НАУЧНАЯ СТАТЬЯ
УДК 622.1:528.4
https://doi.org/10.56195/20793332-2026-26-4-24-30

SCIENTIFIC ARTICLE
UDC 622.1:528.4

Geodynamic test site of the Zhilandy ore field: practice and prospects

G. Meirambek, K. B. Rysbekov, M. B. Nurpeisova✉, S. T. Soltabayeva, Sh. K. Aitkazinova
Kazakh National Research Technical University K. I. Satpayev (Satbayev University), Almaty, Republic of Kazakhstan
✉ *marzhan-nurpeissova@rambler.ru*

Abstract. Information is presented on the copper deposits of Kazakhstan that are being developed in the central region and their role in the development of the mining industry. To ensure reliable prediction and prevention of hazardous geodynamic phenomena in the area where a group of deposits is being mined, it is proposed to establish a geodynamic monitoring system. This group includes long-term operating copper ore deposits. The establishment of a geodynamic test site and the implementation of integrated monitoring observations will ensure the stability of mining operations, as well as the industrial and environmental safety of the region as a whole.

Keywords: copper ore deposits, geology, stress–strain state, rock mass, monitoring, geodynamic test site, monitoring, management

Financing: Study was carried out with the financial support of the Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan (Grant No.AP AP23489269).

For citation: Meirambek G., Rysbekov K.B., Nurpeisova M.B., Soltabayeva S.T., Aitkazinova Sh.K. Geodynamic test site of the Zhilandy ore field: practice and prospects. *Mine Surveying and Subsurface Use.* 2026; 26 (4): 24-30. https://doi.org/10.56195/20793332-2026-26-4-24-30.

Геодинамический полигон Жиландинского рудного поля: практика и перспективы

Г. Мейрамбек, К. Б. Рысбеков, М. Б. Нурпеисова✉, С. Т. Солтабаева, Ш. К. Айтказинова
Казахский национальный исследовательский технический университет имени К. И. Сатпаева (Satbayev University),
г. Алматы, Республика Казахстан
✉ *marzhan-nurpeissova@rambler.ru*

Резюме. Представлена информация о меднорудных месторождениях Казахстана, разрабатываемых в Центральном Казахстане, и их роли в развитии горнодобывающей промышленности страны. Для обеспечения надежного прогнозирования и предупреждения опасных геодинамических явлений в районе разработки группы месторождений предложено создание системы геодинамического мониторинга. В рассматриваемую группу входят длительно эксплуатируемые меднорудные месторождения. Создание геодинамического полигона и проведение комплексных мониторинговых наблюдений обеспечат устойчивость ведения горных работ, а также промышленную и экологическую безопасность региона в целом.

Ключевые слова: меднорудные месторождения, геология, напряженно-деформированное состояние, массив горных пород, мониторинг, геодинамический полигон, управление

Финансирование: Исследование проведено при финансовой поддержке Комитета науки Министерства образования и науки Республики Казахстан (грант № АП AP23489269).

Для цитирования: Мейрамбек Г., Рысбеков К.Б., Нурпеисова М.Б., Солтабаева С.Т., Айтказинова Ш.К. Геодинамический полигон Жиландинского рудного поля: практика и перспективы. *Маркшейдерия и недропользование*. 2026; 26 (4): 24-30. (In Russ.). https://doi.org/10.56195/20793332-2026-26-4-24-30.

Introduction

Large-scale mining of solid mineral deposits significantly alters the natural stress–strain state of the upper Earth's crust, often triggering hazardous geodynamic phenomena, including rockbursts, mining-induced seismicity, and ground deformation. Reliable prediction and prevention of these processes remain a major scientific and engineering challenge due to the complexity of geological conditions, heterogeneity of rock masses, and the continuous changes in their physical and mechanical properties during mining operations [1–3].

Long-term studies of the Zhezkazgan natural–technical system, comprising underground mines, concentrators with tailings storage facilities, and copper smelters in Karaganda, Balkhash, Zhezkazgan, and Satpayev, have confirmed that intensive mining activities substantially affect the regional geodynamic regime and the environment [4, 5]. At the same time, the depletion of reserves at the Zhezkazgan deposit necessitates the development of new copper ore deposits within the Zhilandinskaya group to expand the mineral resource base of Central Kazakhstan.

Currently, conditions are being established to expand the mineral resource base of Central Kazakhstan through the development of the Zhilandinskaya group of copper deposits, including East Saryoba, West Saryoba, Kipshakpai, Karashoshak, and Itauyz (Fig. 1).

