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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
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Z.I. Chernenko*, M.A.Mizernaya, I. E. Mataibayeva, N.A. Zimanovskaya, 2024.
D. Serikbayev East Kazakhstan Technical University,
Ust-Kamenogorsk, Kazakhstan.
E-mail: Zinchernenko@mail.ru

GOLD ORE DEPOSITS ASSOCIATED WITH CARBONATE FORMATIONS (EAST KAZAKHSTAN)

Zinaida Chernenko – candidate of geological and mineralogical Sciences, PhD, associate professor, School of Earth, D.Serikbaev East Kazakhstan technical university, E-mail: Zinchernenko@mail.ru. https://orcid.org/0000-0002-3137-8300;
Marina Mizernaya – candidate of geological and mineralogical Sciences, PhD, associate professor, D.Serikbaev East Kazakhstan technical university, Mizernaya58@bk.ru Orcid.org/0000-0001-8618-7352;
Indira Mataibayeva – Ph.D, vice dean, School of Earth, D.Serikbaev East Kazakhstan technical university, indi.mataybaeva@mail.ru https://orcid.org/0000-0003-05507591;
Natalya Zimanovskaya – PhD, associate professor, School of Earth, D.Serikbaev East Kazakhstan technical university, nata_zim@mail.ru. ORCID 0000-00029881-690X https://orcid.org/0000-0002-9881-690X.

Abstract. *Goal*. The goal is to study processes contributing to gold deposits formation in East Kazakhstan, associated with carbonate formations, in order to obtain the results confirming sufficiently high potential for the identification of unconventional types of deposits with fine and free gold in carbonate formations of the region, which may be of industrial importance.

Method. Analysis of literary and stock materials, field studies within the known gold deposits. As well as evaluation of known and new geological-industrial types of deposits for gold using high-precision methods of rocks and minerals research to detect gold in the laboratories: “IRGETAS” D. Serikbaev EKTU and Geological-Ecological Institute LLP. Suzdal, Mirazh, Zhanan, Zhaima, and some areas and sites in Western Kalba (Baibura and others) deposits to a certain extent can be referred to the Carlin type of gold mineralization in East Kazakhstan.

Outcomes. Collection, summarization and analysis of collected geological materials resulted in revealing the main feature of gold spatial confinement, as well as gold-mercury and nickel-cobalt mineralization in weathering crusts to the Zaisan sutural zone of eastern Kazakhstan.

The obtained results reflect the fundamentality of the research and confirm sufficiently high prospects for identifying unconventional type of deposits with fine and free gold in island-arc volcanic-carbonateterrigenous formations of the region. They may be of industrial importance and cost-effectively exploited with the use of modern technologies.

Scientific novelty. The theoretical novelty of the research is that a new approach to the study and evaluation of gold-bearing structures of West Kalba zone and adjacent areas of Zharma-Saur is used.

Practical significance. Great scientific and practical importance is given to Gorny Altai and Kazakhstan continental margins junction area, where the Zaisan sutural zone (Semipalatinsk, Priirtyshye and other areas) with axial Charsko-Gornostaevskiy suture and the main gold-bearing structures of the region are concentrated. A large East-Kazakhstan gold belt is predicted here, and its northwestern and south-eastern flanks have not been studied sufficiently yet. In this regard, taking into account the stated methodological approaches, there is a certain potential for further development of research works in theoretical and applied aspects aimed at strengthening the raw material base for East Kazakhstan gold mining industry.

Key words: gold, carbonate formations, potential, East Kazakhstan.

З.И. Черненко*, М.А. Мизерная, И.Е. Матайбаева,
Н.А. Зимановская, 2024.
Д.Серікбаев атындағы Шығыс Қазақстан техникалық университеті,
Өскемен, Қазақстан.
E-mail: Zinchernenko@mail.ru

КАРБОНАТТЫ ТҮЗІЛІМДЕРМЕН БАЙЛАНЫСТЫ АЛТЫН РУДАСЫНЫҢ КЕН ОРЫНДАРЫ (ШЫҒЫС ҚАЗАҚСТАН)

