности во всём мире является вовлечение в разведку и отработку месторождений, характеризующихся более сложными инженерно-геологическими и гидрогеологическими условиями, а также залегающих на больших глубинах. В связи с этим возрастает техногенная нагрузка на геологическую среду, следствием чего становится развитие непредвиденных инженерно-геологических процессов (ИГП), приводящих к технологическим осложнениям при разведке и отработке месторождений. Известны многочисленные случаи, когда из-за недостаточной изученности, а также отсутствия надлежащей оценки и прогноза трещиноватости и нарушенности добычного массива горных пород и их влияния на устойчивость горных выработок происходили аварии, в том числе с человеческими жертвами; в отдельных случаях горные работы приходилось консервировать. При освоении месторождений твёрдых полезных ископаемых увеличение извлекаемых объёмов горной массы, глубины работ и протяжённости подземных выработок

усиливает роль техногенных факторов в формировании гидрогеологических процессов. Повышение интенсивности буровзрывных работ и изменение схем ведения горных работ не только усиливают проявление техногенных процессов, осложняющих разработку месторождений, но и провоцируют развитие различных гидрогеологических и инженерно-геологических явлений. При этом трансформируются природные гидрогеологические условия: изменяются режим и направления движения подземных вод, условия их формирования и естественной инфильтрации, а при подземном способе отработки - динамика трещинных вод; в отдельных случаях усиливается приток воды в забое штольни. Обеспечение высокой эффективности и безопасности работы современных добывающих предприятий практически невозможно без всестороннего изучения, оценки и прогноза инженерно-геологических условий разработки месторождений на всех стадиях их разведки и эксплуатации.

Ключевые слова: трещина, процесс, устойчивость, выработка, прогноз, инженерная геология, горная порода

Introduction Some researchers indicate that the strength and deformation properties of massifs are inextricably linked with the direction of fracturing, while others believe that with a sufficiently large ratio of the size of the considered section of the massif (H) to the size of the natural structural block (L), both the strength and deformation properties will be the same in all directions and will not depend on the direction of the crack systems (quasi-isotropy). Thus, one can cite dozens and hundreds of works on the study of engineering and geological conditions of MTPI. (Muller, 1971; Terzaghi, 1961.).

This study by Nekash Radouane, M. Boukelloul and M. Fredj published in the journal Procedia Earth and Planetary Science, "Stability Analysis of Underground Mine Workings and its Application in the Chaabet El Hamra Mine, Algeria," analyzes the stability of the room and pillar mining system of the Chaabet El Hamra zinc deposit in Algeria. It compares the pillar stress assessment method using the tension zone method (TIM) with finite element modelling (FEM) to assess safety, structural integrity and potential failure zones in a mine (Petukhova,1972; Radouane et al, 2015).

Literary review. Cala, Marek; Stopkovich, Agnieszka; Kowalski, Michal; Blayer, Mateusz; Cyran, Katarzyna; D'obyrne, Kajetan also studied the stability analysis of underground mine workings with complex geometry in their studies (Marek et al, 2016).

H.B. Sahu, N. Prakash and S. Jayanthu considered underground mining as a solution to environmental problems – a strategic approach to sustainable mining in the future. (Sahu et al, 2015).

However, the above mentioned should not be noted that in recent years, the funnel-shaped collapse of which occurred precisely during the processes of mineral extraction has become more frequent; the study of these phenomena will require the use of specific engineering-geological research, namely, the development of rock fracturing in the disturbance of the rock massif; the information does not allow use for specific deposits, especially for deposits located in mountain-folded areas and, in general, in the conditions of the MTPI of Uzbekistan, but gives general directions for the study of engineering-geological and hydrogeological conditions of the MTPI during exploration and it is possible to assess the reliability of the information obtained by comparison.

Khandiza deposit is located on the territory of Sariasi district of Surkhandarya region, in Surkhantau mountains (south-western spurs of Hissar range). The area of the field is characterized by sharply dissected mountainous relief with absolute heights of 1400-2000 m. The geological structure is mainly composed of complex-dislocated sedimentary, volcanogenic and metamorphic rocks interrupted by various igneous rocks. Khandizinskoye ore field includes the polymetallic deposit of the same name, gold-silver-polymetallic occurrence of Chinarsay site and a number of lead and zinc ore occurrences – Novasay, Chornova, Gurud, Yangaklyk and others. It is confined to the Khandizinskaya volcanotectonic structure, located on the eastern flank of the Effusive Fault, which controls the manifestations of Lower Carboniferous volcanism. These rock complexes are typical of folded geosynclinal areas and crystalline basement of platforms. The relationships of the individual rock complexes are complex – numerous tectonic faults of different orders, significant fracturing of rocks, and unequal extent and depth of distribution. (Agzamova et al, 2020).