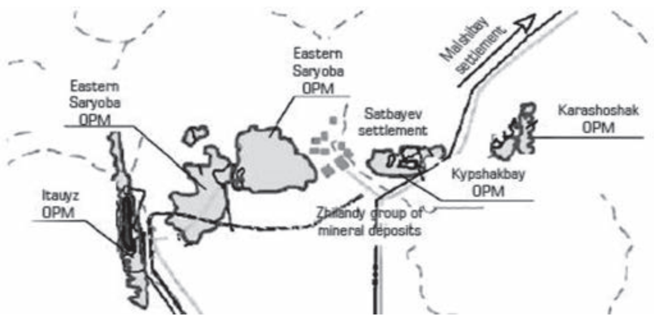

Fig. 1. **Zhilandy group of deposits**

The aim of this study is to develop an integrated geodynamic monitoring approach for assessing the state of the rock mass by considering both natural and mining-induced factors and applying advanced monitoring methods to improve geomechanical control and ensure safe mining operations.

Methods

The study employed an integrated approach that included engineering-geological investigation of the structural and tectonic setting of the rock mass, instrumental mine surveying observations using modern surveying equipment and monitoring tools developed by the authors, as well as geomechanical process management.

Results and discussion

Geology and structure

The engineering-geological and mining-technical conditions of a giant copper deposit located in Central Kazakhstan were investigated. Within the ore field, proven and approved reserves of categories B + C1 + C2 are sufficient to classify the deposit as a major industrial mining project. A total of 11 ore deposits comprising 109 ore bodies have been identified and explored within the ore field [6, 7]. The largest ore deposits are confined to the Taskuduk Horizon. They exhibit a northeast strike, extend for up to 3,200 m, have thicknesses ranging from 0.5 to 17 m, and reach a down-dip extent of up to 1,400 m (Fig. 2).

In the studied area, the southwestern part of the orefield is complicated by high-order folds and faults, the largest of which is the Saryoba transpressional fault of submeridional strike. Its length is more than 10 kmwith a width of 250–400m, the main plane dips to the west at an angle of 25–30°. The Saryoba transpressional fault divides the one field into two almost equal parts. TheWest Saryoba deposit is located in the western half, and East Saryoba is located in the eastern half. Rock mass is complicated by tectonic disturbances, rock contacts, and contains mine workings of various shapes and sizes, which greatly complicates their development.

