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

№2
2026

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

CENTRAL ASIAN ACADEMIC
RESEARCH CENTER

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

2 (476)

MARCH – APRIL 2026

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, 2026

The scientific journal News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences has been indexed in the international abstract and citation database Scopus since 2016 and demonstrates stable bibliometric performance.

The journal is also included in the Emerging Sources Citation Index (ESCI) of the Web of Science platform (Clarivate Analytics, since 2018).

Indexing in ESCI confirms the journal's compliance with international standards of scientific peer review and editorial ethics and is considered by Clarivate Analytics as part of the evaluation process for potential inclusion in the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), and Arts & Humanities Citation Index (AHCI).

Indexing in Scopus and Web of Science ensures high international visibility of publications, promotes citation growth, and reflects the editorial board's commitment to publishing relevant, original, and scientifically significant research in the fields of geology and technical sciences.

«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық рефераттивтік және ғылымиметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық рефераттивтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

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).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

Индексирование в Scopus и Web of Science обеспечивает высокую международную востребованность публикаций, способствует росту цитируемости и подтверждает стремление редакционной коллегии публиковать актуальные, оригинальные и научно значимые исследования в области геологии и технических наук.

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
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 Communications of the Republic of Kazakhstan Nº KZ50VPY00121155, issued on 05.06.2025
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/

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктеуші: «Орталық Азия академиялық ғылыми орталығы» ЖШС (Алматы қ.).
Қазақстан Республикасының Ақпарат және коммуникациялар министрлігінің Ақпарат комитетінде 05.06.2025 ж. берілген № KZ50VPY00121155 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 technology 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 коммуникаций и Республики Казахстан № KZ50VPY00121155, выданное 05.06.2025 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/

CONTENTS

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 2.
Number 476 (2026), 223–252

https://doi.org/10.32014/2026.2518-170X.626

UDC: 622.272
IRSTI: 52.13.04

©Kuldeyev Ye.[1], Negmatov S.[2], Nurpeissova M.[1]*, Kirgizbaeva D.[1], Donenbayeva N.[3], 2026.
[1]Kazakh National Research Technical University named after K.I. Satbayev, Almaty, Kazakhstan;
[2]Tashkent State Technical University named after I. Karimov, Tashkent, Uzbekistan;
[3]Eurasian National University named after L.N. Gumilyov, Astana, Kazakhstan.
E-mail: marzhan-nurpeissova@rambler.ru

GEODYNAMIC POLYGON OF THE ZHILANDY ORE FIELD: RESULTS AND PROSPECTS

Kuldeyev Yerzhan — Candidate of technical sciences, Professor, Satbayev University, Almaty, Kazakhstan,
E-mail: kuldeev_erzhan@mail.ru, https://orcid.org/0000-0001-8216-679X;
Negmatov Soibjon — Doctor of Technical Sciences, Professor, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan,
E-mail: s.s.negmatov@mail.ru, https://orcid.org/0000-0002-4276-2607;
Nurpeissova Marzhan — Doctor of technical sciences, Professor, Satbayev University, Almaty, Kazakhstan,
E-mail: marzhan-nurpeissova@rambler.ru, https://orcid.org/0000-0002-3956-5442;
Kirgizbaeva Dinara — PhD, Associate Professor, Satbayev University, Almaty, Kazakhstan,
E-mail: d.kirgizbaeva@satbayev.university, https://orcid.org/0000-0002-5043-4275;
Donenbayeva Nazgul — PhD, Senior lecturer, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan, E-mail: donenbayeva_ns@enu.kz, https://orcid.org/0000-0003-15830-0746.

Abstract. The features of geomechanical processes and ways of addressing them at the mines of the Zhilandinsky ore field of Kazakhmys Corporation are considered. The aim of this work is to improve industrial and environmental safety in the development of the Zhilandinsky group of deposits through совершенинg monitoring methodologies, forecasting hazardous geotechnical processes, and managing these processes by developing reinforcing mixtures based on industrial waste. *Methodology.* A comprehensive approach was applied, including engineering–geological analysis of the structural and tectonic framework of the rock mass with detailed mapping of disturbed zones, faults, and crushed rock areas using modern instruments and monitoring tools, as well as control of deformation processes in open pits and underground workings using strengthening solutions developed by the authors. *Results.* For reliable forecasting and prevention of hazardous geomechanical and geodynamic phenomena in the Zhilandinsky ore field area, a geodynamic testing site has been established, incorporating modern measurement systems and industrial safety support tools. Using the facilities of this geodynamic site, important patterns of crack formation and rock mass collapse have been identified, and methods for their prevention have been substantiated. The novelty of the developed methods and tools is confirmed by patents of the Republic of Kazakhstan included in the Derwent patent database.

The research results have been implemented at operating mining enterprises within the projects "Comprehensive monitoring of slow deformation processes of the earth's surface during large-scale development of ore deposits in Central Kazakhstan" and "Development of a highly efficient methodology for monitoring the geotechnical condition of the rock mass and methods for managing deformation processes," and have also been used in the educational process at Satbayev University.

Keywords: rock bursts, geodynamics, tectonic structure, stress–strain state, rock mass, geomechanical monitoring, stabilizing (or reinforcing) grouts

Financing. This study was carried out within the framework of the State Fund of the Ministry of Science and Higher Education of the Republic of Kazakhstan (AP 26100471).

