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

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

# Х А Б А Р Л А Р Ы

# ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Казахский национальный исследовательский
технический университет им. К. И. Сатпаева

# N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university
named after K. I. Satpayev

## SERIES
## OF GEOLOGY AND TECHNICAL SCIENCES

**4 (436)**

**JULY – AUGUST 2019**

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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

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

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

**«ҚР ҰҒА Хабарлары. Геология мен техникалық ғылымдар сериясы».**
**ISSN 2518-170X (Online),**
**ISSN 2224-5278 (Print)**
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген **№10892-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

---



Редакцияның мекенжайы: Қазақстан, 050010, Алматы қ., Қабанбай батыра көш., 69а.
Қ. И. Сәтбаев атындағы геология ғылымдар институты, 334 бөлме. Тел.: 291-59-38.

Типографияның мекенжайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

**«Известия НАН РК. Серия геологии и технических наук».**
**ISSN 2518-170X (Online),**
**ISSN 2224-5278 (Print)**
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы)
Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан **№10892-Ж,** выданное 30.04.2010 г.

Периодичность: 6 раз в год
Тираж: 300 экземпляров

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18,
http://nauka-nanrk.kz /geology-technical.kz

---



Адрес редакции: Казахстан, 050010, г. Алматы, ул. Кабанбай батыра, 69а.
Институт геологических наук им. К. И. Сатпаева, комната 334. Тел.: 291-59-38.

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

**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: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty)
The certificate of registration of a periodic printed publication in the Committee of information and archives of the Ministry of culture and information of the Republic of Kazakhstan N 10892-Ж, issued 30.04.2010

Periodicity: 6 times a year
Circulation: 300 copies

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://nauka-nanrk.kz/geology-technical.kz

---



Editorial address: Institute of Geological Sciences named after K.I. Satpayev
69a, Kabanbai batyr str., of. 334, Almaty, 050010, Kazakhstan, tel.: 291-59-38.

Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty

**N E W S**
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
**SERIES OF GEOLOGY AND TECHNICAL SCIENCES**
ISSN 2224-5278
Volume 4, Number 436 (2019), 121 – 127 **https://doi.org/10.32014/2019.2518-170X.105**

UDK 622.235.669

**A. Ye. Vorobev[1], G. P. Metaxa[2], Ye. M. Bolenov[2], A. S. Metaxa[2], Zh.N. Alisheva[2]**

[1]The Peoples' Friendship University of Russia, Moscow, Russia,
[2]D. A. Kunayev Mining Institute, Almaty, Kazakhstan.
E-mail: fogel_al@mail.ru, gmetaksa@mail.ru, ebolenov@mail.ru,
zhannat_86.2007@mail.ru, metaxa_anna@mail.ru

# DIGITIZATION OF THE MINING INDUSTRY. CONCEPT AND MODERN GEOTECHNOLOGY

**Abstract.** The current state of digitalization in the mining industry is reflected in international and regional regulations of all technically developed countries. In 2015, in the Russian Federation it was planned to create the first industrial consortium to develop the concept of "smart quarry". The general initiator of the project was the VIST Group, as well as a number of mining companies in Russia and Kazakhstan. Belarus's partner is BELAZ, which successfully tested the first unmanned heavy dump truck in history. In the "Smart Quarry" project, an important technological direction is 3D modeling in resource extraction. Here is an interesting example of the Russian company Vizerra, which creates a virtual reality model of a career and an automated control system for mountain transport complexes based on the GLONASS satellite navigation technology and a robotized process control system for open-pit mining. The concept of a "smart" (intellectual) career is also widely developed in other countries where the mining industry has a high value (Australia, Canada, Chile). The Smart Career project was included in the list of AutoNet pilot projects of the National Technology Initiative. In the Republic of Kazakhstan, by the example of processing waste from the Zhezkazgan copper-smelting production, a new geotechnology is being created that assumes one hundred percent digitization of these processes. The combination of the results of experimental studies and implemented developments allows us to predict the successful implementation of digitalization processes in the mining and industrial sector of Kazakhstan. This paper reflects the following features of the digitalization of new geotechnologies developed in the Republic of Kazakhstan.