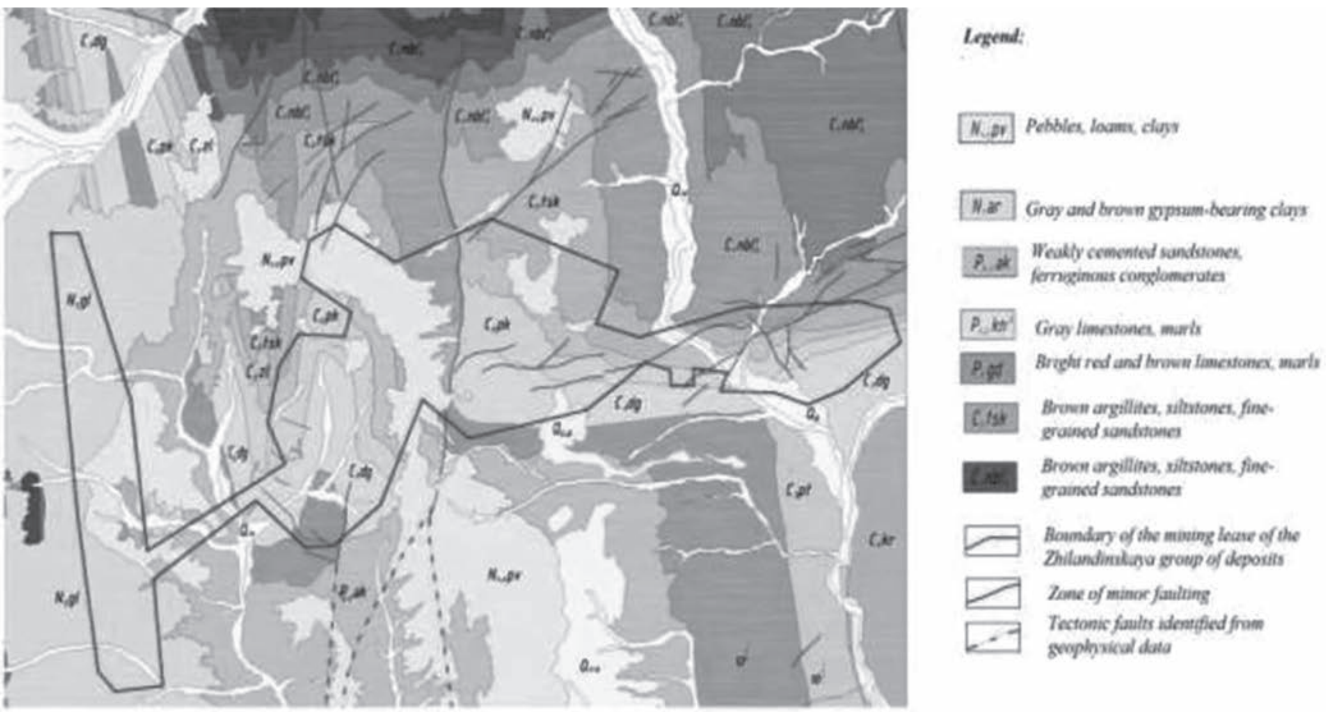

Fig. 2. **Geological and structural map of the Zhilandinskaya grourp of deposits (M 1:50 000)**

Physical and mechanical properties of rocks

The rock mass is complicated by tectonic faults, lithological contacts, and mining excavations of various shapes and sizes, which significantly complicate mining operations.

The structural features of the rock mass were investigated through field observations of rock outcrops, and its physical and mechanical properties (PMP) were determined.

Tests of the physical and mechanical properties of the rocks were conducted at the Geomechanics Laboratory of Satbayev University. The obtained results made it possible to establish graph-analytical relationships between the strength properties of the rock mass and the depth of occurrence, thereby enabling prompt refinement of bench-by-bench stability calculations for mining excavations (Fig. 3).

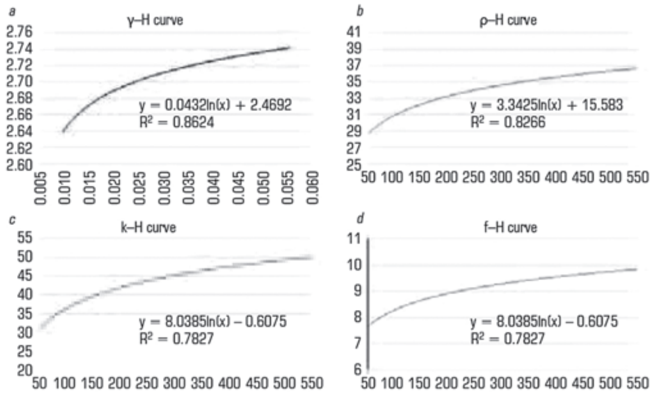

***Fig. 3.* Strength properties versus occurrence depth occurrences H for massive limestone: (a) density γ; (b) internal friction angle ρ; (c) cohesion k; (d) rock hardness f**

Curves of changes in rocks properties were drawn according to averaged indicators over depth after 50 m. Assessment and reliability of determining dependencies were made according to formulas of mathematical statistics. Deviation of calculated curves from empirical ones varies within 5-8%, and for the most part curves coincide with each other. Data analysis also shows that strength properties of rocks change markedly with depth of their occurrence [8].

The same dependencies were also obtained for a number of fields in Kazakhstan, namely for the Akzhal field; Akbakai, Sayak et al. To find general patterns of variability of strength and structural properties of rocks, data of a number of deposits are also generalized and graphic-analytical relationships between average density, cohesion, strength of rocks and their depth are established. Curves of changes in rock properties were drawn according to averaged group indicators at depth intervals of 50 m. To compare results obtained on the object under study with data from other mines, combined graph of relationship of rock properties was compiled (Fig. 4).

Based on studies carried out, quantitative and qualitative characteristics of rock properties of several deposits, including Saryoba deposit, were obtained. These characteristics will be used in solving several technical problems in open pits and underground mines: in assessment stability of ledges and sides of open pits: calculated pillars and marginal ceilings, to generalize results of instrumental observations and understand physical side of displacement process [20].