For citations: *Kuldeyev Ye., Negmatov S., Nurpeissova M., Kirgizbaeva D., Donenbayeva N. Geodynamic Polygon of the Zhilandy Ore Field: Results and Prospects. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. 2026. No.2. Pp. 237–252. DOI: https://doi.org/10.32014/2026.2518-170X.626*

©Көлдеев Е.[1], Негматов С.[2], Нұрпейісова М.[1], Қырғызбаева Д.[1], Дөненбаева Н.[3], 2026.

[1]Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті, Алматы, Қазақстан;

[2]И. Каримов атындағы Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан;

[3]Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан;

E-mail: marzhan-nurpeissova@rambler.ru

ЖЫЛАНДЫ РУДАЛЫҚ АЛАҢЫНЫҢ ГЕОДИНАМИКАЛЫҚ ПОЛИГОНЫ: НӘТИЖЕЛЕРІ ЖӘНЕ КЕЛЕШЕГІ

Көлдеев Ержан — техника ғылымдарының кандидаты, профессор, Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті, Алматы, Қазақстан,
E-mail: kuldeev_erzhan@mail.ru, https: //orcid.org/0000-0001-8216-679X;

Негматов Сайибжан — техника ғылымдарының докторы, профессор, Ислам Каримов атындағы Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан,
E-mail: s.s.negmatov@mail.ru, https: //orcid.org/0000-0002-4276-2607;
Нұрпейісова Маржан — техника ғылымдарының докторы, профессор, Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті, Алматы, Қазақстан,
E-mail: marzhan-nurpeissova@rambler.ru, https: //orcid.org/0000-0002-3956-5442;
Қырғызбаева Динара — PhD, қауымдастырылған профессор, Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті, Алматы, Қазақстан,
E-mail: d.kirgizbaeva@satbayev.university, https://orcid.org/0000-0002-5043-4275;
Дөненбаева Назгул — PhD, аға оқытушы, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан,
E-mail: donenbayeva_ns@enu.kz, https: //orcid.org/0000-0003-15830-0746.

Аннотация. «Қазақмыс» корпорациясының Жыланды кен алабы кеніштерінде геомеханикалық процестердің көріну ерекшеліктері және оларды шешу жолдары қарастырылған. *Жұмыстың мақсаты. М*ониторинг жүргізудің әдістемесін жетілдіру, қауіпті геотехникалық процестерді болжау және ол процестерді басқару үшін өндіріс қалдықтарынан нығайтқыш қоспалар әзірлеу арқылы Жыланды кен орындары тобының игерілуінің өндірістік және экологиялық қауіпсіздігін арттыру. *Әдістемесі.* Заманауи аспаптар мен мониторинг құралдарын пайдалана отырып, жарықшақталып бұзылған учаскелерді, уатылып опырыла құлаған тау жыныстары аймақтарын егжей-тегжейлі картаға түсіру негізінде тау жыныстары массивінің құрылымдық-тектоникалық құрылысына инженерлік-геологиялық талдау жүргізуді, сондай-ақ карьерлер мен жерасты қазбаларындағы деформациялық процестерді авторлар әзірлеген нығайтқыш ерітінділер арқылы басқаруды қамтитын кешенді тәсіл қолданылды. *Нәтижелері.* Жыланды кен алабы ауданында қауіпті геомеханикалық және геодинамикалық құбылыстарды сенімді болжау және алдын алу үшін құрамына заманауи өлшеу кешендері мен өндірістің өнеркәсіптік қауіпсіздігін қамтамасыз ету құралдары кіретін геодинамикалық полигон құрылды. Геодинамикалық полигон құралдарын қолдану арқылы тау жыныстары массивінде жарықшақтардың пайда болуы мен опырылу заңдылықтары анықталып, олардың алдын алу тәсілдері негізделді. Әзірленген әдістер мен құралдардың жаңалығы Қазақстан Республикасының өнертабыс патенттерімен расталған және Derwent патенттік деректер базасына енгізілген.

Зерттеу нәтижелері «Орталық Қазақстан кен орындарын ірі ауқымда игеру кезінде жер бетінің баяу деформациялық процестерін кешенді мониторингтеу» және «Тау жыныстары массивінің геотехникалық жағдайын бақылаудың жоғары тиімді әдістемесін әзірлеу және деформацыиялық процестерді басқарудың әдістерін әзірлеув» жобаларын іске асыру барысында қолданыстағы тау-кен кәсіпорындарында енгізілді, сондай-ақ Satbayev University оқу процесінде пайдаланылды.

Түйін сөздер: тау-кен соққысы, геодинамика, тектоникалық құрылым, кернеулі-деформациялық жай күй, тау жыныстарының массиві, геомеханикалық мониторинг, беріктеуіш ертінділер

©Кульдеев Е.[1], Негметов С.[2], Нурпеисова М.[1], Киргизбаева Д.[1], Доненбаева Н.[3], 2026.

[1]Казахский национальный Исследовательский технический университет имени К.И. Сатпаева, Алматы, Казахстан;

[2]Ташкентский государственный Технический университет имени И.Каримова, Ташкент, Узбекистан;

[3]Евразийский национальный университет имени Л.Н. Гумилева, Астана, Казахстан.