**Keywords:** digitalization, geotechnology, leaching, ecology, waste, functional diagram, experiment.

The existing concept of digitalization in the mining industry has a number of significant differences from the developed modern methods of automation of production, working from the industrial power grid.

Using the example of digitalization of the leaching process, it is shown that to implement this concept, an integrated approach to the study and subsequent use of natural mass transfer processes using an autonomous mode of operation is necessary.

A digitalization matrix is proposed for obtaining specified properties when implementing various interaction mechanisms at the phase boundaries. It is shown that the existing system does not possess sufficient knowledge-intensiveness and therefore the digitalization of the mining industry should be carried out taking into account the development of new geotechnologies, providing for an autonomous power supply.

**Introduction.** He relevance of the work is due to the need to replace unproductive labor with automated 3 D processes. Last year, a representative forum was held in the city of Minsk, which outlined the main priorities in the digitalization of the mining industry. It was shown that the digitalization process is already well underway in many enterprises, covering the logistic, economic and analytical areas [1, 2]. The software is carried out according to the fractal principle with a pyramidal complication depending on the volume of operations performed. According to these conceptual features, particular tasks are solved that do not require scientific content, i.e. It is based on existing technology. A number of processes that

exclude the presence of a person are automated, the development of the information flow depends entirely on the characteristics of the power supply system.

A common disadvantage of the achievements presented in the reports is the complete lack of solutions to environmental problems and social problems associated with the release of a large number of personnel. In addition, the existing restrictions related to the digitization of old technologies cannot provide a breakthrough to new solutions, to new geotechnologies.

In the modern mining industry there are a number of geotechnologies that do not require human presence in the underground space during the mining method of mining. The technologies associated with the processes of cold nuclear fusion (CNF) and other, for example, information technologies are being actively developed. Digitization of future geotechnologies requires a high level of professionalism for the successful solution of the tasks. This paper gives an example of the creation of a new geotechnology for leaching of enrichment wastes, TMT, poor ores and dumps [3, 4]. In this connection, there are problems of studying all the natural processes that accompany this phenomenon. The results of physical modeling showed the feasibility of such processes in real conditions without the use of expensive services of the industrial power grid. In addition, special attention should be paid to the deep study of natural phenomena in order to develop such geotechnologies, in which conditions are created for an autonomous mode of self-feeding and regulation of productivity. In the presented work there is an opportunity to analyze the difference between the concept (lat. – system of understanding) of digitalization, the reliability of which depends on the state of the power unit and the concept of digitalization of the mining industry, which is developed taking into account the influence of the complex interaction of natural factors.

**Methods.** To solve this problem, physical modeling methods have been used, for which the necessary theoretical substantiations have been created in the form of digitalization matrices for the processes of obtaining specified properties. The advantage of the modeling method created by us is an integrated approach to all the natural phenomena of a real array.

**The result** of this work is the development of a new project for the restoration of disturbed lands, which provides for the complete digitalization of all processes occurring in natural conditions. The draft sketch being developed has an autonomous power supply, which allows to fully automate the following processes:

- dissolution and sedimentation of minerals;
- their mass transfer depending on the position by countries of the world;
- tidal - tidal effects;
- capillary interactions.

Figure 1 shows the layout of processing nodes in such a project. A distinctive feature of the project is the presence of a bypass channel, a constant water level in which is maintained automatically.