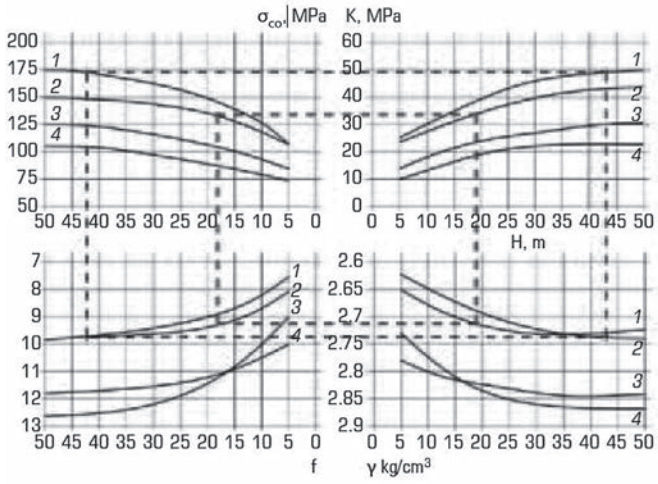

***Fig. 4.* Relationships between rock properties and their depth: 1 - Saryoba deposit; 2 - Akzhal deposit, 3 - Sayak deposit, 4 -Akbakai deposit**

Stress-strain state of massif

The most important geomechanical characteristic of rock mass is its stress-strain state (SSS). To date, various methods and techniques have been developed to control SSS of rock mass. Among the main ones are: method of SSS unloading VNIMI, core disking, etc. To study stress state of rock masses in the Central Kazakhstan field, authors developed “Seismoacoustic method for predicting SSS of rock mass” [9]. Seismoacoustic method for predicting SSS of rock mass includes installing sensor of seismoacoustic signals emitted by natural sources in rock mass, after which parameters of these signals are determined.

In the proposed Seismoacoustic method for predicting SSS of rock mass, including installation of sensor for seismoacoustic signals emitted by natural sources in rock mass, determining parameters of these signals. Registration of seismoacoustic signals is carried out by sensor in wells drilled in mine workings at various horizons. Method is characterized by simplicity and speed of measurement with high reliability of results.

Scheme for implementing method is shown in Fig. 5 - scheme for measuring stresses using core unloading method at the end of well 4. To do this, end of the well is ground with special disk mounted on the rod and strain gauge 1 is pressed tightly onto the end. Cable from strain gauge is passed into a hollow drill rod and an annular gap 2 with help of a crown. As a result, the elastic expansion of the core 3 occurs, which is fixed by a measuring tensometer in three directions, the results of which are shown in Table 1.

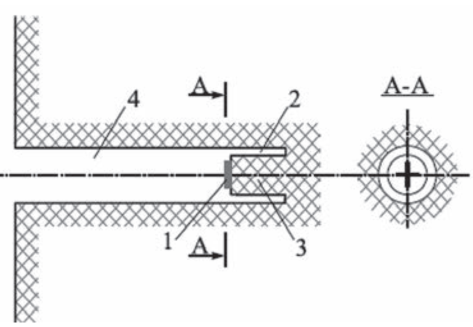

***Fig. 5.* Scheme for measuring stresses**

After measuring deformations core is broken off and sent to laboratory in special package to determine elastic rocks characteristics.

Table 1

Results of measuring natural stresses in the Saryoba deposit

Depth from the daylight surface, H, m	Average stress values, MPa			Sum of horizontal l stresses, ($\sigma_x + \sigma_y$), MPa
	σ_x	σ_y	$\sigma_z = \gamma H$	
60	5,2	3,3	2,2	8,5
60	5,0	3,2	2,0	8,2
120	7,8	4,4	3,3	12,2
120	6,3	5,7	3,5	12,0
180	9,1	6,6	5,4	15,7
180	10,5	5,1	5,2	15,6
240	12,1	7,1	6,7	19,2
240	14,0	5,1	7,2	19,1
240	13,7	5,3	6,8	19,0
300	12,2	10,4	8,6	22,6
300	14,0	9,0	8,2	23,0
300	13,8	8,8	8.5	22,6
260	8,6	6,3	4,1	14,9
280	9,0	6,5	4,2	15,6
300	10,2	7,3	5,0	17.5
460	14,8	10,4	4,3	25,2
460	17,1	8,6	5,8	25,7
460	18.5	7,3	6,0	25,8
500	20,1	10,1	6,7	30,2
500	20,5	10,6	7,2	31,1
500	20,7	10,7	6,8	31,4

Note: σ_z *is the average value of the voltage acting in the vertical direction;* σ_x *is the average value of the normal stress acting in the meridional direction;* σ_y *the average value of the normal voltage acting in the latitudinal direction.*

Analyzing Table 1 and results of determining natural stresses obtained for other mines, one cannot but notice following features of distribution of horizontal stresses in rock mass. Firstly, horizontal stresses exceed vertical ones in their values, secondly, at equal depths from day surface in hard rocks, horizontal stresses have higher values than relatively weak ones, thirdly, vertical stresses are on average close to the value of γH regardless on the strength of the rock.