E-mail: marzhan-nurpeissova@rambler.ru

ГЕОДИНАМИЧЕСКИЙ ПОЛИГОН ЖИЛАНДИНСКОГО РУДНОГО ПОЛЯ: РЕЗУЛЬТАТЫ И ПЕРСПЕКТИВЫ

Кульдеев Ержан — кандидат технических наук, профессор, Казахский национальный Исследовательский технический университет имени К.И. Сатпаева, Алматы, Казахстан, E-mail: kuldeev_erzhan@mail.ru, https://orcid.org/0000-0001-8216-679X;

Негматов Сайибжан — доктор технических наук, профессор, Ташкентский государственный Технический университет имени И.Каримова, Ташкент, Узбекистан, E-mail: s.s.negmatov@mail.ru, https://orcid.org/0000-0002-4276-2607;

Нурпеисова Маржан — доктор технических наук, профессор, Казахский национальный Исследовательский технический университет имени К.И. Сатпаева, Алматы, Казахстан, E-mail: marzhan-nurpeissova@rambler.ru, https://orcid.org/0000-0002-3956-5442;

Киргизбаева Динара — PhD, ассоциированный профессор, Казахский национальный Исследовательский технический университет имени К.И. Сатпаева, Алматы, Казахстан, E-mail: d.kirgizbaeva@satbayev.university, https://orcid.org/0000-0002-5043-4275;

Доненбаева Назгуль — PhD, старший преподаватель, Евразийского национального университета имени Л.Н. Гумилева Астана, Казахстан, E-mail: donenbayeva_ns@enu.kz, https://orcid.org/0000-0003-15830-0746.

Аннотация. Рассмотрены особенности проявления геомеханических процессов и пути их решения на рудниках Жиландинского рудного поля Корпорация «Казахмыс». *Целью работы* является повышение промышленной и экологической безопасности разработки Жиландинских групп месторождений на основе совершенствования методики ведения мониторинга, прогнозирования опасных геотехнических процессов и управления этими процессами путем разработки укрепляющих смесей из отходов производства. *Методология.* Использован комплексный подход, включающий инженерно-геологический анализ структурно-тектонического строения горного массива с детальным картированием нарушенных участков, разломов, зон дроблёных пород на основе использования современных приборов и средств мониторинга, а также управления деформационными процессами на карьерах и подземных выработках укрепляющими растворами, разработанных авторами. *Результаты.* Для надежного прогнозирования и предотвращения опасных геомеханических и геодинамических явлений

в районе Жиландинског рудного поля создан геодинамический полигон, состав которого входят современные измерительные комплексы и средства обеспечения промышленной безопасности производства. С применением средств геодинамического полигона выявлены важные закономерности проявления трещинообразования и обрушения массива горных пород и обоснован способ их предотвращения. Новизна разработанных методов и средств подтверждена патентами на изобретения РК, включёнными в патентную базу данных Derwent.

Результаты исследовании внедрены на действующих горно-добывающих предприятиях при выполнении проектов «Комплексный мониторинг медленных деформационных процессов земной поверхности при крупномасштабном освоении рудных месторождений Центрального Казахстана» и «Разработка высокоэффективной методики мониторинга за геотехническим состоянием горного массива и управления деформационными процессами», а также использованы в учебном процессе Satbayev University.

Ключевые слова: горные удары, геодинамика, тектоническая структура, напряжённо-деформированное состояние, массив горных пород, геомеханический мониторинг, укрепляющие растворы

Introduction. Technogenic seismicity is significant challenge arising during large-scale mining operations in complex rock massifs. It can result in severe technical and economic consequences, such as technogenic earthquakes, rock bursts, and landslides, and in some cases, even lead to human casualties. This issue is underscored by findings presented at the International Symposium on Rock Bursts and Mine Seismicity in Mines (Rockburst, 2005; Melnikov, 2010).

Management of technogenic seismicity has garnered increasing attention, as evidenced by growing number of publications addressing this topic (Trubetskoy, 2020; Mikhailova et al., 2018; Rylnikova et al., 2016).

Geodynamic support for development of solid mineral deposits is typically based on engineering approaches tailored to specific mining and geological conditions. However, such approaches often fail to account for structural features of underworked strata, as well as physical and mechanical properties of rocks and geological environment. This limitation affects reliability of geomechanical assessments in real mining scenarios. These factors can be incorporated into calculations by integrating and analyzing results of subsoil monitoring.

Objects of the study are copper ore deposits of the Zhilandy group of JSC «Kazakhmys Corporation» in Kazakhstan. Since explored copper ore reserves of the Zhezkazgan deposit are gradually being developed, at the present stage there is a need to identify ore reserves to extend life of this deposit for another 40-50 years, as well as to develop new deposits near cities of Zhezkazgan and Satpayev.

At present, conditions are being created for expanding the mineral resource base of Central Kazakhstan. These are the deposits: Eastern and Western Saryoba, Kipshakpai, Karashoshak, Itauz, developed by the Zhilandy mine (Figure 1).

Figure 1. Zhilandy group of deposits.

Department of Mine Surveying and Geodesy at Satbayev University conducts comprehensive studies of geodynamic processes, enabling more accurate assessments of the nature and parameters of tectonic stress fields, particularly in areas of intensive mining activity. These studies leverage modern equipment and observation tools developed by the authors. This work is exemplified by ongoing research under grant projects, including: AP08857097: "Comprehensive monitoring of slow deformation processes on the earth's surface during large-scale development of ore deposits in Central Kazakhstan" (2020-2022), AP14871828: "Research and development of highly effective methodology for monitoring geotechnical state of rock massif to assess and predict deformation processes during deposit development "(2022-2024) and AR23489269 "Geotechnical monitoring of the geodynamic state of the geological and structural environment of a rock massif during subsoil development to ensure industrial reliability» (2024-2026).

On this basis, goal was set, idea was substantiated and structure of complex monitoring and modeling of stress-strain state of the rock mass in Central Kazakhstan was formulated.