Зинаида Черненко – геология-минералогия ғылымдарының кандидаты, PhD, Д. Серікбаев атындағы Шығыс Қазақстан техникалық университеті, «Жер туралы ғылымдар мектебінің» доценті, E-mail: Zinchernenko@mail.ru, https://orcid.org/0000-0002-3137-8300;
Марина Мизерная - геология-минералогия ғылымдарының кандидаты, PhD, доцент, Д. Серікбаев атындағы Шығыс Қазақстан техникалық университеті, Mizernaya58@bk.ru, Orcid.org/0000-0001 - 8618-7352;
Индира Матайбаева – ф.ғ.к., Д. Серікбаев атындағы Шығыс Қазақстан техникалық университеті, «Жер туралы ғылымдар мектебі» деканының орынбасары, indi.mataybaeva@mail.ru https://orcid.org/0000-0003-05507591;
Наталья Зимановская - PhD, доцент, Д. Серікбаев Шығыс Қазақстан техникалық университеті, «Жер туралы ғылымдар мектебі»; nata_zim@mail.ru; https://orcid.org/0000-0002-9881-690Х б.

Аннотация. *Мақсаты* – облыстың карбонатты түзілімдерінде ұсақ және бос алтыны бар кен орындарының дәстүрлі емес түрлерін анықтаудың жеткілікті жоғары әлеуетін растайтын нәтижелерді алу үшін Шығыс Қазақстанда карбонатты түзілімдермен байланысты өнеркәсіптік маңызы болуы мүмкін алтын кен орындарының пайда болуына ықпал ететін процестерді зерттеу.

Әдісі. Әдеби және қор материалдарын талдау, белгілі алтын кен орындарындағы далалық зерттеулер. Сондай-ақ зертханаларда алтынды анықтау үшін тау жыныстары мен пайдалы қазбаларды зерттеудің жоғары дәлдіктегі әдістерін қолдана отырып, алтынға арналған кен орындарының белгілі және жаңа геологиялық-өнеркәсіптік түрлерін бағалау: «ИРГЕТАС» Д .Серікбаев АТЫНДАҒЫ ШҚТУ ЖӘНЕ «Геологиялық-Экологиялық Институт» ЖШС. Суздаль, Мираж, Жанан, Жайма және Батыс Қалбадағы (Байбура және басқалары) кейбір аудандар мен учаскелерді белгілі бір дәрежеде Шығыс Қазақстандағы алтын минералдануының карлин типіне жатқызуға болады.

Нәтижелер. Жиналған геологиялық материалдарды жинау, топтау және талдау нәтижесінде Шығыс Қазақстанның Зайсан сутуральды аймағына ауа райының қыртыстары алтынның кеңістіктік шектелуінің, сондай-ақ алтын-сынап пен никель-кобальттың минералдануының негізгі ерекшелігі анықталды.

Алынған нәтижелер зерттеудің негізділігін көрсетеді және аймақтың аралдық-доғалы жанартау-карбонатетриг түзілімдерінде ұсақ және бос алтыны бар кен орындарының дәстүрлі емес түрін анықтаудың жеткілікті жоғары перспективаларын растайды. Олар өнеркәсіптік маңызы бар және заманауи технологияларды қолдану арқылы үнемді пайдаланылуы мүмкін.

Ғылыми жаңалығы. Зерттеудің теориялық жаңалығы-Батыс Қалба аймағы мен Жарма-Саурдың іргелес аудандарының құрамында алтыны бар құрылымдарды зерттеу мен бағалаудың жаңа тәсілі қолданылады.

Практикалық маңызы. Алтай Таулары мен Қазақстанның континентальды шеттерінің түйіскен жеріне үлкен ғылыми және практикалық мән беріледі, мұнда Зайсан тігісті аймағы (Семей, Ертіс және басқа аудандар) осьтік Чарско-Горностаевский тігісімен және облыстың негізгі алтыны бар құрылымдары шоғырланған. Мұнда Шығыс Қазақстанның үлкен алтын белдеуі болжанып отыр, оның солтүстік-батыс және оңтүстік-шығыс қапталдары әлі жеткілікті зерттелмеген. Осыған байланысты, аталған әдіснамалық тәсілдерді ескере отырып, Шығыс Қазақстанның алтын өндіру өнеркәсібінің шикізат базасын нығайтуға бағытталған теориялық және қолданбалы аспектілер бойынша ғылыми-зерттеу жұмыстарын одан әрі дамытудың белгілі бір әлеуеті бар.