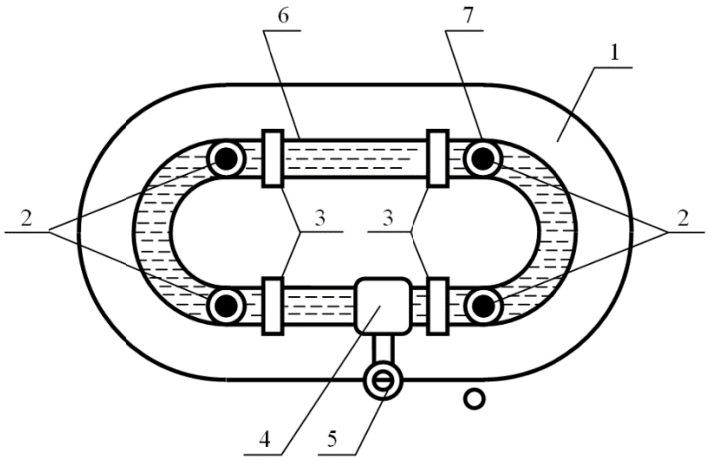


Figure 1 – Scheme of the location of mineral processing units for leaching of minerals:
1 – polygon array; 2 – collectors (4 pieces); 3 – gateway system elements (4-5 pieces);
4 – water treatment unit; 5 – well; 6 – polygon bypass channel; 7 – power converter unit (4 pieces)

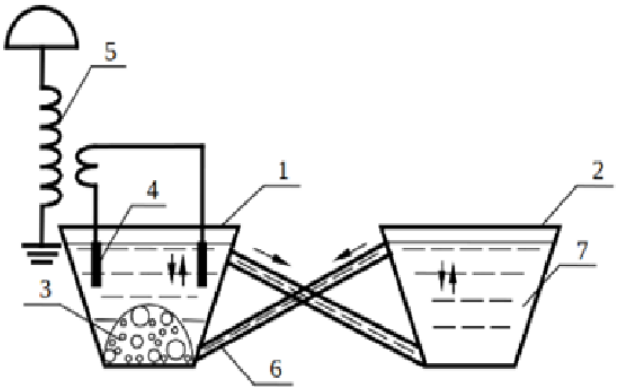


Figure 2 – Functional diagram of the leaching process: 1 – main reactor; 2 – auxiliary reactor; 3 – ore to be processed; 4 – electrodes; 5 – converter; 6 – piping; 7 – productive solution

The functional diagram is shown in Figure 2, it implements the transverse interaction of the following flows:

- concentration ΔC: ΔC = C1 - C2, (1)
- capillary: FT = FH, (2)

where FT is the force of gravity; FH is the surface tension force;

- convection: ΔT = T1 - T2, (3)
- gravitational: P = mg - ma, (4)

where P is weight; m - Mass; a - Acceleration; g - Free fall acceleration.

**Discussion.** For each of the listed mass transfer streams, there are mechanisms developed to control them in the automatic control mode of each process separately and in complex combinations [5]. Physical modeling of these processes was carried out in the laboratory. Pilot – industrial tests were successfully carried out in Zhezkazgan on copper smelting production wastes. The obtained results allow us to predict the economically - beneficial implementation of the development on all types of dumps, poor ores and industrial wastes of existing industries.

Here it should also be noted that according to the concept of M. V. Lomonosov [6] each field is an autonomous reactor, continuously reproducing those obtained minerals, which are due to the geometrical location of the reservoir massif. These problems also require research, although they are related to the solution of problems of cold nuclear fusion (NSF). In this case, it is necessary to know the conditions for focusing incoming external influences.

At the stage of carrying out laboratory work, it is possible to analyze the possibilities of the mechanisms controlling the properties in the reactions taking place at the interface (see table 1).

Table 1 – Matrix of digitalization of the processes of obtaining specified properties at the system output (interaction mechanisms at the interface) (3x3)

| Levels of consideration, m / Electronic $> 10^{-12}$ | Frequency range, (Hz) $c^{-1}$ | | | |
|---|---|---|---|---|
| | Films of liquid metals $10^{-12}$ - $10^{-15}$ | Liquid film $10^{-12}$-$10^{-9}$ | Films of organic compounds $10^{-9}$ - $10^{-6}$ | Type of controlled process |
| Lattice $> 10^{-9}$ | Elastic and inelastic scattering (exoemission) | Ionization | Radiation - chemical reactions | Intraphase Uniformity |
| Structural $> 10^{-6}$ | Phototransformation | Surface - active processes | Structuring, oxidation, reduction | Concentration disequilibrium |
| Control method | Heat generation | Sorption, desorption | Polymerization (synthesis, destruction) | Interphase disequilibrium |
| Levels of consideration, m | Change in contact conditions of heterogeneous phases | Resonance | Capacitive | Method of kinetic correspondences of reactions of actions and response |

This table shows the main mechanisms controlling the chemical and physical properties of the processes occurring at the interface, depending on the spatial-temporal parameters of the «impact-response system» [7, 8].

