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Study of geochemical characteristics of the Bakyrchik ore zone

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ABSTRACT

The article presents a study on the geochemical characteristics of the ore deposits in the Bakyrchik ore area (Bakyrchik, Glubokiy Log, Zagadka, Promezhutochnoe), which is located in the Zharminsk district of the Abay region in Eastern Kazakhstan.The aim of the study is to identify and describe the geochemical characteristics of the ore deposits in the Bakyrchik ore field, and to analyze the distribution and zonation of elements within ore bodies and areas of dispersed mineralization. The results of spectral analysis on 30 rock samples collected from various depths (550–700 meters) in the vertical mineralization profile of the Bakyrchik field. Samples were taken from core material from different wells in different areas of the field, including Bakyrchik, Glubokiy Log, Zagadka, and Promezhutochnoe, as well as from zones of ore bodies and other areas such as zones of fracture, mylonite, calcite, and sulfide mineralization, considering lithological features. Based on the results of geochemical studies conducted, the characteristics and differences in geochemical properties of large and small ore deposits have been identified, and the distribution of chemical elements within zones of dispersed mineralization has been described. The practical significance of this work lies in the fact that the revealed patterns of element distribution and geochemical zoning to predict the presence of new ore deposits, interpret chemical anomalies, estimate the level of erosion of mineralization, and optimize exploration and assessment efforts in other areas within the ore field.

Keywords: geochemical zonation, ore bodies, near-ore halos, Bakyrchik zone, gold-arsenic mineralization, diffuse mineralization.

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Introduction

Kazakhstan occupies a leading position among countries with a rich mineral resource base, particularly in the field of gold mining. However, in recent decades, there has been a decline in easily accessible gold deposits, leading to the need for strategies to develop "blind" deposits – those hidden at considerable depths or covered by dense sedimentary rocks. With the increasing demand for gold in world markets and the dwindling supply of readily available raw materials, studying the geochemical characteristics of ore bodies becomes crucial.

The Bakyrchik ore zone is a strategically important gold mining facility due to its significant reserves and unique geochemical zoning. The study of gold-antimony-arsenic and gold-tungsten zones in the Bakyrchyk ore field allows us to gain a deeper understanding of the patterns of ore formation in difficult tectonic conditions [[1], [2], [3]].

The aim of the study is to study the geochemical characteristics of ore objects in the Bakyrchik ore field, as well as to analyze the zoning and distribution of elements in ore bodies and areas of scattered mineralization. This will contribute to developing methods for predicting hidden deposits, which is particularly important for gold-bearing areas with dense sedimentary rock cover [[4], [5], [6]].

The practical significance of the study lies in the analysis of patterns of distribution of elements that can be used to predict new ore bodies and assess the level of erosion of mineralization. The results have the potential to optimize exploration activities both in Kazakhstan and other regions with similar geological features, which will strengthen Kazakhstan's position in the gold market and ensure the sustainable development of its mining industry.

The relevance of studying this ore field is in the fact that it provides an in-depth and detailed approach to studying geochemical patterns, which can improve the efficiency of exploration and assessment work. Unlike other studies, which often focus on individual elements or associations, this study looks at a complex geochemical zone with the identification of four distinct zones, each with unique geochemical characteristics. This method allows not only identifying new ore bodies but also more accurately predicting their size and composition.