Thus, all types of stresses change with depth, especially the sum of the horizontal stresses ($\sigma_x + \sigma_y$) changes according to a certain pattern [10].

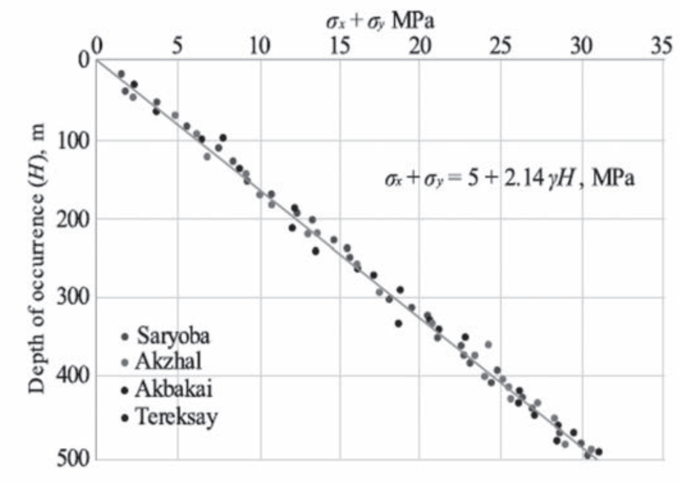

Fig. 6. **Change in sum of horizontal stresses ($\sigma_x + \sigma_y$) with depth**

Naturally, there was a desire to compare the stress results obtained by us with the results of similar studies by other researchers. The analysis of the collected data on stress in rock masses in different regions was linked to their type of tectonic structure. For comparison, Figure 6 shows data for the Akbakai, Akzhal (Kazakhstan), Tereksai mines of the Kyrgyz Republic and East Saryoba.

According to figure 6, the relationship between stress and depth is considered to be rectilinear, then the correlation relationship is determined by the following formula

$$У = a + в \cdot X, \quad (1)$$

where У– sum of principal horizontal stresses, ($\sigma_x + \sigma_y$);

X – mining depth, H; *a* and *в* – equation parameters.

$$\text{or } \sigma_x + \sigma_y = 5 + 0{,}06 \cdot H, \text{ MPa}. \quad (2)$$

If we pay attention to formula (1), then normal stresses are also related to volumetric weight of rocks. Then formula (2) will have the following form:

$$\sigma_x + \sigma_y = 5 + 2{,}14\gamma H, \text{ МПа}, \quad (3)$$

where γ – volumetric weight of rock $2{,}8 \cdot 10^{-2}$ MPa;

H – depth from the surface, м;

relationship correlation coefficient is $r = 0{,}92$.

Graphical-analytical dependences obtained as a result of performed research make it possible to give qualitative and quantitative assessment of changes in the properties of rocks. There is a stable correlation between indicators. With some known indicators, it seems possible to determine others using graphs, thereby opening possibility of predicting the properties of rocks within the deposits. Initial data for this are rocks names, their depth of occurrence, and individual characteristics, such as specific density of rocks and others, determination of which does not require labor-intensive laboratory studies.

Instrumental observations of the state of the array

According to the 3-block of recommended methodology, to conduct observations of rock mass state, especially when prospecting a giant copper field, occupying a large area and consisting of several deposits, occurring in various deep horizons, it is necessary to create a high-precision geodetic substantiation. To provide a huge area, classic option of creating geodetic networks in the fields is rather labor-intensive. It requires large financial costs for the organization and production of observations. In this regard, it is proposed to replace extended leveling lines with local geodetic constructions in the form of profile lines and check "clusters" of geodetic and leveling stations. Complex application of ground and space geodetic methods allows monitoring observations to cover entire territory of field, as well as to increase efficiency of observations and reduce capital costs for their implementation [11].

Traditional geodetic networking over a vast area of a mine field takes much labor and money. Authors propose to replace long leveling lines with local geodetic imaging in the form of geodynamic profiles, profile lines and control clusters of geodetic and leveling points. Integrated application of ground and space geodetic methods will make it possible to cover the entire mine field area with monitoring observations, as well as to increase efficiency of observations and to reduce a large area and designed for deep seams, authors suggest covering a mine field with chief branches of base (reference), support (initial) and check points of ground control and leveling [22]. All key points are located in accordance with the layout of ore veins (see Fig. 2) and are tied to the points of the State Geodetic Network (Fig. 7).