Purpose of the study – to improve the industrial and environmental safety of the development of the Zhylandy group of deposits by enhancing the methodology for monitoring and forecasting hazardous geomechanical processes through modeling of the stress–strain state of the rock mass.

Methodology. Study employs comprehensive approach that includes engineering-geological analysis of structural-tectonic framework of rock mass, with detailed mapping of disturbed areas, faults, and crushed rock zones. It incorporates instrumental mine surveying observations using modern devices and monitoring tools developed by authors. Additionally, approach evaluates changes in the stress-strain state of rock mass through modeling of structure and homeometry of adjacent rock mass.

Results and discussion. *Mining-geological and mining-technical conditions* of the Zhilandy groups of deposits have been studied in detail. 11 ore deposits have been identified in the ore field, in which 109 ore bodies have been explored. The largest deposits are confined to the taskuduk horizon. They strike north-east, extend for up to 3200 m, have a thickness of 0,5 to 17 m, and dip up to 1400 m (Figure 2).

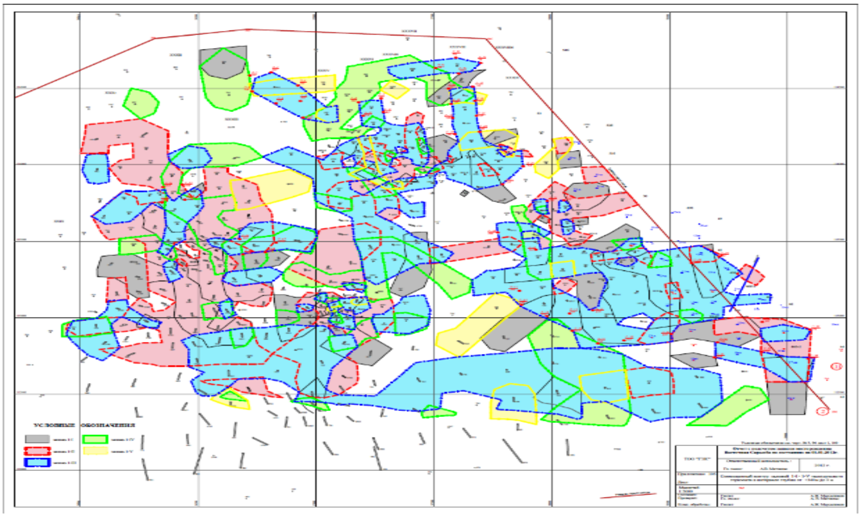


Figure 2. Combined contour of ore deposits in the depth range from +340 m till 0 м.

Rock massif is complicated by tectonic faults, rock contacts, and contains mine workings of various shapes and sizes, which significantly complicates their development (Nurpeisova et al., 2020).

Structural features of rock massif play a critical role in the development of geomechanical and geodynamic processes during mining operations. Displacement of rocks during underground mining and stability of quarry slopes are directly influenced by tectonics and massif's structural characteristics. To enhance efficiency of rock fracturing surveys, we utilized a Leica Scan Station 3D scanner, which provided detailed data on crack orientation and fault structures (Figure 3). The laser scanning results were processed using the Maptek I-Site Studio software package, enabling calculation of crack orientation parameters such as strike azimuth, dip angles, and dimensions of rock blocks (Seredovich, 2009).

a) b)

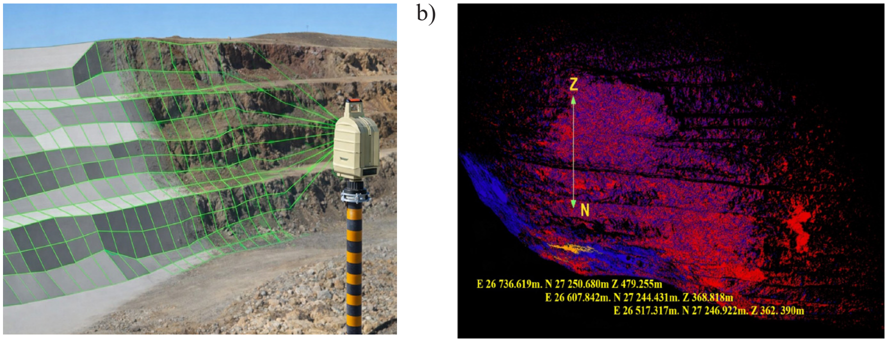


Figure 3. Survey of rock fracturing and survey results: a) survey with laser scanner installed on a permanent ground benchmark; b - elements of crack occurrence on computer screen.

Physical and mechanical properties (PMP) of massif rocks were studied, revealing graphic and analytical dependencies of rock strength properties relative to their depth of occurrence. These findings enable prompt adjustments to horizon-by-horizon calculations for mine working stability (Bazaluk et al., 2022; Method, 2021). Studies provided quantitative and qualitative characteristics of the rocks in the Central Kazakhstan deposits. These characteristics will be instrumental in addressing several technical challenges in both quarries and underground mines, including: assessing stability of quarry benches and slopes, designing calculated pillars and limit ceilings, generalizing results from instrumental observations, and clarifying understanding of physical processes underlying rock displacement.

The most important geomechanical characteristic of rock mass is its *stress-strain state* (SSS). Various methods and techniques for monitoring the SSS of rock mass have been developed to date. We have developed a «Seismoacoustic method for predicting SSS of rock mass" to study SSS of rock mass and implemented it in production (Nurpeisova et al, 2023; Patent, 2022).