Түйін сөздер: алтын, карбонатты түзілімдер, потенциал, Шығыс Қазақстан**.**

З.И. Черненко*, М.А. Мизерная, И.Е. Матайбаева, Н.А. Зимановская
Восточно-Казахстанский технический университет им. Д. Серикбаева,
Усть-Каменогорск, Казахстан.
E-mail: Zinchernenko@mail.ru

МЕСТОРОЖДЕНИЯ ЗОЛОТА, СВЯЗАННЫЕ С КАРБОНАТНЫМИ ФОРМАЦИЯМИ (ВОСТОЧНЫЙ КАЗАХСТАН)

Зинаида Черненко – кандидат геолого-минералогических наук, Ph.D, доцент «Школа наук о Земле» Восточно-Казахстанского технического университета им. Д.Серикбаева, E-mail: Zinchernenko@mail.ru. https://orcid.org/0000-0002-3137-8300;
Марина Мизерная – кандидат геолого-минералогических наук, Ph.D, доцент, Восточно-Казахстанский технический университет им. Д. Серикбаева, Mizernaya58@bk.ru Orcid.org/0000-0001 - 8618-7352;
Индира Матайбаева – кандидат технических наук, заместитель декана «Школа наук о Земле» Восточно-Казахстанского технического университета им. Д. Серикбаева, indi.mataybaeva@mail.ru https://orcid.org/0000-0003-05507591;
Наталья Зимановская – кандидат технических наук, доцент «Школа наук о Земле», Восточно-Казахстанского технического университета им. Д. Серикбаева, nata_zim@mail.ru . ORCID 0000-00029881-690X https://orcid.org/0000-0002-9881-690X.

Аннотация. *Цель*. Изучение процессов, способствующих формированию золоторудных месторождений Восточного Казахстана, ассоциирующихся с карбонатными формациями, для получения результатов, подтверждающих достаточно высокие перспективы выявления в карбонатных формациях региона нетрадиционных типов месторождений с тонкодисперсным и свободным золотом, которые могут иметь промышленное значение.

Методика. Анализ литературных и фондовых материалов, полевые исследования в пределах известных золоторудных месторождений. А также оценка известных и новых геолого-промышленных типов месторождений золота с использованием высокоточных методов исследования горных пород и минералов на выявление золота в лабораториях: «ИРГЕТАС» ВКТУ им. Д. Серикбаева и ТОО «Геолого-экологический институт». В Восточном Казахстане к карлинскому типу золотого оруденения в определенной степени можно отнести месторождения Суздальское, Мираж, Жанан, Жайма, Жанама, а также некоторые участки и объекты в Западной Калбе (Байбура и другие).

Результаты. В результате сбора, обобщения и анализа собранных геологических материалов выявляется главная закономерность о пространственной приуроченности золотого, а также золотортутного и никель-кобальтового оруденения в корах выветривания к Зайсанской сутурной зоне Восточного Казахстана.

Полученные результаты отражают фундаментальность исследований и подтверждают достаточно высокие перспективы выявления в островодужных вулкано-карбонатно-терригенных формациях региона нетрадиционного типа

месторождений с тонкодисперсным и свободным золотом, которые могут иметь промышленное значение и рентабельно отрабатываться с применением современных технологий.

Научная новизна. Теоретическая новизна исследований заключается в новом подходе к изучению и оценке золотоносных структур Западно-Калбинской зоны и прилегающих районов Жарма-Саура.

Практическая значимость. Большое научное и практическое значение придается области сочленения Горноалтайской и Казахстанской континентальных окраин, где выделяется Зайсанская сутурная зона (Семипалатинское, Прииртышье и другие районы) с осевым Чарско – Горностаевским швом и концентрируются главные золотоносные структуры региона. Здесь прогнозируется крупный Восточно-Казахстанский золоторудный пояс, северо-западный и юго-восточный фланги которого ещё недостаточно изучены. В этой связи с учётом изложенных методических подходов, имеется определенный потенциал дальнейшего развития научно-исследовательских работ в теоретическом и прикладном аспектах, направленных на укрепление сырьевой базы для золотодобывающей промышленности Восточного Казахстана.

Ключевые слова: золото, карбонатные формации, перспектива, Восточный Казахстан.

Introduction. East Kazakhstan is one of the most important gold mining regions of Kazakhstan. One of the possible reserves is evaluation of gold deposits associated with carbonate formations, especially in weathering crusts. Carbonate rocks themselves are valuable minerals and, in addition, they are considered as a favorable environment for the concentration of certain types of endogenous mineralization (Fe, Cu, Pb, Zn, Au, Sb, Hg, W, etc.).