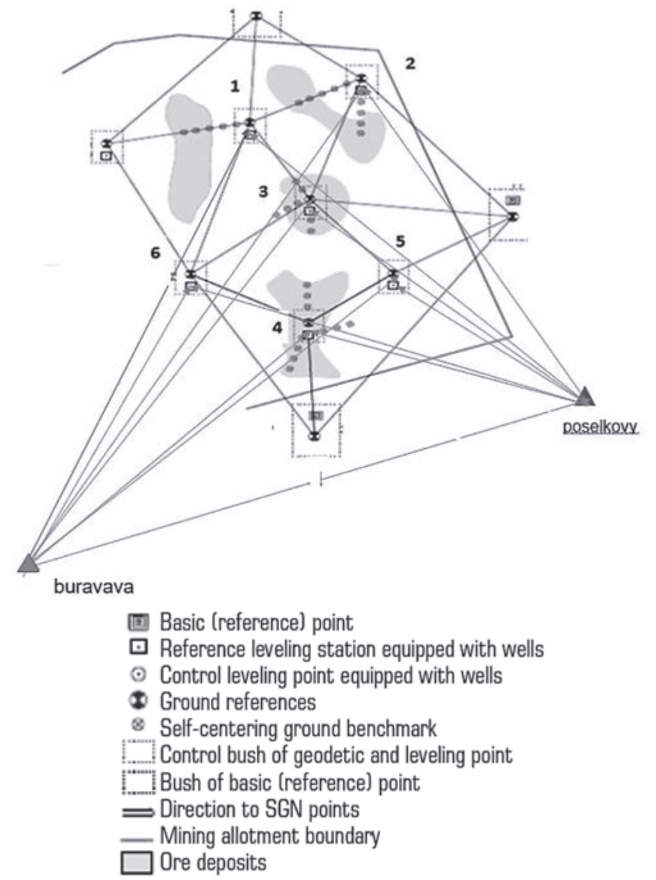

Fig. 7. **Scheme of observation network location dynamic polygon and triangulation points**

Instrumental observations showed complexity of field work, especially transferal of equipment (tool, tripod, rails, etc.) from one point to another. In this regard, to speed up installation and measurement operations, permanent forced centering points (FCP) have been developed to be set at the reference point during geomechanical monitoring. FCP belongs to geodetic centers for new instruments and signals [12, 13].

Purpose of this invention is to improve accuracy of centering and to enhance efficiency of measurement at observation points unequipped with tripods. The new device allows fast and accurate centering, and also eliminates using tripods. Plane coordinates and the preliminary heights of these points were determined by the satellite method using Leica GS16 3.75G geodetic satellite receiver. The final heights of the points were determined by class II geometric leveling method using Trimble Dini03 digital level and barcode rails (Fig. 8).

To determine spatial data of control points laid on the site of geodynamic polygon, method of network positioning in the static observation mode was used. All static measurements were made along the baseline at this point. Duration of observation is 80 minutes. Reference bases are installed at the triangulation point Poselkovy and Burovaya (Fig. 7). As initial data, adjusted coordinates of points are taken, according to certain parameters of the transition from WGS-84 to the local coordinate system and heights.

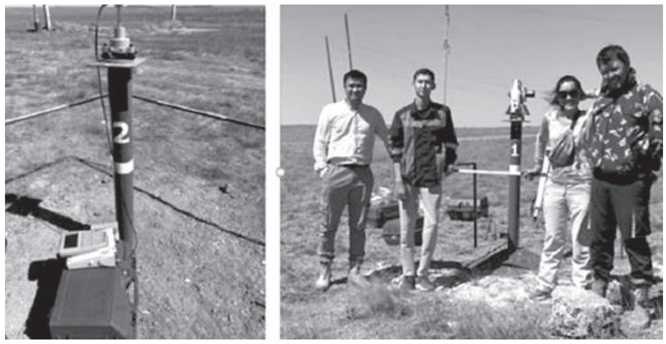

Fig. 8. **Monitoring by GPS receivers and electronic tacheometers Basic (reference) point installed at permanent forced centering points**

Geomechanical processes control

Strength and stability of inter-chamber support pillars, as well as stability of adjacent rock mass are determined by degree of their fracturing. Strengthening technology of fractured massif should ensure complete filling of cracks in massif with various compositions and reliably fasten individual structural blocks into a single whole. Tailings of processing plant of the Saryoba mine were studied as a filler for hardening mixtures for fractured rock masses in a quarry, as well as disturbed inter-chamber pillars and ceilings in underground workings.