Characteristic features of tectonic movements are evident in the edge massifs of the Eastern Saryoba quarry. In the studied quarry, large sections of talus and collapses have developed along the entire working edge. These occurrences are primarily caused by saturation of clayey rocks with water, along with discrepancies between actual parameters and those recommended for maintaining stability.

In addition to laser scanning at the Vostochny quarry, survey was conducted using a MATRICE 300 RTK UAV, which is built on advanced hardware and software platform and features a wide array of functions powered by artificial intelligence. Survey results were used to create a 3D model of the Vostochny quarry, which will serve as basis for designing observation station (Figure 4).

a)

b)

Figure 4. Landslides on the eastern *(a)* and southern *(b)* sides of the Eastern Saryoba quarry.

The scale of the impact from open-pit mines, their waste dumps, tailings storage facilities, and underground mining is such that their effects overlap, creating complex patterns in the formation of secondary stress fields. One aspect of this phenomenon is isostatic vertical displacements. Therefore, the scale of production that has developed in this area requires in-depth study and monitoring of the ongoing processes to prevent uncontrolled, catastrophic manifestations of geomechanical phenomena.

Under such conditions, effective and safe extraction of ore veins is possible only through the organization of geomechanical monitoring of the rock mass condition, which involves: systematic observations of the spatial and temporal geomechanical processes arising in the rock mass as a result of mining operations; mathematical processing of observation results; comprehensive analysis and forecasting of the rock mass condition; and the development of measures to manage adverse processes.

Monitoring state of rock massif during development of extensive deposits, which span multiple ore bodies and extend across various depth horizons, necessitates creation of a geodynamic testing area (GTA). To provide visual overview of study area and facilitate development of GTA profile line layouts, aerial survey was conducted at the East Saryoba deposit using unmanned aerial vehicle (UAV) equipped with a satellite receiver from Topodrone. Resulting orthophotoplan of the survey area is shown in Figure 4.

For a more detailed and economically efficient study of geodynamic processes-especially considering significant depths and scattered distribution of ore veins across field - geomechanical school at Satbayev University proposed and implemented a new approach to GTA creation. This approach involves "nodal" branches consisting of reference points and deformation leveling benchmarks (Novyi podkhod, 2021; Nurpeisova et al., 2023). All nodal points within the Geodynamic Network (GDN) are strategically located in alignment with ore veins and are connected to triangulation points of the State Geodetic Network (Figure 5a).

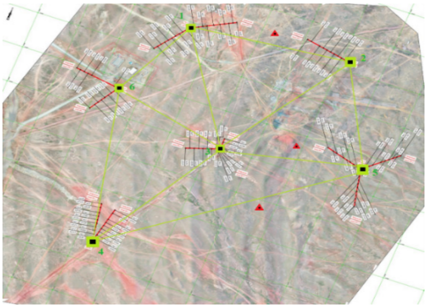
a)  b) 

Figure 5. *a* - Orthophotomap with a diagram of location of profile lines on geodynamic polygon (green - control points; red - triangulation points) 5. *b* - GPS observations at permanent forced centering points.

Design of the GDP reference points has been improved (Figure 5, b). Technical result of invention of permanent geodetic point of forced centering (PGPFC) is increase in accuracy and efficiency of measurements in absence of tripods at observation points, ensuring protection of device from external influences (such as rain, snow). Patent of the Republic of Kazakhstan for invention was received for the design of the PGPFC (Patent, 2021).

In 2023, based on geomechanical study of mining and geological conditions of the field, designs for observation stations were developed: ground and underground. Projects address issues of creating geomechanical monitoring system based on instrumental surveying and geodetic observations using electronic total station and GPS receivers of satellite positioning system.

The widespread introduction of electronic tacheometers and satellite GPS devices into the practice of surveying and geodetic work provides a unique opportunity to quickly and accurately determine displacement parameters of rock mass and conduct regular, continuous observations of changes in these parameters over time.

Years of experience surveying instrumental observations over deformations of rock mass at the mine allowed to introduce permanent forced centering points for GPS equipment and electronic total station devices (Rysbekov et al., 2024).

To study state of adjacent rock mass in quarries laser scanning method was used. Laser scanning allows to create digital model of the entire surrounding space, representing it as a set of points with spatial coordinates.

Combined open-pit mining leads to redistribution of stresses, causing their increased concentration below bottom of quarry and rock displacement of masses towards the worked area.. Open pit wall deformations can change stress state around underground workings and complicate their mining. On the basis of complex geomechanical monitoring carried out at the field Saryoba in the period 2021-2024. The scheme of displacement of rocks (Figure 6).

a) b)

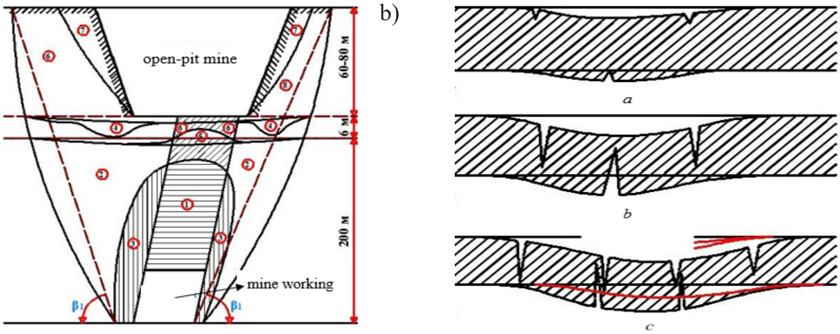


Figure 6. *a* - Scheme of rocks deformation at the combined working; 6. *b* - Scheme of cracks formation in the sub-quarry layer during its undermining.