The development of theoretical aspects of the digitalization of the mining industry requires systemic knowledge of the properties of substances for different levels of consideration.

In systematization of knowledge about solid materials, the most significant are the size of their structural elements (spatial characteristic) and the period of their oscillations around the equilibrium position (temporary characteristic). Then, according to the level of significance, the space-time parameters of the influencing medium follow, since the state of the material under external influence depends on the relaxation time. The effect of external power is more dependent on the boundary conditions for the interaction of direct and reverse processes [9–15].

To identify causal relationships when exposed to external sources of variable fields with a solid substance, spatial-temporal parameters affecting the mass transfer, state and boundary conditions of the interacting phases are selected. At the same time, the following distance scales for any level of structures were selected for systematization by spatial attribute:

- macroscopic – near the scale of zero degree, $10^0$ м · 1 м;
- polycrystalline, $10^{-3}$ м;
- monocrystalline, $10^{-6}$ м;
- lattice, $10^{-9}$ м;
- electronic, $10^{-12}$ м.

Each model, changing through three orders of distance [7], has a specific leading element of the structure, its own group of relations of the physical model, its own group of mathematical realizations. Each group corresponds to a specific range of vibrations of the elements of the structure, which differs from each other by three orders of magnitude [16-20]. The analysis of causal relationships is performed according to the scheme (table 2) of the dialectical-logical approach to any problem under consideration, i.e. taking into account the categories of single, common and universal for each spatial level (B.A. Koyshibaev).

This scheme contains information for the analysis of cause and effect, taking into account the large-scale (spatial) signs in combination with the time (frequency spectrum) possibilities of manifestation. If the vertical columns arrange the levels of consideration by the scale of the distances, and the horizontal - the vibration frequencies (temporal sign) of the corresponding elements of the structure for each level, then you can systematize all types of mass transfer for solids [21-26]. In addition, for the mathematical implementation it is necessary to take into account the capacitive capabilities in the absorption of a certain type of radiation, which is entirely determined by the state of the material at the moment of radiation. Therefore, there is a need to systematize according to the same signs of solid states (table 3). During the analysis, the dialectical principles developed by BA Koyshibaev were used.

Table 2 – Matrix of system interconnections for the processes of accumulation and discharge of voltages for a solid substance, taking into account the space-time features

| Private range, Hz / Levels of consideration, m | Oscillation spectrum of electrons, $10^{15}$–$10^{12}$ | Oscillation spectrum of point defects, $10^{12}$–$10^{9}$ | Oscillation spectrum of linear defects, $10^{9}$–$10^{6}$ | Oscillation spectrum of other discontinuities $10^{6}$–$10^{3}$ |
|---|---|---|---|---|
| Electronic, $10^{-12}$ | Contact potential difference | Self diffusion | Polarization | Electroacoustic emission |
| Lattice, $10^{-9}$ | ThermoEMF (thermal conductivity) | Diffusion (concentration transfer) | Polymorphic transformations | Martensitic transformations |
| Structural, $10^{-6}$ | Thermo Magnetism | Intragranular deformation | Grain boundary deformation | Twinning |
| Real sample scale, $10^{-3}$ | Thermoelectro Resilience | Newtonian current | Non-newtonian flow | Superplasticity |