In this regard, it is advisable to make a map of changes in engineering-geological, hydrogeological conditions by degree of stability during underground development in advance.

Materials and methods. The methodology of drawing up predictive maps of changes in hydrogeological and engineering-geological conditions is given, according to which we have built maps of Khandiza deposit. These maps are recommended to be built on the basis of geological and industrial assessment of explored and exploited deposits to take into account possible complications affecting the cost of extracted raw materials, as well as at the stage of underground mining for the correct choice of mining technology and measures to prevent negative consequences caused by unfavorable processes and phenomena. (Miraslanov 2015, Miraslanov et al, 2014)

The map identifies categories of areas with different degrees of engineering-geological stability: stable (unchanging); medium-stable (medium-changing); unstable (highly changing).

Analysis and generalization of engineering-geological materials allowed to draw up maps of forecasting changes in hydrogeological and engineering-geological conditions during field development. These maps are made in two variants. The first variant is a zoning map, which reflects the intensity of changes in engineering-geological conditions, where unchanging, weakly changing, strongly changing and very strongly changing areas are distinguished during mining.

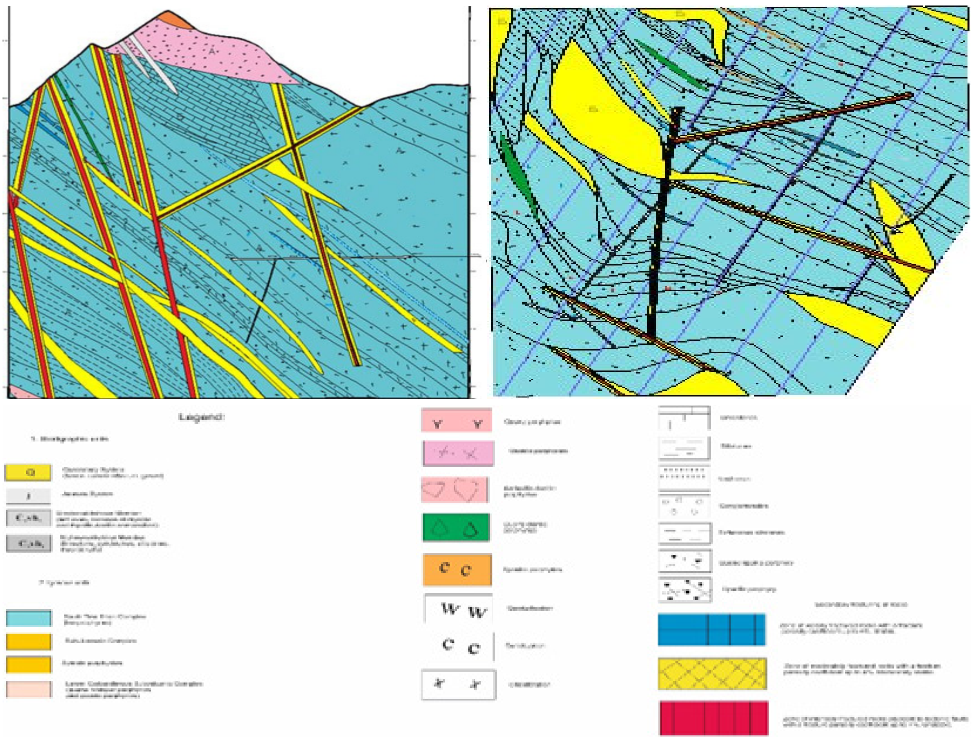
Results and discussions. The results of the conducted research allowed to use for practical purposes the method of multifactor engineering-geological forecasting taking into account disturbance and fracturing and their influence on the stability of mine workings. The peculiarities of lithologic structure of rocks, tectonic features, hydrogeological and engineering-geological conditions during the field exploitation were taken into account when selecting sites. The second option is the actual forecast of changes in engineering-geological conditions of mineral deposits.

The map is prepared according to the category of engineering-geological potentials of changes in natural conditions in connection with the proposed mining operations, based on the identified patterns of changes in engineering-geological characteristics of rocks, processes developed in them, as well as the predicted elements. In addition to the main data (geological-tectonic structure, hydrogeological conditions), such indirect data as geophysical (logging) materials, information on the condition of the support in the mine workings were used in drawing up this map.