On the basis of the conducted research, we have proposed a solution for strengthening fractured rocks containing filler, cement and process water. To reduce the cost of the solution, tailings from concentrating plants were used as a filler. Dry superplasticizer Neolit 400 is well compatible with Portland cements, cement - up to 37%, tailings of processing plants - up to 52%, and the rest is water.

The technical novelty of the created solution was confirmed by the patents of the Republic of Kazakhstan for the invention [14, 15].

Conclusions

1. A geospatial database for the ore deposits of Central Kazakhstan was established, integrating geological, geomechanical, and geodetic information. Three-dimensional geological and geomechanical models were developed to characterize the stress-strain state and spatial evolution of the rock mass during mining. The obtained regression relationships (R = 0.92) confirmed the reliability of predicting changes in rock strength properties.

2. An improved methodology for integrated geodetic monitoring of geodynamic test sites was developed, including the design of monitoring networks and the installation of high-precision instruments on permanent forced-centering stations. The proposed approach increases measurement accuracy and repeatability, expands monitoring coverage, and reduces labor intensity and operational costs.

3. A resource-efficient strengthening grout based on mineral processing tailings was developed to reinforce quarry slopes, waste dumps, and underground pillars. The technology improves rock mass stability, reduces deformation hazards, and promotes the environmentally sustainable utilization of mining waste.

4. The proposed integrated methodology for geomechanical monitoring and rock mass stability management provides a scientific basis for improving geotechnical monitoring systems and can be applied to ore deposits of Central Kazakhstan and other deposits of the Zhilandinskaya Group to enhance the long-term safety and efficiency of mining operations.

REFERENCES

1. Adushkin V.V., Turuntaev S.B. Anthropogenic Seismicity: Induced and Trigger. Moscow, 2015: 364.
2. Melnikov N.N. Environmental Problems in the XXI Century and the Development of Subsoil. *Development of the Subsoil and Environmental Problems of the XXI Century: collection of scientific papers*. 2010; (1): 26-45.
3. Yang Z., Gao Q., Li M.-h., Zhang G. Stability Analysis and Design of Open-Pit Mine Slope in China: A review. *Electronic Journal of Geotechnical Engineering.* 2014; (19): 10247-10266.
4. Mikhailova N.N., Uzbekov A.N. Tectonic and man-made earthquakes in Central Kazakhstan. *News of NAS RK. Series of geology and technical sciences*. 2018; 3 (429): 327-337.
5. Rylnikova M.V., Yun A. B., Terentyeva I. V. Replenishment of retired capacities of mines at the stage of finalizing balance reserves of the deposit - condition for environmentally balanced development of the Zhezkazgan region. *Mine Surveying*. 2016; 5: 6–10.
6. Begalinov A., Khomiakov V., Serdaliyev Y., et al. Formulation of Methods Reducing Landslide Phenomena and the Collapse of Career Slopes during Open-Pit Mining. *E3s Web Conf.* 2020; 168: 00006. https://doi.org/10.1051/e3sconf/202016800006.
7. Bondarenko V., Symanovych G., Koval O. The Mechanism of Over-coal Thin-Layered Massif Deformation of Weak Rocks in a Longwall. *Geomechanical Process. During Underground Mining*. 2012: 41–44. https://doi.org/10.1201/b13157-8.
8. Method for Predicting FMS and SSS of an Array: Certificate of Entry into the State Register of Rights to Objects Protected by Copyright, No. 19300. G. M. Kyrgizbayeva, M. B. Nurpeisova. July 12, 2021.
9. Patent RK No. 35898. Seismoacoustic Method for Predicting the SSS of an Array. M. B. Nurpeisova, M. Zh. Bitimbaev, K. B. Rysbekov, G. M. Kyrgizbayeva; successor in title. UNIV KAZANAT RES TECH. Publication date: 14.10.2022. Derwent Primary Accession Number: 2024-B08861.
10. Makarov A.B. Practical Geomechanics: A Manual for Mining Engineers. Moscow, 2006: 391.
11. Abdiev A., Mambetova R., Abdiev A., Abdiev S. Development of Methods for Assessing the Mine Workings Stability. *E3s Web Conf.* 2020; 201: 01040. https://doi.org/10.1051/e3sconf/202020101040.
12. Patent of the Republic of Kazakhstan No. 35798. Ground-Based Permanent Geodetic Point for Forced Centering of Instruments. M. Nurpeisova, K. Rysbekov, Sh. Aitkazinova [et al.] ; successor in title. UNIV KAZA NAT RES TECH. March 11, 2021. Derwent Primary Accession Number: 2022-C4343S.
13. Bazaluk O., Petlovanyi M., Zubko S., et al. Instability Assessment of Hanging Wall Rocks during Underground Mining of Iron Ores. *Minerals.* 2021; 11 (8): 858. https://doi.org10.3390/min11080858.
14. Patent K36246-B. Method of Consolidating the Slope of a Quarry / A. A. Bek, N. S. Donenbayeva, M. B. Nurpeissova et al.; UNIV KAZA NAT RES TECH. Derwent Primary Accession Number: 2024-C48648.
15. Meirambek G., Rysbekov K.B., Babets D.V., et al. Sarybayev N. Integrated geomechanical modeling of the rock mass based on radar observations for identifying the displacement zone. *Engineered Science.* 2026; 41: 2227. https://doi.org/10.30919/es2227.