The State balance sheet of the Republic of Kazakhstan accounts for reserves of 237 deposits, which include 122 primary deposits, 81 complex deposits, and 34 placer deposits. Gold deposits have been found in all regions of Kazakhstan, and East, North and Central Kazakhstan hold the leading positions in terms of reserves level. (Shcherba G.N., Dyachkov B.A., Nakhtigal G.P. 1984:240 p., Shcherba G.N., Dyachkov B.A., Stuchevsky N.I.. 1998:304 p.)

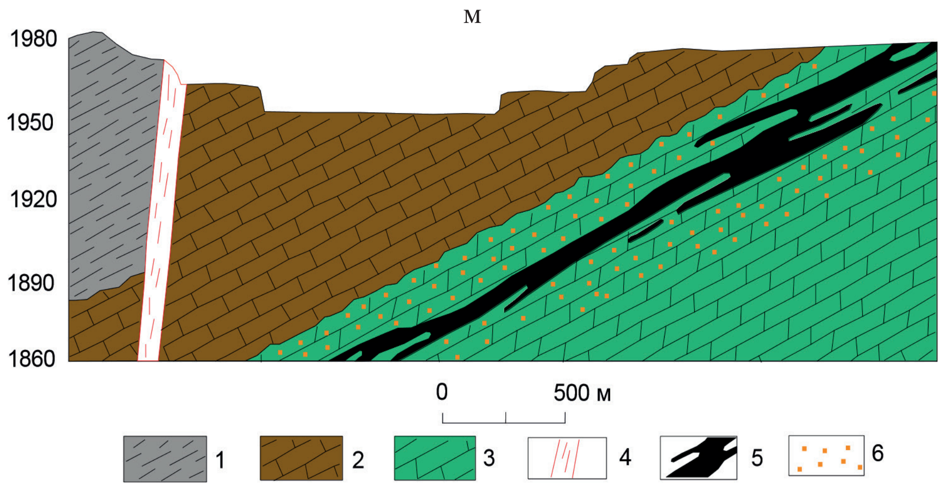
The distribution of gold deposits associated with carbonate formations at the global level was reviewed in literature. It was found that such deposits are known in a number of countries (the USA, Canada, China, Russia, Uzbekistan, etc.). The reference is the Carlin-type deposits with significant gold reserves (the USA). (Narseev V.A. 2002: 4.)

Carlin deposit is located in Nevada state. (Padtke A. S. 1267: U.). Here gold mineralization is confined to carbonate rocks of early Silurian, which are discordantly overlapped by limestones of Devonian age (Figure 1). The ore-bearing strata is fractured by faults and broken by quartz porphyry dikes. (Bakunin 10. I., Buryak V.A., Perestoropip A.V 2001: 159 c.) The main ore body is represented as a shallow-dipping stratified deposit composed of albitized quartz bearing carbonate rocks with clay minerals "spots". Decarbonatization, silicification, argillitization, and calcitization processes are evident in them. (Emsbo P., Hutchinson RW, Hofstra A.H., Volk J.A. et al. Bettles K.H., Baschuk G.J., Jonson C.A.1999:3).

According to A.S. Radtke and B.J. Scheiner, the carbonaceous substance of ore-bearing strata, which contributed to the formation of gold-organic compounds, had a great influence on gold deposition. Pyrite is the most common in ores, antimonite, galena, sphalerite, cinnabar, auripigment and other minerals also occur. Gold is very fine, submicroscopic with particle size up to 0.2 μ, so ore bodies are identified only by sampling results. (Emsbo P., Hofstra A.H., Lauha E.A. et al 2003:46).

In terms of reserves, this is a large deposit (110 tons of gold at an average grade of 10 g/t). It belongs to a new promising type of gold deposits associated with quartz bearing limestones. (Padtke A. S. 1267. U).

Analogous or similar deposits have been discovered in Canada, China, Uzbekistan, Russia, and other countries. (Ye Z., Kesler S.E., Essene E.J., Zonar P.B., Borhauer J.I. 2003: 17). A lot of works provide examples of some Russian deposits - Kuranakhskoye, Ulakhanskoye, Vorontsovskoye, etc. (Vetluzhskikh Kim, 1997; Sazonov et al. (Vetluzhskikh and Kim, 1997; Sazonov et al., 1998; Bakulin et al., 2001; Naumov et al., 2002). (Wells J.D., Mullens T.E. 1973: 14).