Zones: 1- collapse; 2- smooth deflection; 3 - ultimate stress state; 4, 5, 6 - tension and compression in the sub-quarry layer; 7- landslide prism; 8 - edge array; A-B - line separating zones 7 and 8 - sliding surface

a - the first appearance of cracks in bending layer; b - opening of crack depth; c - destruction of the layer under alternating deformations.

It identifies two areas: *unloading* and *high rock pressure*, and eight zones, distinguished by characteristic features peculiar only to these zones.

Unloading area is divided into zones characterized by varying degrees of rock mass disturbance: collapse, through and local cracks. According to this scheme, eight zones can be distinguished in the undermined stratum, which differ in conditions of deformation and degree of cracking. The main attention was paid to study of bearing capacity of quarry bottom (ceiling of the 1st horizon) and sublevel pillars. The pillars are initially in an elastic state, but over time, salt pillars can turn into a plastic state (or a state of fluidity), for example, due to the development of rheological processes. The plastic state is characterized by a more than tenfold increase in the compliance of the pillars while maintaining their stressed state. The collapse of rocks in the roof of workings (under-quarry layer) occurs after the tensile and compressive strength of the rocks is exceeded, as a result of which the massif is broken into blocks by a system of cracks. As a result of the deflection of the layer, tensile stresses appear in it and at a certain span they reach the tensile strength of the rocks and transverse cracks begin to appear on the upper and lower surfaces of the layer.A further increase in the span leads to corresponding increase in tensile stresses and cracks development.

*Use of mining and metallurgical complex (MMC) wast*e. Since the ultimate goal of all geomechanical studies is to ensure industrial safety, we have developed grouting solutions for strengthening disturbed surfaces in order to prevent further collapse of pit slopes and underground workings (Kuldeyev et al., 2021).

The monitoring results of mining facilities at the Zhilandinsk mine (both in the open pit and underground levels) showed that the largest number of collapses is associated with fractured rocks, and the volume of collapses increases over time as the workings remain open.. Observations of workings driven through fractured rocks revealed that they are stable for a month. After two to three months, stabs up to 10-15 cm in size are formed. Stabbing and collapses develop within six months, roof collapse occurs in the form of domes. This dramatically increases volume and labor intensity of tunneling works, as well as costs of fastening and repairing workings.

To prevent workings collapse passed through fractured rocks, anchor supports with metal mesh, chain-link and sprayed concrete are used. However, rocks roof separation from transport roadway and significant destruction of rocks indicates that this support does not solve problem of ensuring stability of workings and does not prevent deformations development. As result, after 2 - 3 years of standing workings, lining collapses and major overhaul is required. Therefore, effective solution to fixing issue and controlling geomechanical properties of rocks is of particular importance for the near-side massifs of open-pit and for underground workings driven through fractured rocks (Bek et al., 2020).

Different strength characteristics of rocks in massif and sharp decrease during exposure and contact with air and water predetermine the need for differentiated approach to managing rocks properties with varying fracturing degrees. One of the most common methods is sprayed concrete strengthening of disturbed areas, ie, injection of cement solution until massif is completely saturated.

One of the most widely used methods of reinforcement is the cementation of rock masses. The cement grout is prepared based on cement and water.

The technical result is an increase in the reliability of reinforcing quarry bench slopes and the prevention of rock sloughing from the slope surface through the use of mining and metallurgical complex (MMC) waste.

Such a method of ensuring the stability of quarry slopes and benches is a complex task, the solution of which should include not only the determination of stable slope parameters, but also their management to achieve better economic outcomes and efficient use of natural resources. The main objective here is to develop reinforcing grouts with low cost and high strength.

To achieve this result, we investigated raw materials: Portland cement PC 400-D0 (M400), produced by «Central Asia Cement» JSC (Karaganda region, Kazakhstan), waste from the processing plant of the Zhilandinsky mine, CP tailings, functional additive «Reparatur», manufactured by «Ading» (North Macedonia) and polycarboxylate additive «Neolit 400» (Russia).

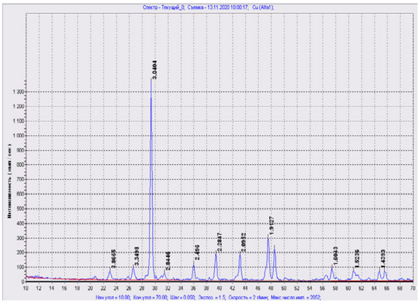
The selection of waste from the processing plant of the Zhilandinsky mine is justified by the following reasons:

– to improve the environmental condition of the region through their complete utilization with environmental and economic efficiency;

– to use the composition of the waste to develop special cementing solutions for more effective strengthening of rock fractures in underground workings.

X-ray of these tails is shown in (Fig. 7, a), it can be seen that it mainly shows reflections (peaks) characteristic of calcium carbonate (CaCO3), with interplanar distances d, Å: 3.8665; 3.3498; 3.0404; 2.8446; 2.496; 2.2847; 2.0952; 1.9127; 1.77; 1.6287; 1.60; 1.5236; 1.4393. (Figure 1, b) shows the DTA analysis, where endothermic effect is recorded at 950 ° C, showing limestone dissociation.

a)



b)

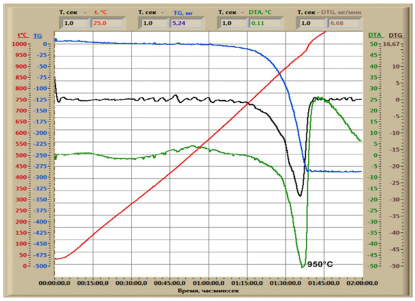


Fig. 7. X-ray (a) and derivatogram (b) Zhilandinskaya processing plant.