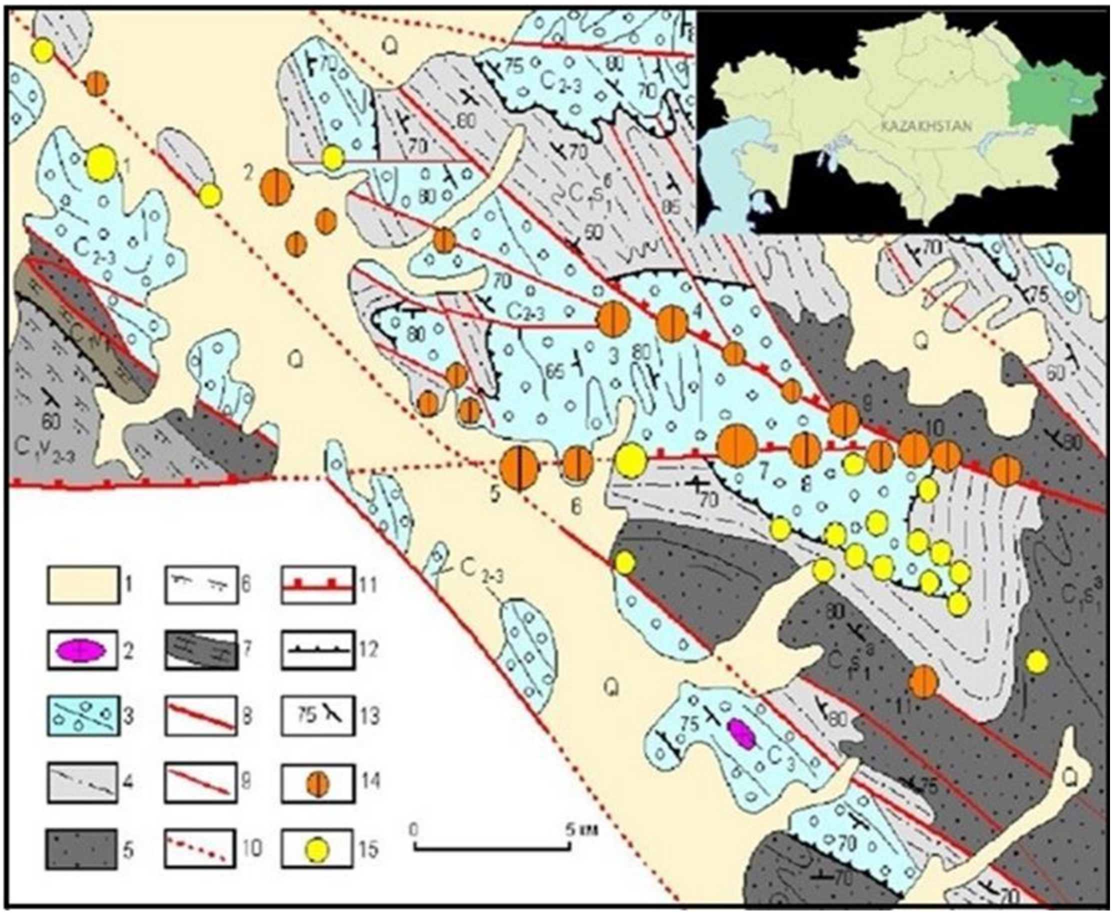

Figure 1 - Geological map of the Bakyrchik ore field (using materials by V.I. Tikhonenko)

1 – Quaternary deposits; 2 – 7 – geological formations: 2 – plagiogranite-granodiorite, C_3; 3 – Molasses limnic carbonaceous, C_{2-3}, 4 – grauvaccian silty-lithic sandstone, C_{1s} (4 – upper sandstone – siltstone and 5 – lower sandstone subformations), 6 – flyschoid carbonate-calcareous – terrigenous, C_{1v2-3}, 7 – limestone – sandstone – silty, C_{1v1}; 8 – 11 – discontinuous faults (8 – deep, 9 – shallow faults, 10 – under loose sediments, 11 – ore-controlling), 12 – thrust, 13 – elements of formation, 14 – 15 – ore formations (14 gold-arsenic – carbonate, 15 gold-quartz). Deposits: 1– Espe, 2 – Kostobe, 3– Dalny I, 4– Dalny, 5– Bolshevik, 6– Chelobai, 7 – Bakyrchik, 8 – Glubokiy log, 9 – Promezhutochnoe, 10 – Bizhan

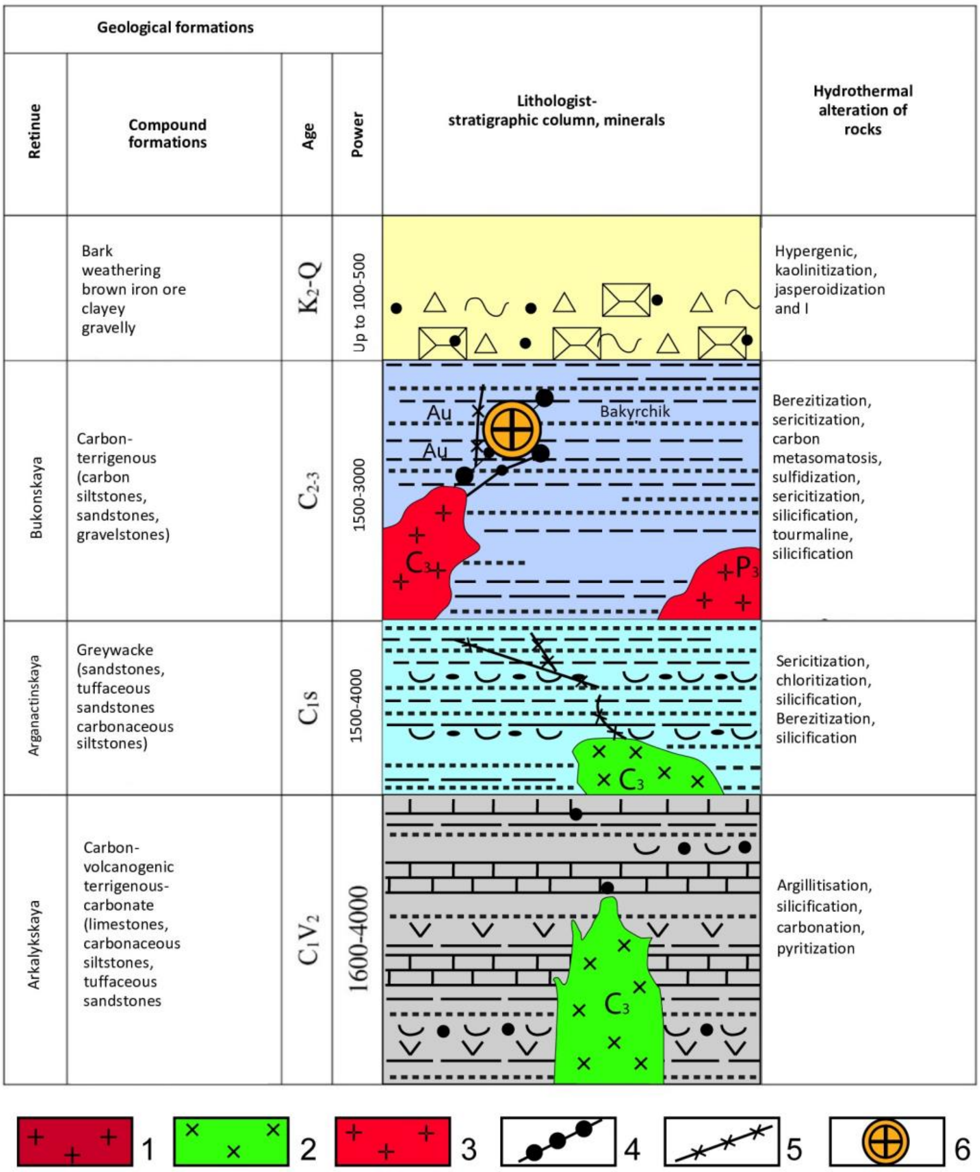

Figure 2 - Lithological and stratigraphic column of the area with metallogenic load (according to M. S. Rafailovich and B. A. Dyachkov)