1 - Venini Formation (C), shales and quartzites; 2 - Popovich Formation (D), gray limestones, locally dolomitic and argillaceous limestones; 3 - Robert Mountains Formation (S1), laminated dolomitite and argillaceous siltstones; 4 - faulting; 5 - ore zone; 6 - altered (albitized) rocks.

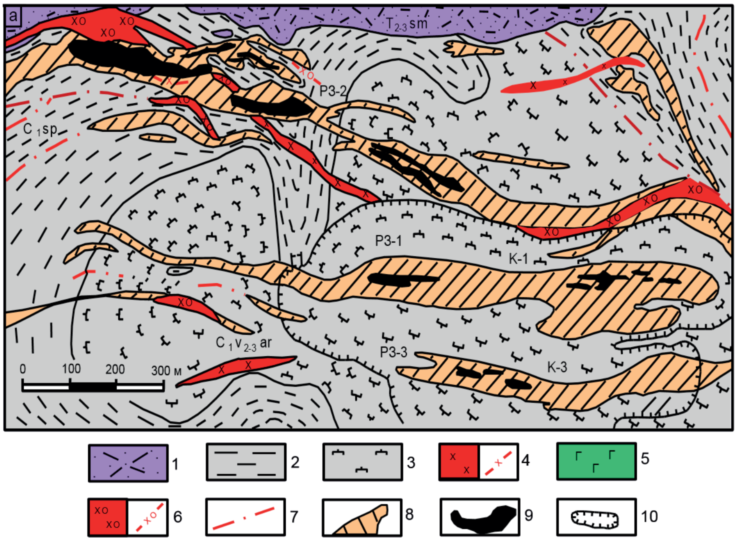
Figure 1: Geologic section across Carlin deposit. According to D.M. Hausen and P.F. Kerr

In Kazakhstan, V.A. Globa and V.A. Narseev for the first time focused on the need for a special study of gold content in carbonate-bearing formations, highlighting them as an indicator attribute in predicting and searching for gold deposits in activization areas. (Naumov E., Borisenko A., Kovalev K., Kalinin Y., Fedoseev G., Seltmann R. 2011:3). According to statistics, more than 500 ore deposits are located in the carbonate-bearing rock complexes, and there are much fewer deposits (134) in oreparent intrusive complexes. The authors recommend to focus on the detection of Kuranakh-type and Carlin apocarbonate-type gold deposits during prognostic-metallogenic works in Kazakhstan. According to these prospecting indicators, similar deposits may be discovered in East Kazakhstan region. The areas on the northwestern flanks of the Charsk and West-Kalba zones (within the Semipalatinsk Preirtyshye) are especially promising.

In East Kazakhstan, Suzdalskoye, Mirazh, Zhanan, Zhaima deposits, and some areas and sites in West Kalba (Baibura and others) to a certain extent can be referred to the Carlin type of gold ore. (Kalinin Yu.A, Kovalev K.R., Naumov E.A., Kirillov M.V. 2011:16.)

The considered type of gold ore is associated with rocks of island-arc terrigenous-carbonate formations subjected to contact-metasomatic and dynamo metamorphic transformations in melange zones, cover overthrust structures and halos, hidden gold-bearing hypabissal massifs and dikes of medium-basic composition (C2) and moderately acidic granitoids (C3). (Rafailovich M.S.. 2009: 304) Carbonate sediments seem to be a favorable tectonically prepared medium (in the form of structural-lithological and geochemical traps) for gold deposition and concentration. The leading ore formation is gold sulphide vein-disseminated one (Suzdalskoye, Mirazh, Baibura, etc.). (Narseev V.A. 2002: 4.)