СВЕДЕНИЯ ОБ АВТОРАХ

Гульдана Мейрамбек –
канд. техн. наук, профессор, зав. кафедры маркшейдерского дела и геодезии, Казахский национальный исследовательский технический университет имени К. И. Сатпаева (Satbayev University), г. Алматы, Республика Казахстан; https://orcid.org/0000-0003-3959-550X

Канай Бахытович Рысбеков –
канд. техн. наук, профессор кафедры маркшейдерского дела и геодезии, Казахский национальный исследовательский технический университет имени К. И. Сатпаева (Satbayev University), г. Алматы, Республика Казахстан; https://orcid.org/0000-0003-3959-550X

Маржан Байсановна Нурпеисова –
д-р техн. наук, профессор кафедры маркшейдерского дела и геодезии, Казахский национальный исследовательский технический университет имени К. И. Сатпаева (Satbayev University), г. Алматы, Республика Казахстан; https://orcid.org/0000-0002-3956-5442; e-mail: marzhan-nurpeissova@rambler.ru

Сауле Темирбулаовна Солтабаева –
канд. техн. наук, профессор, профессор кафедры маркшейдерского дела и геодезии, Казахский национальный исследовательский технический университет имени К. И. Сатпаева (Satbayev University), г. Алматы. Республика Казахстан; https://orcid.org/0000-0003-1330-2174

ABOUT THE AUTHORS

Goldana Meyrambek –
Cand. Sci. (Eng.), Professor, Head of the Department of Mine Surveying and Geodesy, Kazakh National Research Technical University K. I. Satpayev (Satbayev University), Almaty, Republic of Kazakhstan; https://orcid.org/0000-0003-3959-550X

Kanai B. Rysbekov –
Cand. Sci. (Eng.), Professor, Department of Mine Surveying and Geodesy, Kazakh National Research Technical University K. I. Satpayev (Satbayev University), Almaty, Republic of Kazakhstan; https://orcid.org/0000-0003-3959-550X

Marzhan B. Nurpeisova –
Dr. Sci. (Eng.), Professor, Department of Mine Surveying and Geodesy, Kazakh National Research Technical University K. I. Satpayev (Satbayev University), Almaty, Republic of Kazakhstan; https://orcid.org/0000-0002-3956-5442; e-mail: marzhan-nurpeissova@rambler.ru

Saule T. Soltabayeva –
Cand. Sci. (Eng.), Professor, Department of Mine Surveying and Geodesy, Kazakh National Research Technical University K. I. Satpayev (Satbayev University), Almaty, Republic of Kazakhstan; https://orcid.org/0000-0003-1330-2174

Шынар Касымкановна Айтказинова –
PhD, профессор кафедры маркшейдерского дела и геодезии, Казахский национальный исследовательский технический университет имени К. И. Сатпаева (Satbayev University), г. Алматы, Республика Казахстан;
https://orcid.org/0000-0002-0964-3008

Shynar K. Aitkazinova –
PhD, Professor, Department of Mine Surveying and Geodesy, Kazakh National Research Technical University K. I. Satpayev (Satbayev University), Almaty, Republic of Kazakhstan;
https://orcid.org/0000-0002-0964-3008

Критерии авторства:
Авторы заявляют о равном вкладе каждого в работу над статьей.

Contribution:
The authors declare the equal contribution of everyone to the work on the article.

Конфликт интересов:
Авторы заявляют об отсутствии конфликта интересов.

Conflict of interest:
The authors declare no conflict of interest.

Информация о статье
Поступила в редакцию: 15.07.2026
Поступила после рецензирования: 31.07.2026
Принята к публикации: 07.08.2026

Article info
Received: 15.07.2026
Revised: 31.07.2026
Accepted: 07.08.2026