1-5 – magmatic formations and sub-formations of the collision stage: 1 – leucogranite (the Delbegetey complex, P_2), 2 – gabbro-diorite-granodiorite granodiorite complex (Kunush complex, C_3) 3 – small intrusive plagioclase granites (Kunush complex. C_3), 4 – dikes of mottled composition, 5 – medium basic composition (Kunush complex and its analogs, C_3; geological and industrial minerals: 6 – giant Bakyrchik deposit

In addition, a significant difference of this study is the attention to zones of dispersed mineralization (ZDM), which are usually considered only as by-products in most world studies. In this case, these zones have been analyzed in detail, making it possible to identify promising areas more accurately and avoid mistakes when selecting objects for further work.

Knowledge of the features of zonation of ore bodies and halos helps increase the accuracy of predictive models and effective planning for exploration work.

The Bakyrchik ore field is an important gold mining facility in Kazakhstan. Its peculiarity lies in the unique geochemical zoning of the ore bodies, which makes it possible to deeply study the patterns of ore formation in a complex tectonic environment [[7], [8]].

The analysis of near-ore halos and zones of scattered mineralization at this facility contributes to the development of new methods for predicting "blind" deposits. Successful development of these "blind" gold deposits within the Bakyrchik ore field would make it possible to apply the results obtained in other areas. This would strengthen Kazakhstan's position on the global gold market and ensure steady growth in the mining industry.

Geological settings. According to the traditional scheme of structural and formation zoning of the Zaisan fold region, the district is located in the central part of Kalba synclinorium, within the Kalba-Naryn structural and formation zone, extending in a narrow band along the West Kalba fault (Fig. 1) [[9], [10]].

The following stratigraphic units of the Paleozoic group are involved in the geological structure of the area (Fig. 2):

1. Arkalyk formation (C_{1ar});
2. Aganaktin formation (C_{1ag});
3. Bukon formation (C_{2bk}).

Formations of weathering crusts, of areal and linear morphological types, are conventionally attributed to the Mesozoic period. The weathering crust develops along Paleozoic rocks, sedimentary and igneous in origin, lies under a cover of Neogene-Quaternary sediments and, in places, comes to the surface on tops of hills and steep slopes [[11], [12]]. According to conditions of occurrence and the structure of the weathered crust within the area they are divided into two types: areal and linearly fractured. According to chemical properties they belong to sialite. Depending on the source rock, the weathering crusts are divided into kaolin and nontronite [13].

Cenozoic deposits (Neogene and Quaternary) are also widely distributed within the area. They form river valleys, intermountain depressions, and areas covered with foam, covering 20-30% of the territory with uneven coverage. Neogene deposits are products of crustal erosion, weathering, and sedimentation in lake-lagoon conditions. They are mainly developed in the valleys of the Kyzyl-Su and Kuely rivers. Quaternary sediments (clay, sandy loam, loam, sand, pebble) fill all lowered relief forms and form terraces in river valleys and outflow cones. The total thickness is 40-70 meters. The area is characterized by a weak magmatic activity in the form of intrusive bodies of serpentinite ultramafic rocks, several dike formations of varied composition, and small intrusions of gabbro and granite. The largest intrusions are part of the Char complex, located southwest outside the Contract Square.

Intrusive complexes are distinguished on the territory of the district – the ultrabasic (Charsky) complex (C1v), granodiorite-plagiogranite (C3-P), gabbro-monzocite-granite (T1) [[14], [15], [16]].

Discontinuous faults on the territory of the region manifest themselves in the form of large faults of the first order, which serve as boundaries of large tectonic blocks and have a north-western strike, intrablock faults of the same strike (of the second order), as well as near-latitude and latitudinal carboniferous faults [[17], [18], [19]].

Research methods

In this paper, the patterns of distribution of geochemical features of the Bakyrchik ore field objects are analyzed and characterized: Bakyrchik, Glubokiy Log, Zagadka, Promezhutochnoe.

Core testing of core drilling wells was carried out on ore bodies, crushing zones, mylonite, hardening, and sulfide mineralization, with lithology considered. 30 core samples were analyzed using the spectral method at the Central Laboratory of Bakyrchik Mining Enterprise, which is accredited and registered with the State System for Technical Regulation in Kazakhstan. To analyze the geochemical features of ore bodies, spectral analysis was performed initially for 17 elements: gold (Au), arsenic (As), antimony (Sb), copper (Cu), molybdenum (Mo), tungsten (W), cobalt (Co), vanadium (V), lead (Pb), zinc (Zn), nickel (Ni), chromium (Cr), manganese (Mn) , iron (Fe), calcium (Ca) and magnesium (Mg). However, only 6 elements were selected for further detailed study: gold (Au) arsenic (As) antimony (Sb) Copper (Cu), Molybdenum (Mo) and tungsten (W). This choice is due to the fact that some elements were not found in significant concentrations or were not geochemically interesting in the context of the research objectives. Selected elements play a key role in ore formation processes and reflect characteristic geochemical patterns in the Bakyrchik ore zone. Their analysis revealed the geochemical zonation, features of the mineralization distribution, and relationships between elements, which are crucial for predicting new ore deposits and optimizing exploration and evaluation efforts. Narrowing the set of analyzed elements ensured a focus on the most relevant data, increasing the efficiency of interpretation and application of results.