To strengthen disturbed rock masses in underground workings, taking into account the water saturation of the rocks, we have developed a new effective grout. The components for preparing the grout are taken in the following proportions: Portland cement PC 400 – up to 18%; tailings from processing plants – up to 71.2%; "Reparatur" additive – 1.5%; superplasticizer Neolit 400 – 0.3%; the remainder is water (water–cement ratio is about 0.5) – 9% (Patent КЗ KZ36246-B. 2024).

After dosing the components, the cement, tailings, and additives are loaded into a concrete mixer and thoroughly mixed. Then water is added and mixing continues. The prepared composition is transported to underground workings and injected into fractures of disturbed underground excavations. To determine strength, samples measuring 7×7×7 cm were molded from the composition and compacted on a vibrating table for 45 seconds. After one day, the samples were removed from the molds and stored under moist conditions for 28 days, after which physical and mechanical tests were carried out, the results of which are presented in Table 1.

Table 1. Physical and mechanical properties of the resulting solution.

Composition of the solution, mass.%					Indicators	
Portland cement	Tailings of CP	«Reparatur»	Neolit 400	Industrial water of CP	strength compression, MPa	Movement mixture, cm
18	71,2	1,5	0,3	9	21,5	100

Technical novelty of created solution was confirmed by patents of the Republic of Kazakhstan for invention (Patent 36220, 2023).

Based on the conducted research, we have developed a grout for strengthening fractured rock masses of open-pit slopes, containing a filler, cement, and process water. To reduce the cost of the grout, it is proposed to use tailings from processing plants as a filler, which are large-tonnage industrial wastes requiring extensive storage areas.

The results of the physical and mechanical tests of the obtained grout are presented in Table 2.

Table 2. Physical and mechanical properties of the grout.

No	Grout composition, wt.%				Compressive strength, MPa	Flexural strength, MPa	Slump, mm
	Cement	Tailings	Neolit 400	Water			
1	32	52	0.16	15.9	32.4	4.3	150
2	33.4	49.3	0.13	16.3	35.7	5.1	145
3	37	47	0.11	16.9	36.9	5.7	142

The technical novelty of the developed grout has been confirmed by patents of the Republic of Kazakhstan for the invention (Patent К36246-Б.2024; Kuldeyev, Negmatov, 2025).

Conclusions. As a result of comprehensive monitoring of the condition of the Zhilandinsky group of deposits in Central Kazakhstan, the following have been implemented in production:

– a geospatial database of ore deposits in Central Kazakhstan has been created; the stress-strain state (SSS) and physical-mechanical properties (PMP) of the rock mass in the lower horizons of the mine have been studied to ensure industrial and environmental safety;

– a regional “cluster-based” method of a geodynamic testing site has been developed;

– a design of a permanent geodetic forced-centering station (GFCS) has been developed, improving the productivity and accuracy of observations;

– a composition of a reinforcing grout made from mining waste has been developed to increase the stability of disturbed sections of pit slopes and underground workings.

The novelty of the developed methods and technologies is confirmed by patents of the Republic of Kazakhstan included in the Derwent patent database.

References

Bek A.A., Donenbaeva N.S., Aitkazinova Sh.K., Nurpeisova M.B. (2020) Issledovanie prochnostnykh kharakteristik gornykh porod na rudnike «Akzhal» s tsel'yu ukrepleniya oslablennykh uchastkov [Study of the strength properties of rocks at the Akzhal mine to strengthen the weakened areas]. Journal «Young Scientist». – No.33 (323). - P.20-25. https://moluch.ru/archive/323/73183/ (in Russian).

Bek A.A., Donenbayeva N.S., Nurpeisova M.B., Aitkazinova Sh.K., Nukarbekova Zh.M., Derbisov K.N. (2023) Sostav rastvora dlya ukrepleniya narushennykh gornykh porod v podzemnykh vyrabotkakh. Patent Respubliki Kazakhstan [Composition of a grout for strengthening disturbed rock masses in underground workings Patent of the Republic of Kazakhstan]. – No. 36220 RK. Dated April 5, 2023. (in Russian).

Bek A.A.; Donenbayeva N.S.; Nurpeisova M.B.; Aitkazinova Sh.K.; Nukarbekova Zh.M.; Derbisov K.N. (2024) Method of consolidating the slope of a quarry. Patent of the Republic of Kazakhstan No. KZ36246-B. Assignee: Kazakh National Research Technical University. Derwent Primary Accession Number: 2024-C48648. (in English).

Kuldeyev E.I., Negmatov S.S. (2020) Razrabotka resheniy na osnove tekhnogennykh otkhodov dlya ukrepleniya treshchinovatykh poverkhnostey [Development of solutions based on technogenic waste for strengthening fractured surfaces]. Tashkent: Uzbek Scientific-Technical and Production Journal “Composite Materials”. – No.3. – P. 23-30. (in Russian).

Kuldeyev E.I., Rysbekov K.B., Donenbayeva N.S., Mietenko N.A. (2021) Modern methods of geotechnic – effective way of providing industrial safety in mine. Eurasian mining. - No.2. - P. 61-66. https://doi.org/10.17580/em.2021.02.04 (in English).

Kyrgizbaeva G.M., Nurpeisova M.B. (2021) Metod prognozirovaniya FMS i SSS massiva [Method for predicting FMS and SSS of an array]. Certificate of entry into the state register of rights to objects protected by copyrigh. – No. 19300. (in Russian).