When assessing the engineering-geological potential, a complex of the following factors is taken into account: composition and properties of rocks, depth of groundwater occurrence, engineering-geological processes and phenomena (expected collapses and extrusions in mine workings), as well as rock disturbance and fracturing.

The field is categorized as areas with varying degrees of engineering-geological resistance to changes in natural and mining conditions. feature No.1

Assessment of changes in engineering and geological conditions during underground mining (using the Navasai deposit as an example). scale 1:1000.



Let's consider categories with high engineering-geological potential (EGP), which means the sensitivity of the site to external impact, its margin of stability in relation to the engineering load.

Site "A" – stable unchanging, composed of sandstone, intersected by tectonic disturbances with zones of faults of coarse-grained porphyritic rocks, groundwater porosity is 0.35%, water yield 0.5-1.0%. Water flow rate of wells varies in the range Q = 0.004-0.007 l/s; specific flow rate q = 0.001-0.003 l/s; filtration coefficient Kf = 0.00035 m/day; water conductivity Km = 0.049-0.11 m3/day.

The rocks are massive strong, weakly and moderately fractured, characterized by high strength indices δsj = 49.4-70.2 MPa. The fracture void ratio (FDR) is 1-2.5%. Around the mine workings in some intervals, groundwater outlets of 0.001-0.094 l/s are possible.

Measures to improve hydrogeological and engineering-geological situation: it is necessary to carry out preventive works in some areas to centralize groundwater in separate, closely located sections, to use them as reservoirs for accumulation of groundwater with subsequent withdrawal to the surface (elimination of long-term accumulation of water). In the zones of fragmented and disturbed sections, it is necessary to fix them.

Site "B" – medium stable, medium-altered, with average engineering-geological potential, composed of rhyolite porphyries, in some intervals (sections) sandstones and siltstones, in the upper horizon weak and medium-altered massif with weak fracturing, monolithic, massive, there are numerous open fractures with CTP 2.5%, sediments poorly watered with occasional manifestation of fracture water, aquifers with poor water yield. Porosity is 0.37-0.95%, water yield is 1-3%. Water flow rate of wells is Q = 0.008-0.1 l/s; specific flow rate q = 0.004-0.006 l/s; filtration coefficient Kf = 0.00036-0.00087 m/day; water conductivity Km = 0.12-0.29 m^3/day; groundwater yields from 0.012 to 0.1 l/s. There are developed longitudinal and diagonal according to falling cracks, compressive strength from 40.5 to 60.2 MPa.

Measures to improve the hydrogeological and engineering-geological situation: it is necessary to prepare troughs for groundwater drainage in the nearest mine workings, sections, serving as containers for temporary accumulation of mine water in some areas; from the structural measures: strengthening of some weakened, highly fragmented areas in some intervals, systematically carry out works to centralize groundwater for drainage to the surface to prevent infiltration down to deep horizons.

Site "B" – unstable (highly variable) with low engineering-geological potential (EGP), composed of highly altered, wrinkled and fractured tuforiolite porphyries, intersected by tectonic disturbances with fault zones, in some intervals often interbedded sandstones, siltstones, siliceous-carbonate rocks. Porosity is 1.08-2.56% and water yield is 3.0-8.6%. Fractured groundwater, represented by several horizons and lenses, is confined to the zones of tectonic disturbances and crushing zones, cavernous rocks are water-bearing with strong water seepage, the flow rate of water seepage is up to 15 l/sec. Water flow rate of wells is Q = 0.015-0.055

l/s; filtration coefficient Kf = 0.00085-0.00088 m/day; fracture void ratio (FDR) 3-6.0%. The strength values are 3.25-3.31 MPa.

Measures to improve the hydrogeological and engineering-geological situation: it is necessary to develop ore deposits with consolidation of the excavated space in certain areas, as well as to concentrate groundwater and drain it to the surface, to prevent long-term accumulation. In the zones of fragmented and tectonically disturbed areas it is necessary to fix. Expected water inflow at this site (interval) is from 7.0 to 15.0 l/s.

Changes in the predicted main components of the geological environment in natural conditions are as follows: exogenous geological processes, fracturing and rock disturbance, physical and mechanical properties of rocks and hydrogeological conditions.

Of the exogenous geologic processes in natural conditions, the most common are weathering, crumbling, and blowing of rocks. They are confined to exposed areas under abundant precipitation in the valleys of sai valleys.

The construction according to the methodology is focused on taking into account important criteria and factors identified as a result of the conducted studies, as well as the relationship between the intensity of fracturing and core yields.