Sampling was carried out by cutting the core along the axis in a stone-cutting machine. After that, half was sent for testing, and the other half remained as a backup.

Results and Discussion

A comparative analysis of the geochemical features of zonation, including antimony enrichment, transition from antimony to gold mineralization, association of gold with arsenic and tungsten with gold mineralization revealed characteristic zones in the vertical range of the studied area:

1. Upper antimony – gold-arsenic zone; which are characterized by a sharp predominance of antimony over gold and arsenic;

2. The first intermediate – gold-arsenic-antimony zone (with or without weakly manifested tungsten mineralization);

3. The second intermediate zone is mainly a gold-arsenic zone (without antimony, often with weakly manifested tungsten mineralization). Sometimes there is an increase in concentrations of cobalt, vanadium, copper, and molybdenum.;

4. The root – gold-tungsten-arsenic zone (often with an abnormally high content of copper and molybdenum). The tungsten content reaches tenths of a percent, and tungsten is strongly correlated with copper. The zone can be represented as an area of combination of two clearly manifested geochemical associations: gold-arsenic and tungsten-copper (with molybdenum) [20].

An analysis of the geochemical distribution showed that the zonation of elements in the ore bodies of Bakyrchik's ore zone is formed by the vertical profile of mineralization. Figure 3 shows the distribution of main and associated elements, revealing a concentric zoning structure resembling a funnel-shaped beam.

The bundle-like development of ore bodies, accompanied by contrasting vertical differentiation of elements, can be used to interpret chemical anomalies, linking ore bodies and assessing the level of erosion in other parts of an ore field. Thus, two geochemical zones (gold-arsenic-antimony and gold-arsenic with tungsten) are distinguished at Zagadka site, corresponding to the first intermediate and second intermediate zones.

Antimony-gold-arsenic mineralization can be attributed to the upper ore erosion section.

The presence of a second independent ore body with tungsten-containing gold-arsenic ores at deep levels is justified by geochemical zoning, analogy with the vertical scale of mineralization, and data on erosion sections