Table 3 – The matrix of solid states by space-time basis

| Private range, Hz / Levels of consideration, m | Oscillation spectrum of electrons, $10^{15}$–$10^{12}$ | Oscillation spectrum of point defects, $10^{12}$–$10^{9}$ | Oscillation spectrum of linear defects, $10^{9}$–$10^{6}$ | Oscillation spectrum of other discontinuities $10^{6}$–$10^{3}$ |
|---|---|---|---|---|
| Electronic, $10^{-12}$ | Conductive state | Ionized | Ordered | Scale effects |
| Lattice, $10^{-9}$ | Monocrystalline state | Polycrystalline state of solid solutions | Polymorphism (transformation) | Magnetostriction Electrostriction |
| Structural, $10^{-6}$ | Amorphous state | Polycrystalline state of mechanical mixes | State of phase boundaries | Shape memory effect, piezo effect |
| Real sample scale, $10^{-3}$ | Elastic state | Plastic condition | Hardened, weakened state | Superplasticity, fragility |

Thus, the combination of the obtained results of experimental studies and the developed theoretical background for digitalization in the mining industry allows us to draw the following conclusions:

1. The existing concept of digitalization in the mining industry has a number of significant differences from the developed modern methods of automation of production, working from the industrial power grid.

2. Using the example of digitalization of the leaching process, it is shown that to implement this concept, an integrated approach to the study and subsequent use of natural mass transfer processes using an autonomous mode of operation is necessary.

3. A digitalization matrix has been proposed for obtaining given properties when implementing various interaction mechanisms at phase boundaries.

**А. Е. Воробьев[1], Г. П. Метакса[2], Е. М. Боленов[2], А. С. Метахса[2], Ж. Н. Алишева[2]**

[1]Российский университет дружбы народов, Москва, Россия,
[2]Д. А. Кунаев атындағы Тау-кен ісі институты, Алматы, Казахстан

## ТАУ-КЕН ӨНЕРКӘСІБІН ЦИФРМЕН ҚАМТАМАСЫЗ ЕТУ. ТҰЖЫРЫМДАМА ЖӘНЕ ҚАЗІРГІ ЗАМАНҒЫ ГЕОТЕХНОЛОГИЯ

**Аннотация.** Тау-кен өнеркәсібіндегі цифрландырудың ағымдағы жағдайы барлық техникалық дамыған елдердің халықаралық және өңірлік ережелерінде көрініс тапты. 2015 жылы Ресей Федерациясында «ақылды карьер» тұжырымдамасын әзірлеу үшін алғашқы өнеркәсіптік консорциум құру жоспарланған. Жобаның бас демеушісі VIST Group, сондай-ақ Ресей мен Қазақстанның бірқатар тау-кен компаниялары болды. Белоруссияның серіктесі БЕЛАЗ болып табылады, ол тарихтағы бірінші ұшқышсыз ауыр самосвал табысты сыналды. «Smart Quarry» жобасында маңызды технологиялық бағыт ресурстық өндірісте 3D моделдеу болып табылады. Ресейлік компания Vizerra - мансаптың виртуалды нақтылық моделін және ГЛОНАСС спутниктік навигациялық технологияға негізделген тау-кен көлік кешендерін басқарудың автоматтандырылған жүйесін жасайды және ашық карьерді өндіруге арналған роботталған үдерісті басқару жүйесін қызықтырады. "Ақылды" (зияткерлік) мансап тұжырымдамасы өндіруші өнеркәсіп жоғары мәнге ие басқа елдерде де кең дамуда (Австралия, Канада, Чили). "Ақылды мансап" жобасы Ұлттық технологиялық бастаманың "AutoNet" пилоттық жобаларының тізбесіне енді. ҚР-да Жезқазған мыс балқыту өндірісінің қалдықтарын өңдеу мысалында осы процестерді жүз пайыз цифрландыруды болжайтын жаңа геотехнология құрылуда. Тәжірибелік зерттеулер мен енгізілген әзірлемелердің алынған Нәтижелерінің жиынтығы Қазақстанның тау-кен-өнеркәсіп саласындағы цифрландыру процестерінің табысты іске асырылуын болжауға мүмкіндік береді. Бұл жұмыста ҚР-да әзірленетін жаңа геотехнологияларды цифрландырудың мынадай ерекшеліктері көрсетілген:

- тау-кен саласындағы цифрландыру тұжырымдамасының өнеркәсіптік электр желісінен жұмыс істейтін өндірістерді автоматтандырудың қазіргі заманғы тәсілдерінен бірқатар елеулі айырмашылығы бар.