Significant difficulties in studying fracturing by core often arise when determining the core. Currently, there are several methods for orienting the core when it is torn off from the well bottom. However, in geological exploration work, as a rule, one has to deal with a core that is not oriented at the well bottom.

When studying the nature and degree of fracturing of rocks using drill hole cores, special attention is paid to the number of cracks per meter of core (specific fracturing), the height of core columns, the amount and nature of crushed material, and the presence or absence of a slip surface. These data are subsequently used as the basis for quantitative assessment (Golodkovskaya et al, 1975).

According to L.I. Petukhova (1972), when cores are not preserved and there is no quantitative description, the only reliable indicator is the core yield, which is recorded for each run for all wells, i.e., the material represented by the full volume of exploratory drilling can be used to predict fracturing. As a result of the study, a correlation was established between the intensity of fracturing and the core yield. This dependence is described in the range of 60≤K≤100% by the equation:

$$l = 6{,}9 - 0{,}2\ \mathrm{IK} + 0{,}0017\ \mathrm{K}^2,$$

where K – is the core yield, %; l – is the average size of the units along the borehole axis, m.

The correlation ratio in the equation is 0.81.

The following relationship is recommended for copper-pyrite deposits:

$$L = \left(\frac{\mathrm{K}}{100}\right)^{0,6}.$$

In the guidelines for predicting fracturing (R.A. Takranov, 1977), a relationship was established between the intensity of fracturing and the yield of core for coal deposits in Kuzbass:

$$И = \frac{а}{в},$$

where I – is the intensity of fracturing; b – is the core yield; a is the coefficient: for coals – 25, for host rocks – 10.

It follows from the above that different authors have described the corresponding dependencies for different rocks. The latter need to be clarified with differentiation by rock types that differ in drillability indicators, using a large amount of factual data and modeling results.

The borehole core can be used in another direction, as hairline cracks (under a binocular microscope) and microcracks. Since the elements of occurrence of macro- and microcracks mutually correlate (meaning that the genesis of cracks of the corresponding systems is the same), the occurrence of large disturbances can be used to preliminarily identify the main crack systems. And their intensity will be determined by the intensity of microcracks. However, quantitative relationships in this regard have not been developed.

Thus, the issues of studying rock fracturing are the subject of many scientists' works. The issues of the influence of fracturing on a number of engineering-geological indicators have been resolved. It follows from the review that the most poorly studied issue is the forecast of disturbance and fracturing during exploration.

Changes in the predicted main components of the geological environment under natural conditions are as follows: exogenous-geological processes, fracturing and disturbance of rocks, physical and mechanical properties of rocks and hydrogeological conditions.

Of the exogenous geological processes in natural conditions, the most common are weathering, crumbling, and blowing of rocks. They are confined to exposed areas with abundant precipitation in the valleys of the sais.

The analysis of the results of studies of engineering-geological characteristics of rocks shows that changes in physical and mechanical properties of lithological homogeneous rocks do not vary by area and depth. Their changes are connected with disturbance, fracturing and watering of the rock massif. The rock massif, depending on tectonic disturbance and the degree of fracturing, is divided into categories of areas: monolithic, weakly fractured, moderately fractured and strongly fractured.

1. Weakly fractured is characterized by the minimum density of cracks: 1-3 cracks per linear meter of core, 1-2 cracks per 1x1 m^2 of site. Fracture void ratio (FDR) is 0.1-0.3%. There are no changes in engineering and geologic conditions.

2. Medium fractured areas are located near discontinuities and in the zones of lower-order leading faults that do not have a crushing zone, where the density of 2-3 fractures per linear meter of core, 3-5 fractures per 1x1 m^2 of the site. The fracture

void ratio is 0.5-0.8%. The fracturing and physical and mechanical properties of rocks change, new cracks are formed, and the area of moisture around the mine workings increases.

3. Strongly fractured areas are located directly in the crushing zone, disturbances where the rocks are mostly fine-blocky. The fracture void ratio is 1-5.0%. The following characteristics are studied: stress, fracturing, physical and mechanical properties, hydrogeological conditions, stress concentration of the roof of the mine workings, reduction of block sizes, filling of cracks with water.

Analysis of changes in physical and mechanical properties of rocks shows that physical properties of rocks, except for ore, change within small limits. Specific gravity varies within 2.60 to 2.67 g/km^3, volumetric – within 2.57 to 2.65 g/km^3.