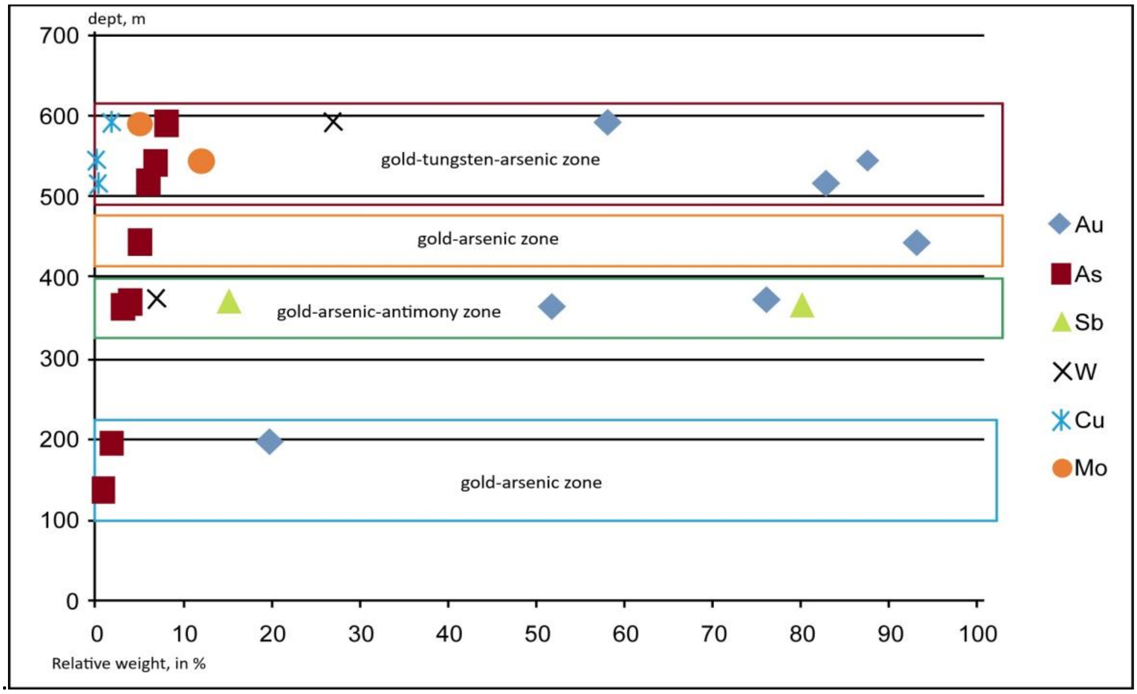

Figure 3 – Distribution of elements in ore bodies in the Bakyrchik ore zone

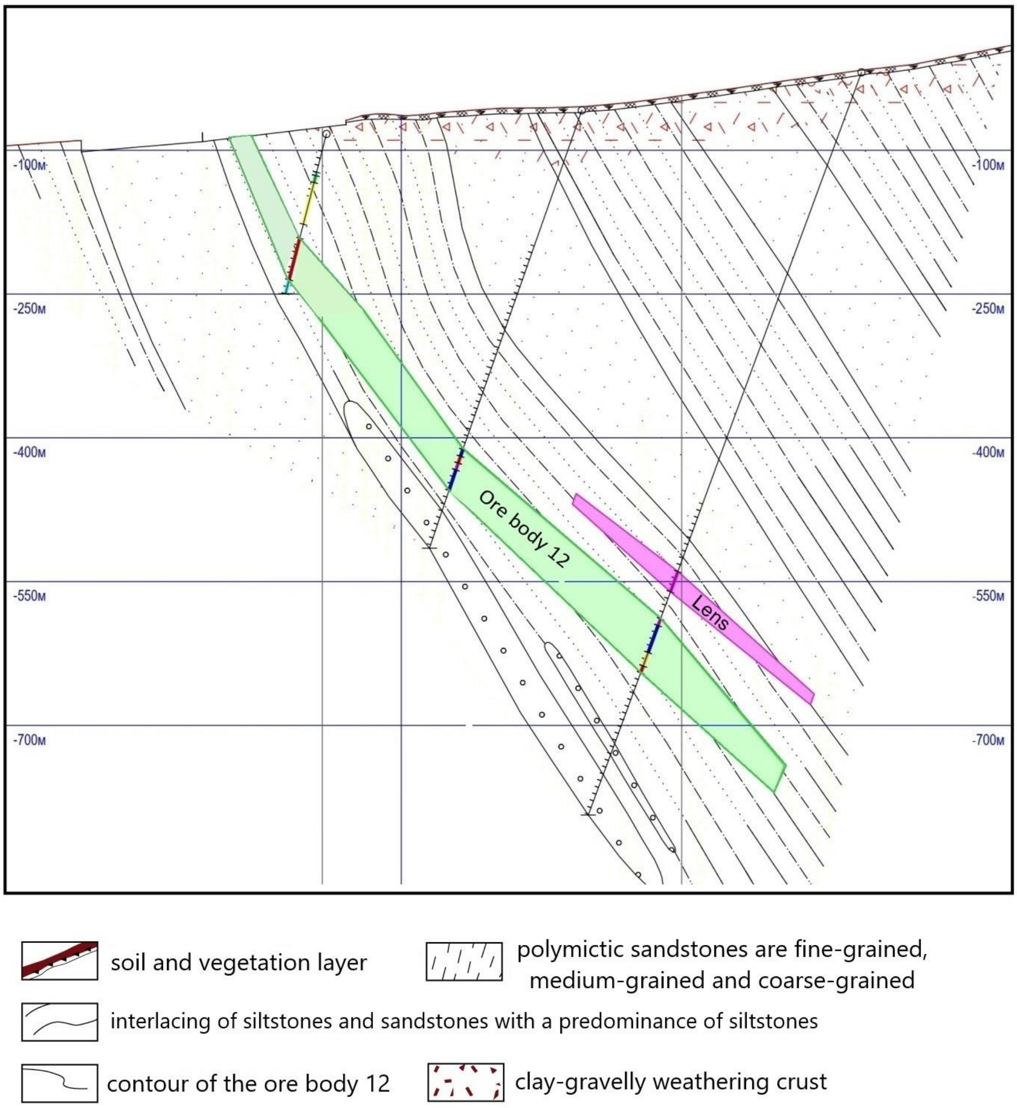

Figure 4 – Geological section of ore body 12

Geochemical features of ore bodies having various sizes

Ore bodies of different sizes vary significantly in their geochemical characteristics.

In the 12 ore body (Fig. 4, 5), the concentration of gold (Au) is unevenly distributed. This indicates local enrichment zones associated with hydrothermal activity. In small ore bodies, gold is distributed more evenly, which indicates their simplified structure and the absence of obvious zonation.

Arsenic (As) in the 12th ore body correlates closely with gold, reaching peaks in the range of 583-599 m, which is typical for arsenopyrite mineralization. In small ore bodies, the concentration of arsenic is low and practically does not change, indicating its lesser role in the formation of these bodies.

Copper (Cu) exhibits similar behavior in both types of ore bodies: its concentration increases at a depth of 702 m, which may be associated with the transition to deeper mineralization zones, where copper plays a major role.

The concentrations of tungsten (W) and molybdenum (Mo) in both types of ore bodies are extremely low, indicating a weak participation of these elements in the mineralization process.

In general, the 12th ore body is characterized by complex zonation and local enrichment zones, reflecting the multilayered nature of its formation. Small ore bodies, in contrast, demonstrate a homogeneous distribution of elements, indicating a more simplified process of formation. This difference highlights the geochemical complexity of large ore bodies compared to smaller ones.