- сілтісіздендіру процесін цифрландыру мысалында осы тұжырымдаманы іске асыру үшін пайдаланудың автономды режимін қолдана отырып, массопереностың табиғи процестерін зерттеуге және кейіннен пайдалануға кешенді тәсіл қажет екендігі көрсетілген.

- фазаларды бөлу шекарасында өзара әрекеттесудің әртүрлі механизмдерін іске асыру кезінде берілген қасиеттерді алу үшін цифрландыру матрицасы ұсынылған. Қолданыстағы жүйенің жеткілікті ғылымды қажет сінетіндігі жоқ екендігі көрсетілген, сондықтан тау-кен саласын цифрландыру автономды энергиямен жабдықтауды көздейтін жаңа геотехнологияларды дамытуды ескере отырып жүзеге асырылуы тиіс.

**Түйін сөздер:** цифрлау, геотехнология, шаймалау, экология, қалдықтар, функционалдық диаграмма, эксперимент.

**А. Е. Воробьев[1], Г. П. Метакса[2], Е. М. Боленов[2], А. С. Метахса[2], Ж. Н. Алишева[2]**

[1]Российский университет дружбы народов, Москва, Россия,
[2]Институт горного дела им. Д. А. Кунаева, Алматы, Казахстан

## ЦИФРОВИЗАЦИЯ ГОРНОЙ ОТРАСЛИ. КОНЦЕПЦИЯ И СОВРЕМЕННЫЕ ГЕОТЕХНОЛОГИИ

**Аннотация.** Современное состояние цифровизации в горной отрасли отражено в международных и региональных постановлениях всех технически развитых стран. В 2015 году в РФ планировалось создать первый промышленный консорциум для разработки концепции «умный карьер». Генеральным инициатором проекта выступали Группа ВИСТ, а также ряд горнодобывающих компаний России и Казахстана. Со стороны Беларуси партнером выступает компания БЕЛАЗ, которая успешно провела испытания первого в истории беспилотного большегрузного карьерного самосвала. В проекте «Умный карьер» важным технологическим направлением является 3D-моделирование в добыче ресурсов. Здесь интересен пример российской компании Vizerra, которая создает модель виртуальной реальности карьера и автоматизированной системы управления горно-транспортными комплексами на основе технологий спутниковой навигации ГЛОНАСС и роботизированной системы управления технологическими процессами открытых горных работ. Концепция «умного» (интеллектуального) карьера широко развивается и в других странах, где добывающая промышленность имеет высокое значение (Австралия, Канада, Чили). Проект «Умный карьер» вошел в перечень пилотных проектов «AutoNet» Национальной технологической инициативы. В РК на примере обработки отходов медеплавильного производства Жезказгана создается новая геотехнология предполагающая стопроцентную цифровизацию этих процессов. Совокупность полученных результатов экспериментальных исследований и внедренных разработок позволяет прогнозировать успешную реализацию процессов цифровизации в горно-промышленной отрасли Казахстана. В данной работе отражены следующие особенности цифровизации новых геотехнологий, разрабатываемых в РК:

- существующая концепция цифровизации в горной отрасли имеет ряд существенных отличий от разрабатываемых современных способов автоматизации производств, работающих от промышленной электросети.

- на примере цифровизации процесса выщелачивания показано, что для реализации этой концепции необходим комплексный подход к изучению и последующему использованию природных процессов массопереноса с применением автономного режима эксплуатации.

- предложена матрица цифровизации для получения заданных свойств при реализации различных механизмов взаимодействия на границах раздела фаз. Показано, что существующая система не обладает достаточной наукоемкостью и поэтому цифровизация горной отрасли должна осуществляться с учетом развития новых геотехнологий, предусматривающих автономное энергоснабжение.