Thus, in natural conditions, the study area can be divided into two categories of areas of relatively safe mining operations: favorable and unfavorable. The first and second zones, i.e. massive and weakly fractured areas, where rocks are highly resistant, belong to the favorable territory. In these zones, no significant deformation in mine workings is observed. The second, unfavorable, area includes medium- and highly fractured areas where the rocks are medium-strength. Mine workings in these zones may develop cave-ins, rock falls and rock dome.

Particularly dangerous are the places where faults and watered crushing zones are crossed. In these areas, when approaching underground mine workings, cave-ins and dumps with high flow rates are possible, cases of groundwater breakthrough occur, and sometimes mining and tunneling operations are suspended.

Here the main question should be aimed at determining the state of the rock massif in connection with development, i.e. to assess the state of stability of mine workings and to predict the zones of formation of engineering-geological processes with possible types and places of formation. For these purposes, calculation methods are used. When selecting design characteristics of underground mining of rock massif, the main engineering-geological characteristics and their variability are taken into account.

The stability of the roof and walls of mine workings is assessed qualitatively and quantitatively. Qualitative assessment is based on the analysis of the identified factors affecting the behavior of rocks after mining. These factors are mainly unfavorably focused on the fracture system and discontinuities: weakened zones and sections, weakened mechanical properties of rocks, water cut and presence of karst voids. In addition, the mining and technical conditions of development, type, size, speed, method of penetration, etc. are of great importance for the intensity of development of various types of deformations and changes in equilibrium within the rock massif.

Quantitative assessment of the stability of underground mine workings is based on the classification of their roof by conditions (signs) of stability or collapse, which are based on the coefficient of potential stability, not fixed roof in the mine workings (S). This coefficient is determined by the formula:

$$S = \frac{m*\delta sj*R}{H*\gamma*q},$$

where m – thickness of the layer or layer separateness having the smallest connection with other blocks; δsj – limit of rock compressive strength in natural or water-saturated state, MPa; R – value inverse to the number of square meters of exposed and unfastened roof ($1m^2$); H – depth of rock occurrence (the block under consideration) from the ground surface, m; γ – average density of rocks above the roof, g/km^3; q – rock fracturing coefficient equal to the square root of the crack density (number of cracks per $1m^2$).

where m – layer thickness or layer separateness having the smallest connection with other blocks; δsj – compressive strength of rocks in natural or water-saturated state, MPa; R – value inverse to the number of square meters of exposed and unconfined roof ($1m^2$); H – depth of rock occurrence (the block under consideration) from the ground surface, m; γ – average density of rocks above the roof, g/km^3; q – rock fracturing coefficient equal to the square root of the crack density (number of cracks per $1m^2$).

According to the typification of P.V.Vasiliev and S.I.Malinin, the following stability categories are distinguished (Table 1).

Table1.Stability Category Table

Stability Category	Value of Potential Stability Coefficient “S”
Highly Unstable	Up to 0.8
Unstable	0.8 – 1.1
Low Stability	1.1 – 2.0
Moderately Stable	2.0 – 3.0
Highly Stable	3.0 – 5.0

To calculate the stability of the roof, characteristic in terms of rock disturbance and the most weakened areas are selected, as well as possible locations of operational mine workings.

Conclusion. To issue a forecast of engineering-geological conditions and, most importantly, disturbance and fracturing of the massif it is recommended to establish the type of the explored field according to the proposed typification and to find a similar developed field and study its conditions.

When selecting the analogous deposit, the following indicators for assessing the similarity of deposits are proposed: structural and tectonic structure of the massif, physical and mechanical properties of rocks, intensity of fracturing and the size of blocks according to the core.

On the basis of the analog deposit not only disturbance and fracturing, but also a number of other engineering-geological and mining-tectonic parameters are predicted (angles of laying of pit sides and ledges, engineering-geological processes, drilling and blasting parameters, oversize yield, losses and dilution, etc.).

There are three systems of fractures around each fault: concordant, normal-sectional and oblique-sectional. The strike of the latter and the fault differs on average by 30°.

Using exploration materials, typing and analogues, the following are predicted: the number and occurrence of fracture systems, the intensity of fracturing in depth, the presence of fracture propagation, as well as data on the length and width of fractures.

It is established that if there are no faults in the area, then there are three systems of cracks, if the faults are oriented in two or three directions, then we have to talk about 5-7 systems of cracks, and, finally, if the field has a series of differently oriented faults, there are 8-12 and more systems of cracks.

At the deposits layered, large fractures are developed mainly at the contacts of layers and rocks at right angles to the layering. At the boundary of ore, ore-bearing, different-type and different-age rocks, an increase in the intensity of fracturing is observed.

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