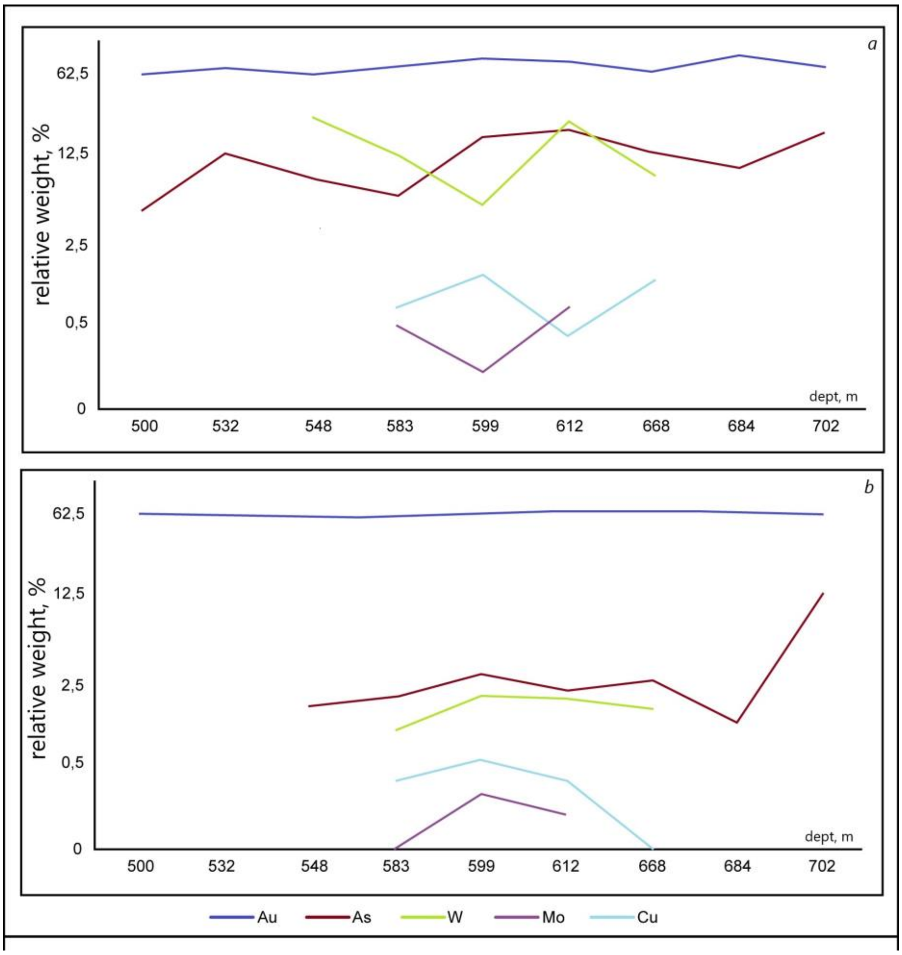

Figure 5 – Distribution of the main and associated components in the 12th ore body (a) and small ore bodies (b).

Geochemical features of zones of dispersed mineralization

In addition to concentrated ore deposits, there are numerous zones of gold-arsenic dispersed 7ineralization (ZDM) in ore fields that are of no practical interest. Due to their high content of gold and arsenic, they resemble near-ore haloes. Therefore, the problem of detecting and disassembling them is urgent. The geochemical features of several reference zones (Bakyrchik and Glubokiy Log) were studied [[21], [22], [23], [24]].

Based on the data obtained, a correlation matrix of near-ore haloes and zone of dispersed mineralization was constructed, which allowed us to assess the relationship between concentrations of various elements (Au, As, W, Cu, Mo) (Fig. 6).

Correlation between elements may indicate that minerals are found together under certain geological conditions. The positive correlation between gold (Au) and arsenic (As), for example, indicates that these elements often occur together in arsenopyrite zones. This is due to the fact that arsenic plays an important role in the formation of gold, suggesting that significant gold deposits may be located within these zones.

On the other hand, a negative correlation between gold and antimony (Sb) may indicate their mutual exclusion under geochemical conditions. This means that in places with high levels of antimony, gold content may be reduced. This information is important to consider when assessing the prospect of deposits.

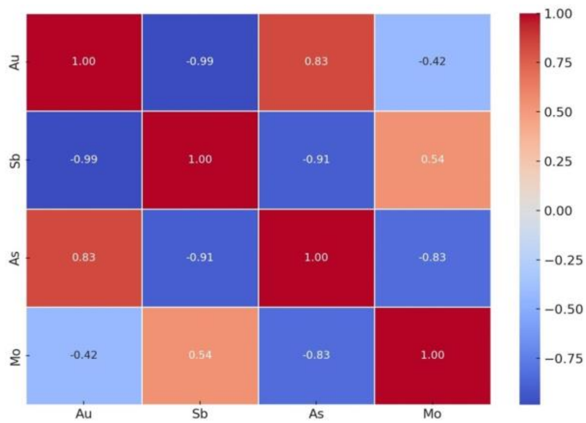

Figure 6 – Correlation matrix of elements near ore halos and zones of dispersed mineralization

The weak correlation of gold with arsenic, molybdenum (Mo) and tungsten (W) may indicate that they belong to different mineralogical associations formed under different conditions, and this knowledge can be useful to geologists and mining engineers in planning exploration and assessing potential deposits.

Based on the above, it can be concluded that the analysis of correlations between elements in areas of dispersed mineralization not only deepens our understanding of geochemical processes but also provides a basis for developing new methods for predicting and evaluating deposits.

Conclusions

The study confirmed the complexity of geochemical processes and emphasized the importance of considering geochemical and geological-structural features for forecasting and evaluating gold ore objects. As a result of this work four main geochemical zones were identified: the upper antimony-gold-arsenic zone, the intermediate gold-arsenics-antimony zone, and the gold-arsensic zone, as well as the root zone of gold, tungsten, and arsenic. These zones show vertical differentiation of elements that is manifested in beamlike structures, most prominent in the axial zones of ore bodies.

Significant differences between large and small ore bodies have been established. In large bodies, such as ore body 12, local gold enrichment zones are observed at depths of 583 meters and 684 meters, associated with a multilayer formation process. These zones are also associated with high correlation with arsenic, indicating the influence of arsenopyrite mineralization. On the other hand, small ore bodies are characterized by a more uniform distribution of elements, indicating a simpler process of their formation.

It has been established that zones of dispersed gold-arsenic mineralization have low concentrations of ore elements. This implies that these zones are not practical for practical use, and despite the presence of gold and arsenic, economic feasibility of developing such areas may be questionable since they do not contain enough minerals for efficient extraction. Therefore, for successful prediction and evaluation of gold ore bodies, it is essential to focus on ore bodies with higher levels of mineralization that are more concentrated.