**Ключевые слова:** цифровизация, геотехнология, выщелачивание, экология, отходы, функциональная схема, эксперимент.

**Information about authors:**

Vorobev A. Ye., Dr. of Sc., professor, The Peoples' Friendship University of Russia; fogel_al@mail.ru; https://orcid.org/0000-0003-0377-8419

Metaxa G. P., Dr. of Sc., Head of Laboratory "Physical and technical problems of development of deposits", D. A. Kunayev Mining Institute, Almaty, Kazakhstan; gmetaksa@mail.ru; https://orcid.org/0000-0001-5271-429X

Bolenov E. M., Lead Engineer, D. A. Kunayev Mining Institute, Almaty, Kazakhstan; ebolenov@mail.ru; https://orcid.org/0000-0002-9465-0543

Alisheva Zh. N., Researcher, D. A. Kunayev Mining Institute, Almaty, Kazakhstan; zhannat_86.2007@mail.ru; https://orcid.org/0000-0003-0929-4984

Metaxa A. S., Junior Researcher, D. A. Kunayev Mining Institute, Almaty, Kazakhstan; metaxa_anna@mail.ru; https://orcid.org/0000-0001-5574-0880

**REFERENCES**

[1] The state program “Digital Kazakhstan” // Approved by the Decree of the Government of the Republic of Kazakhstan, order No. 827 of 12/12/2017.

[2] Tsoy S.V. Fundamentals of the future mine design: Study guide. Almaty, 2011. 516 p.

[3] Chabdarova Yu.I., Nugmanov K.Kh., Shamganova L.S. and others. Geomechanical support of processing of thin deposits of the Zhezkazgan field // IGD them. D. A. Kunayev. Almaty, 2015. 170 p.

[4] Buktukov N.S., Metaksa G.P. Fundamentals of complex monitoring of the state of rocks for solving problems of managing catastrophic events // News of the National academy of sciences the Republic of Kazakhstan. 2014. N 3. P. 96-105. https://doi.org/10.32014/2018.2518-170X

[5] Karabalin U.S., Sarmurzina R.G., Metaxa G.P. The process of accumulation and discharge of stress, depending on the size and shape of the structural components of the landscape in the monitoring processes in oil production // Proceedings of the NAS RK. 2012. N 2. P. 48-52. https://doi.org/10.32014/2018.2518-170X

[6] Lomonosov M.V. A word about the birth of metals from the shaking of the Earth, September 6th, 1757, spoken // On the layers of the earth. M.: Gosgeolitizdat, 1949. 210 p.

[7] Danilenko V.M. Report on the I Vses. shkol on state diagrams in the city of B. Alta. 1978.

[8] Metaksa G.P. Space-time relationships that determine the mechanisms of interaction at the phase boundaries // Dep. In KazNIINTI. Alma-Ata. Reg. N 2938 of 03/30/88.

[9] Vorobev A.E., Chekushina T.V. Methods of electrochemical leaching of metals from ores // Mining information and analytical bulletin (Scientific and technical journal). M., 2014. N 6. P. 176-180.

[10] Lewandowski K.A., Kawatra S.K. (2009) Binders for Heap Leaching Agglomeration, Minerals & Metall. Process. Journal, SME, Littleton. Colorado, USA. Vol. 26, N 1.

[11] McNab B. (2006) Ores Resurrection of the Oresa Rock & Gold Crescent Conference, Townsville, Australia, March 29-30.

[12] Robertson S.W., Vercuil A., van Staden P.J., Craven P., 2005. A Primary Copper Sulphide Ore / 3rd S. African Conf. on Base Metals, SAIMMSymp. Series S39, ISBN 1-919783-74-1. P. 471-484.

[13] Ghorbani Y., Petersen J., Franzidis J-P. Heap leaching technology – Current state, innovations, and future directions: A review // Miner. Process. Extr. Metall. Rev. 2016. 37, 73-119.

[14] Panda S., Akcil A., Pradhan N., Deveci H. Current scenario of chalcopyrite bioleaching: A review of the recent advances to its heap-leach technology // Bioresour. Technol. 2015. P. 694-706.