Kyrgyzbaeva G.M., Nurpeisova M.B., Isagazy M.D., Turumbetov T.A. (2021) Novyi podkhod k sozdaniyu GDP [A New Approach to Calculating GDP]. Certificate of Entry into the State Register of Rights to Works Protected by Copyright. – No. 203602 (in Russian).

Melnikov N.N. (2010). Ekologicheskie problemy XXI veka i osvoenie nedr. Iz knigi «Osvoenie nedr i ekologicheskie problemy XXI veka» [Environmental problems in the XXI century and the development of subsoil]. The book of Development of the subsoil and environmental problems of the XXI century. Moscow, Institute of Comprehensive Exploitation of Mineral Resources, Russian Academy of Sciences. – Vol. 1. – P. 26-45 (in Russian).

Mikhailova N.N., Uzbekov A.N. (2018) Tektonicheskie i antropogennye zemletryaseniya v Tsentral’nom Kazakhstane [Tectonic and man-made earthquakes in Central Kazakhsta]. News of NAS RK. Series of geology and technical sciences. – No. 3. – P. 137-145. (in Russian).

Nurpeisova M., Rysbekov K., Aitkazinova Sh., Donenbaeva N., Nukarbekova Zh., Derbisov K. (2021) Ground-based permanent geodetic point for forced centering of instruments Patent of the Republic of Kazakhstan No. 35798. Assignee: Kazakh National Research Technical University. Derwent Primary Accession Number: 2022-C4343S. (in English).

Nurpeisova M.B., Abenov A.M., Miletenko N.A. (2023) Highly efficient monitoring procedure for deformation pred. iction in copper ore mining. Eurasian Mining. – No. 1. – P.19-24. https://doi.org/10.17580/em.2023.01.04 (in English).

Nurpeisova M.B., Bitimbaev M.Zh., Rysbekov K.B., Kyrgizbayeva G.M. (2022) Seismoacoustic method for predicting the SSS of an array. Patent of the Republic of Kazakhstan No.35898. Assignee: Kazakh National Research Technical University. Derwent Primary Accession Number: 2024-B08861. (in English).

Nurpeisova M.B**.,** Salkynov A.T., Soltabayeva S.T., Miletenko N.A. (2024) Patterns research of geomechanical development processes in combined development method. Eurasian Mining. – Vol.1. – P.7-11. (in English)

Nurpeisova M.B., Bitimbayev M.Zh., Rysbekov K.B., Shults R. (2020) Geodetic substantiation of the Saryarka copper ore region. News of the National Academy of Sciences of the Republic of Kazakh-stan-Series of Geology and Technical Sciences. – Vol.6. – *P.194-202.* https://doi.org/10.32014 /2020.2518-170X.147 (in English).

Rockburst and seismicity in mines proceedings (2005) Australia, Australian Centre for Geomechanics. (in English). https://papers.acg.uwa.edu.au/c/rasim6

Rylnikova M.V., Yun A.B., Terentyeva I.V. (2016) Vosstanovlenie vyrabotannykh moshchnostey shakht na etape opredeleniya ostatochykh zapasov mestorozhdeniya – uslovie ekologicheski sbalansirovannogo razvitiya Zhezkazganskogo rayona [Replenishment of retired capacities of mines at the stage of finalizing balance reserves of the deposit - condition for the environmentally balanced development of the Zhezkazgan region]. Mine Surveying. – No.5. – P. 6-10. (in Russian).

Seredovich V.A. (2009) Nazemnoe lazernoe skanirovanie [Terrestrial Laser Scanning]. Monograph. Novosibirsk: SSGA. – P. 261. (in Russian).

Trubetskoy K. N. (2020) Sostoyanie i osnovnye napravleniya kompleksnogo razvitiya i sokhraneniya resursov nedr Zemli [State and main directions of integrated development and conservation of resources of the earth's interior]. Problems and prospects for integrated development and conservation of the earth's interior, materials of the IV conference of the Intern. scientific school acad. RAS K.N. Trubetskoy, Moscow, Institute of Comprehensive Exploitation of Mineral Resources, Russian Academy of Sciences. – P. 5-11. https://doi.org/10.32454/0016-7762-2020-63-3-8-15 (in Russian).

Bazaluk O., Rysbekov K., Nurpeisova M., Lozynskyi V., Kyrgisbayeva G., Turumbetov T. (2022) Integrated monitoring for the rock mass state during rge-scale subsoil development. Frontiers in Environmental Science. Accepted paper (electronic resource). – Vol. 10. – P.1-12. https://doi.org/10.3389/fenvs.2022.852591 (in English).

Publication Ethics and Publication Malpractice in the journals of the Central Asian Academic Research Center LLP

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the journals of the Central Asian Academic Research Center LLP implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier. com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The Central Asian Academic Research Center LLP follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics. org/files/ u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/ or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the Central Asian Academic Research Center LLP.

The Editorial Board of the Central Asian Academic Research Center LLP will monitor and safeguard publishing ethics.

Requirements for articles design for publication in the journal are available on the websites:

www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Managing Editor: *T. Apendiev*
Editors: *D.S. Alenov, A.Shormakova*
Computer layout: *G.D. Zhadyranova*

Signed for print: April 10, 2026
Format: 70×90 1/16. 26.5 printed sheets. Order No. 2.

«Central Asian Academic Research Center» LLP
Almaty, Shevchenko Street, 28