*Suzdalskoye deposit***.** One of the leading types of gold-sulphide mineralization is Suzdalskoye deposit, located in the south-eastern exocontact of Semeytau volcanic-plutonic structures. Intrusive rocks are represented by dikes and small bodies of diorites, diorite porphyrites, and granodiorite porphyries (C3). According to magnetic prospecting data, a concealed intrusion of presumably intermediate composition is identified in the south-western part of the deposit. The primary goldsulphide mineralization is associated with Late Carboniferous magmatism, and the gold-bearing weathering crusts were formed during the Mesozoic stabilization phase. (Figure 2,3)



1 - tuffaceous sandstones T1 cm; 2 - siltstones and sandstones C1s, 3 - carbonaceous siltstones of the Arkalyk suite (C1v2-3); 4 - 6 intrusives T1: 4 - granitoids; 5 - gabbroids, 6 - graniteporphyries; 7 - faults; 8,9 - zones of gold mineralization: 8 - Au 0.1-2.0 g/t, 9 - Au > 2.0 g/t; 10 - pit outlines; P3 - ore zone, K - open pit

Figure 2: Geological structure of Suzdalskoye deposit (ore zones 1, 2, 3)

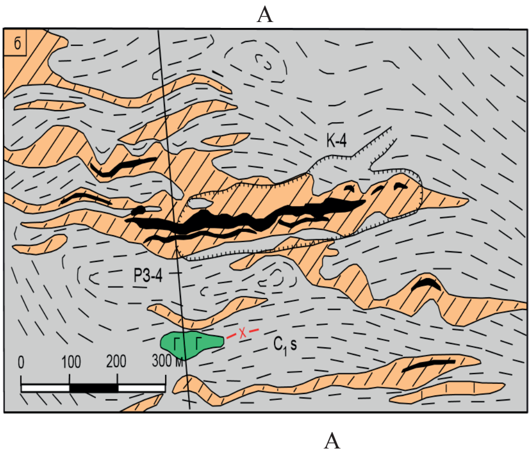


Figure 3. Geological structure of Suzdalskoye deposit (ore zone 4)

Suzdalskoye gold deposit is located in Zhana-Semey district of East Kazakhstan region, 50 km south-west of Semey city. Suzdalskoye gold deposit was discovered by Gornostayevskaya party of Altai Geological and Geophysical Expedition during conditioned geological survey of 1:50000 scale in 1980-84.

Primary ore zones are crushed and highly fractured carbonaceous and calcareouscarbonaceous siltstones, limestones, and sandstones containing gold-bearing quartz-carbonate stockworks. (Hofstra A.N., Levental J.S., Northrop H.R. et al. 1991:5). Gold-sulphide mineralization is represented by two types: predominantly stockwork quartz-carbonate (vein-nested-disseminated) and stratiform (sulphide disseminated in limestones). Composition of ore bodies: pyrite, pyrrhotite, arsenopyrite, chalcopyrite, pale ore, cinnabar, antimonite, scheelite, native gold, fluorite, barite, quartz, carbonate.

(Dyachkov B.A., Mayorova N.P., Chernenko Z.I., Kuzmina O.N.. 2010: 3)

The average gold content is 10 g/t. The shape of native gold is dendritic and amebiform. Concentration of gold is also identified in weathering crusts of kaolinite and hydromicaceous types of linear form with thickness from 1 to 10, rarely 100-200 m. The gold content is variable (from 1 to 90 g/t). Gold-bearing crusts are of industrial significance. (Dyachkov B.A., Chernenko Z.I., Kuzmina O.N. 2005:3).

Comparing the figures of the approved reserves with the reserves that are currently on the balance sheet, we can see that the convergence of gold reserves is almost full.

Collected and analyzed geological and geophysical materials resulted in compiling a structural formational map of carbonate formations location on a scale of 1:500000 in West Kalba zone and in developing geodynamic based common legend to them. The conducted analysis shows that the most significant gold occurrences are spatially associated with carbonate-terrigenous island-arc type formations. (Listiikova E.F. 2003:6).

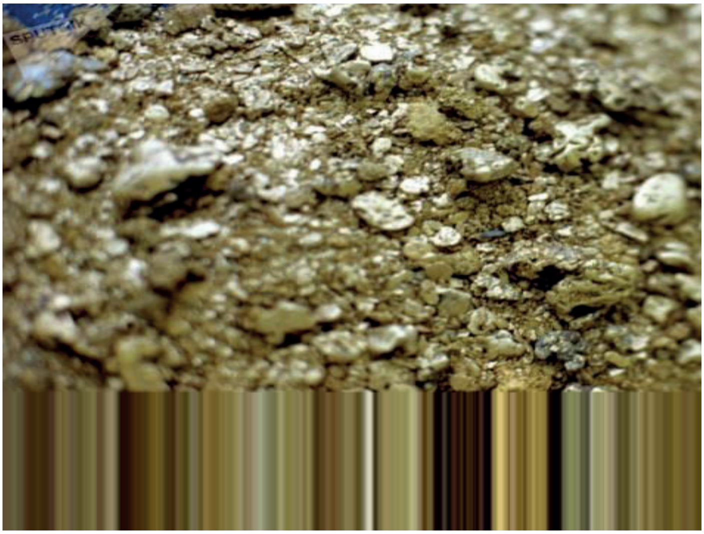


Figure 4: Overview map of Suzdalskoye deposit area.