[15] Valencia J.A., Méndez D.A., Cueto J.Y., Cisternas L.A. Saltpeter mineral heap leaching // Hydrometallurgy. 2008, 90, 103-114.

[16] Moreno, L., Ordóñez J.I., Cisternas L.A. Dissolution Model of Multiple Species: Leaching of Highly Soluble Minerals // Metall. Mater. Trans. B. 2017. 48, 1817-1826.

[17] Chanturiya V.A., Bunin I. Zh., Lunin V.D., Sedel'nikova G.V., Krylova G.S. Underground and heap leaching of uranium // Systems. Methods. Technologies E. G. Hitrov et al. Calculation of load-bearing. 2014. N 4(24). P. 122-126.

[18] Chanturiya V.A., Bunin I.Zh. The highpulsed disintegration method of opening and thinly dissolving mineral complexes // Zolotodobycha. 2006. N 87. P. 10-13.

[19] Koshel E.A., Krylova G.S., Eliseev V.N., Ibragimova N.V., Zhuikov Yu.F., Burmistenko Yu.N. Intensification of gold leaching method: pat. 2245379 Ros. Federatsiya. Opubl. 01/27/2005.

[20] Gurin K.K., Bashlykova T.V., Anan'ev P.P., Boboev I.R., Gorbunov E.P. Recovery of gold from a mixed type ores mixed type // Tsvetnyemetally. 2013. N 5. P. 36-38.

[21] Strizhko L.S., Boboev I.R., Gurin K.K. A method of extracting gold from ores and concentrates: pat. 2522921 Ros. Federatsiya, No. 2013111290/02; zayavl. 3/14/13; opubl. 07/20/14, Byul. No. 20.

[22] Strizhko L.S., Boboev I.R., Gurin K.K., Rabiev F.B. Development of hydrometallurgical deposits for gold deposits // Tsarenyemetally. 2013. N 4. P. 46-49.

[23] Metaksa G.P., Moldabaeva G.Zh., Alisheva Zh.N. Scientific-techical basics of viscosity reduction of the Kazakhstan oils, which provide a significant increase of oil reservoirs // News of the National academy of sciences the Republic of Kazakhstan. Series of geology and technical sciences. 2018. Vol. 3, N 430. P. 191-215.

[24] Kassymkanova Kh., Jangulova G., Bekseitova R., Miletenko N., Baidauletova G., Turekhanova V., Zhalgasbekov Y., Shmarova I. Express-assessment of geomechanic condition of the rock massive and development methods of its strengthening and reinforcing for safe ecological developing of the fields of mineral resorces in hard mountain-geological and mining engineering conditions // News of the National academy of sciences the Republic of Kazakhstan. Series of geology and technical sciences. 2018. Vol. 6, N 432. P. 37-46. https://doi.org/10.32014/2018.2518-170X.33

[25] Murtazin Y.Z., Miroshnichenko O.L., Trushel L.Y. Methods of making of geoinformational and analytical system of groundwater resources in Kazakhstan // News of the National academy of sciences the Republic of Kazakhstan. Series of geology and technical sciences. 2018. Vol. 5, N 431. P. 21-31. https://doi.org/10.32014/2018.2518-170X.6

[26] Kalugin O., Asanov E., Iskanderov R. Method of georadiolocation in complex scientific applied researches // News of the national academy of sciences the republic of Kazakhstan. Series of geology and technical sciences. 2018. Vol. 1, N 427. P. 49-60.

**Publication Ethics and Publication Malpractice**
**in the journals of the National Academy of Sciences of the Republic of Kazakhstan**

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 National Academy of Sciences of the Republic of Kazakhstan 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 National Academy of Sciences of the Republic of Kazakhstan 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 National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайте:

www:nauka-nanrk.kz

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

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

Верстка *Д. Н. Калкабековой*

Подписано в печать 22.07.2019.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
15,7 п.л. Тираж 300. Заказ 4.

*Национальная академия наук РК*
*050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18*