Conflicts of interest. On behalf of all authors, the corresponding author states that there is no conflict of interest.

CrediT author statement: **A. Kopobayeva:** Conceptualization, Methodology, Investigation; **M. Musabayeva:** Investigation, Data curation, Writing draft preparation; **A. Amangeldikyzy:** Visualization, Editing, Writing - Reviewing; N. **Askarova**: Software; **F. Issatayeva:** Supervision.

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Бақыршық кен аймағының геохимиялық сипаттамаларын зерттеу

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Сараптамадан өтті: *18 наурыз 2025*
Қабылданды: *30 сәуір 2025*

ТҮЙІНДЕМЕ
Мақалада Абай облысының Жарма ауданында орналасқан Бақыршық кен аймағының (Бақыршық, Терең сай, Жұмбақ, Аралық) кен денелерінің геохимиялық ерекшеліктерін зерттеу ұсынылған. Зерттеудің мақсаты – Бақыршық кен орнының кен объектілерінің геохимиялық ерекшеліктерін анықтау және сипаттау, сонымен қатар кен денелеріндегі және дисперсті минералдану аймақтарындағы элементтердің аймақтарға бөлінуін және таралуын талдау. Геохимиялық талдау үшін аккредиттелген зертханада зерттелген 30 жынысөзекті сынамалардың спектрлік талдауының нәтижелері пайдаланылды. Әртүрлі тереңдіктегі ұңғымалардың (550-700 м диапазонында) жынысөзегінен алынған сынамалар Бақыршық кен орнының әртүрлі учаскелеріндегі кенденудің вертикальдық профилі бойынша, атап айтқанда, келесі объектілерден: Бақыршық, Терең Сай, Жұмбақ, Аралық, кен денелерінің аймақтарында, сондай-ақ ұсақтау, милониттену, кварцтану және сульфидті минералдану аймақтарында литологиялық ерекшеліктерді ескере отырып талданады. Жүргізілген

геохимиялық зерттеулердің нәтижелері бойынша ірі және ұсақ кенді денелердің геохимиялық сипаттамаларының ерекшеліктері мен айырмашылықтары анықталды, сондай-ақ шашыраңқы минералдану аймақтарында химиялық элементтердің таралу ерекшеліктері сипатталды. Жұмыстың практикалық маңыздылығы мынада: элементтердің таралу және геохимиялық аудандастырудың анықталған заңдылықтары жаңа кен денелерін болжау, химиялық аномалияларды түсіндіру, минералданудың эрозия деңгейін бағалау үшін қолданылады, сонымен қатар кен орнының басқа учаскелеріндегі барлау және бағалау жұмыстарын оңтайландыруға мүмкіндік береді.

Түйін сөздер: геохимиялық аймақтылық, кен денелері, кен маңындағы ореолдар, Бақыршық аймағы, алтын-мышьяк минералдануы, шашыраңқы минералдануы.

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Изучение геохимических характеристик Бакырчикской рудной зоны

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АННОТАЦИЯ

В статье представлено исследование геохимических особенностей рудных тел Бакырчикской рудной зоны (Бакырчик, Глубокий Лог, Загадка, Промежуточное), расположенной в Жарминском районе Абайской области. Целью исследования является выявление и характеристика геохимических особенностей рудных объектов Бакырчикского рудного поля, а также анализ зональности и распределения элементов в рудных телах и зонах рассеянной минерализации. Для геохимического анализа использованы результаты спектрального анализа по 30 керновым пробам, исследованных в аккредитованной лаборатории. Пробы отобраные из керна скважин различных глубин (в диапазоне 550-700м), проанализированы в вертикальном профиле оруденения, на различных участках Бакырчикского рудного поля, в частности, с объектов: Бакырчик, Глубокий Лог, Загадка, Промежуточное, в зонах рудных тел, а также в зонах дробления, милонитизации, окварцевания и сульфидной минерализации, с учетом литологических особенностей. По результатам проведенных геохимических исследований установлены особенности и различия в геохимических характеристиках крупных и мелких рудных тел, а также описаны особенности распределения химических элементов в зонах рассеянной минерализации. Практическая значимость работы заключается в том, что выявленные закономерности распределения элементов и геохимической зональности могут быть использованы для прогнозирования новых рудных тел, интерпретации химических аномалий, оценки эрозионного уровня оруденения, а также позволяют оптимизировать поисковые и оценочные работы на других участках рудного поля.

Ключевые слова: геохимическая зональность, рудные тела, околорудные ореолы, Бакырчикская зона, золотомышьяковая минерализация, рассеянная минерализация.

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References

[1] Soloviev SG, Kryazhev SG, Dvurechenskaya SS, Trushin SI. The large Bakyrchik orogenic gold deposit, eastern Kazakhstan: Geology, mineralization, fluid inclusion, and stable isotope characteristics. Ore Geology Reviews. 2020; 127:103863. https://doi.org/10.1016/j.oregeorev.2020.103863

[2] Kovalev K, Kalinin Yu, and etc. Relationship of antimony with gold mineralization in the ore districts of Eastern Kazakhstan. Russian Geology and Geophysics. 2014; 55:1170-1182. https://doi.org/10.1016/j.rgg.2014.09.003

[3] Mizernaya MA, Miroshnikova AP, Mizerny AI, Zikirova KT, Chernenko ZI. Geology, magmatism and specific features of mineralization of Bakyrchik ore field (Eastern Kazakhstan). Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu. 2023; 2. https://doi.org/10.33271/nvngu/2023-2/019

[4] Ludwig KR. SQUID 1.00, A User’s Manual; Berkeley Geochronology Center Special Publication. 2000; 2:24-55.