Scale 1:200,000

Figure 5. Photo of gold at Suzdalskoye deposit

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Geological structure of Suzdalskoye deposit.

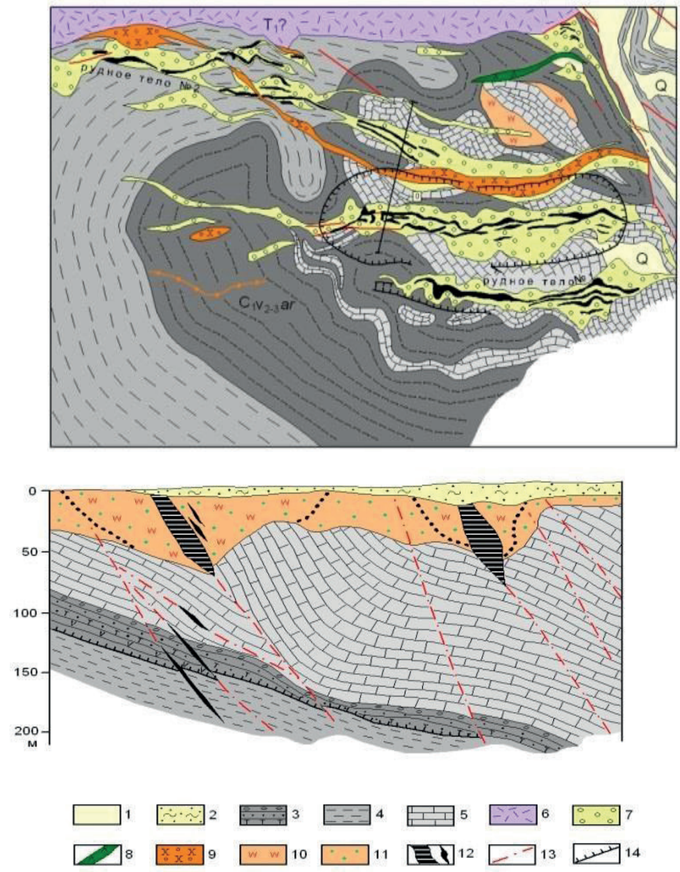
Suzdal tectonic block comprises Suzdalskoye deposit. It is bounded by the Semeytau block in the south-west and low-angle Gornostaevsky thrust in the north-east. The structure of the block involves deposits of Arkalyk suite (second and third benches) and Serpukhovian. (Mizerny A.I., Petrov S.F 2010:3, Dyachkov B.A., Chernenko Z.I., Mizernaya M.A., 2011: 136). Second bench deposits of Arkalyk suite were uncovered during core drilling in the central part (ore bodies 1, 2, 3) of the deposit at a depth of 200 - 300 m directly in the roof of the Gornostayevsky overthrust. They are represented by siliceous siltstones, volcanomictous sandstones, gravelites and, in subordinate quantities, by spread of lava containing andesite and basalt up to 20 m thick. (Fig. 1, 2).

The upper bench of Arkalyk suite in Suzdalskoye deposit is composed of reef limestones (with a large amount of fauna), chemical limestones and marlaceous siltstones. The thickness of the bench varies from 100 to 250 m. The contact with the Serpukhovian carbonaceous siltstones is gradational, it goes through a transitional horizon, which is represented by calcareous carbonaceous siltstones with marlstone and limestone interlayers. The number of interlayers is maximum in the lower part of the horizon and gradually decreases until they completely disappear upwards in the section. The lower contact of the Serpukhovian is along the conditional boundary where calcareous carbonaceous siltstones transit into carbonaceous-argillaceous siltstones. The thickness of the transitional horizon is 70-100 m. Suzdalskoye deposit ore is mainly localized within this horizon.

In the south-western flank of the Suzdal block, deposits of Arkalyk suite upper bench are represented by limestones, calcareous sandstones, and calcareous carbonaceous siltstones.

The Serpukhovian deposits contain mainly carbonaceous-argillaceous siltstones in the central part of the block, and sandstones and silty sandstones on the south-western flank.