[5] Serykh VI, Kopobayeva AN. Patterns of distribution of rare metal deposits in central Kazakhstan. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. 2019; 1:143-150. https://doi.org/10.32014/2019.2518-170X.18

[6] Junussov M, Mohammad A, Longinos S. Geochemical analysis of organic matter associated with gold in ore deposits: A study of Kazakhstan and Hungary. Acta Geochim. https://doi.org/10.1007/s11631-024-00710-5

[7] Windley BF, Kroner A, Guo J, Qu G, Li Y, Chi Zhang. Neoproterozoic to Paleozoic geology of the Altai orogeny, NW China: new zircon age data and tectonic evolution. J. Geol. 2002; 110:719-737. https://doi.org/10.1086/342866

[8] Naumov E, Borisenko A, Kovalev K, Kalinin Y, Fedoseev G, Seltmann R. Gold deposits of Western Siberia and Eastern Kazakhstan: types and ages of mineralization, correlation with magmatic events. Proceedings of the 11th SGA Biennial Meeting Let's Talk Ore Deposits, Antofagasta, Chile. 2011: 82-84.

[9] Rafailovich MS. The geology of gold in Central Asia: the evolution of mineralization, metasomatic formations, explosive breccias, Almaty. 2013, 423.

[10] Dyachkov B, Mizernaya M, Kuzmina O, Zimanovskaya N, Oitseva T. Tectonics and metallogeny of East Kazakhstan. Intechopen. 2017. https://doi.org/10.5772/intechopen.72745

[11] Kuybida ML, Kruk NN, Paderin IP. Plagiogranite magmatizm of Ore Altay region, Russia. Granites and Earth Evolution: geodynamic position, petrogenesis and ore content of granitoid batholiths. First International Geological Conference. 26-29 August, Ulan-Ude, Russia. 2008, 234-257.

[12] Kirwin DJ, Forster CN, Kavaliers I, et.all. The Oyi Tolgoi copper-gold porphyry deposit, South Gobi, Mongolia. Geogynamics ang metallogeny of Mongolia with special emphasis on copper and gold deposits. London: CERCAMS. 2005, 155-168.

[13] Buslov MM, Fujiwara Y, Iwata K, Semakov NN. Late Paleozoic-Early Mesozoic Geodynamics of Central Asia. Geology and Geophysics. 2004; 7. https://doi.org/10.1016/S1342-937X(05)71064-9

[14] Xiao WJ, Windley BF, Huang BC, Han CM, Yuan C, Chen HL, Sun M, Sun S, Li L. End-Permian to mid-Triassic termination of the accretionary processes of the southern Altaids: implications for the geodynamic evolution, Phanerozoic continental growth, and metallogeny of Central Asia. Int. J. Earth Sci. 2009; 98:1189-1217. https://doi.org/10.1007/s00531-008-0407-z

[15] Kanaeva ZK, Kanaev AT, Semenchenko GV. Geological structure of the Bakyrchik gold-arsenic deposit in East Kazakhstan. K.I. Satpayev KSTU, Almaty, 2014.

[16] Soloviev SG, Kryazhev SG, Dvurechenskaya SS, Trushin SI. The large Bakyrchik orogenic gold deposit, eastern Kazakhstan: Geology, mineralization, fluid inclusion, and stable isotope characteristics. Ore Geology Reviews. 2020; 127(3):103863. https://doi.org/10.1016/j.oregeorev.2020.103863

[17] Baibatsha A. Geotectonics and Geodynamics of paleozoic structures from the perspective of plume tectonics: a case of Kazakhstan. International Journal of GEOMATE. 2020; 19(71):194-202. ISSN: 21862982 (P), 2186-2990, Japan. https://doi.org/10.21660/2020.71.31100

[18] Metallogeny of Central Asia from Kazakhstan to Xinjiang – Researchin Progress. CERCAMS-12 Workshop. London: Naturel History Museum. 2008.

[19] Umarbekova ZT, Dyusembaeva KSh. The characteristics and formation of black shale-hosted Bakyrchik-type gold mineralisation. Appl Earth Sci. 2019; 128(2):61-62. https://doi.org/10.1080/25726 838

[20] Dyachkov BA, Mizernaya MA, Maiorova N, Chernenko Z, Maiorov V, Kuzmina O. Geotectonic position and metallogeny of the greater altai geological structures in the system of the central asian Mobile Belt Boo: New Frontiers in Tectonic Research – General Problems sedimentary basins and island arcs. 2011. https://www.intechopen.com/chapters/17106

[21] Rafaylovich MS. The large gold-sulphide deposit of Bakyrchik in Kazakhstan: Geological structure prospecting model. Geology and Mineral Resources. 2009; 4:31-38.

[22] Kuibida ML, Kruk NN, Paderin IP. Plagiogranitic magmatism of the Rudny Altai. Granites and the evolution of the Earth: geodynamic position, petrogenesis and ore content of granitoid batholiths. Ulan-Ude: BSC SB RAS. 2008, 210-211.

[23] Dyachkov BA, Chernenko ZI, Mayorova NP, Mizernaya MA, Kuzmina ON. Geological conditions of formation and location of apocarbonate-type gold deposits in Eastern Kazakhstan. Ust-Kamenogorsk: EKSTU. 2011, 136.