Coal formations within the Suzdal tectonic block are grouped into gently sloping fold structures (wings dip at angles of 10-20 degrees). Two anticlinal structures and an adjacent synclinal fold are identified. Axial planes of anticlinal folds coincide with the central parts of the Suzdal and EastSemeytau tectonic zones. The Suzdal anticline, the most studied in detail, is characterized by a gentle southwestern dip of the axis (16 - 20 degrees) with undulation in the area of ore body 4 and on the south-western flank of the area. The core part of the fold is composed of Arkalyk suite sediments, the wings are built up by the Serpukhovian rocks (Figure 6).



1 - friable quaternary deposits and 2 - Neogene deposits; 3-5 - Arkalyk suite, C1v2-3 (3 - tuffaceous-sandstone bench with andesite-dacite interlayers, 4 - carbonaceous-clay shales, 5 - limestones, calcareous siltstones); 6 - volcanites of the Semytau suite; 7 - gold-sulphide mineralization zones; 8 - dioritic porphyritic dikes and 9 - granodioritic porphyries; 10 - silification zones; 11 - gold-bearing weathering crusts; 12 - ore bodies; 13 - faults; 14 - overthrust. According to I.V. Begaev, V.A. Denisenko.

Figure 6. Geological structure of the Suzdalskoye deposit (plan and section)

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.Gold-bearing weathering crust of Suzdalskoye deposit.

Gold-bearing weathering crusts refer to the exogenous formations and are widely developed on the territory of Kazakhstan. Gold-bearing weathering crusts are formed as a result of chemical weathering of gold-sulphide and gold-quartz-sulphide occurrences and deposits, as well as goldbearing sulphide ores of pyrite deposits. Chemical weathering process of gold-sulphide and goldquartz-sulphide ores results in sulphides oxidation, formation of iron oxides and hydroxides, redeposition of gold and increase of its concentration in weathering crust by several times in comparison with primary gold-bearing ores.

The weathering crust in Suzdalskoye deposit is developed 50-120 m deep and is represented by the kaolinite profile. There are two zones in the weathering crust section, which, in turn, are divided into a number of subzones. The lower zone is represented by structural weathering crusts of considerably hydrous composition. The upper zone is composed of clay unstructured kaolinites of hydromicaceous composition.

The lower hydrous zone, from bottom to top, consists of subzones: -leaching and disintegration of parent rock up to 10 m thick;

- hydromicaceous crust with montmorillonite admixture, 10 m thick;
- Montmorillonite - hydromicaceous crust with montmorillonite content up to 25-35% and up to 5 m thick;

-hydromicaceous crust with kaolinite admixture up to 10-15 % and montmorillonite up to 5-15 %. Subzone thickness is about 8 m.

The upper kaolinite hydromicaceous zone from bottom to top includes the following sub-zones:

- kaolinite-hydromicaceous, characterized by complete disappearance of structural features of the original rock and a sharp increase up to 25-40% of kaolinite. Subzone thickness is about 3 m;
- kaolinite, where the amount of hydrous minerals does not exceed 10 - 20 %, the content of kaolinite increases up to 50-60 % and of montmorillonite up to 20 - 40 %.

The identified zonality is not always clearly evident, but only in cases of homogeneous rocks development. In sections with a thin alternation of sediments with different chemical composition, a regular zonal structure of weathering crust section cannot be identified. Hydromicaceous and kaolinite layers alternation is observed here, and kaolinite layers were formed due to weathering of limestones and malmstones, which are much easier to weather than the host carbonaceous siltstones due to their high porosity and chemical composition.

In kaolinite-hydrosludite zone, as compared to the hydromicaceous zone, crusts are enriched with aluminum, titanium, silicon, and ferric iron. The concentration of potassium, phosphorus, magnesium, calcium, sodium, and ferrous iron decreases.

Analysis of bulk density distribution and total porosity in weathering crust section showed that:

- elements are removed in hydromicaceous zone without restructuring of the rock framework, resulting in a natural decrease in bulk density and, consequently, an increase in total porosity (from

5 to 50%) from the lower subzones to the upper subzones;

- there is restructuring and compaction of the rock due to bulk density reduction in kaolinitehydromica and with that zone.

Gold ore in oxidation zone is cross-cutting in relation to zones and subzones. There is no selective accumulation of gold in any of the weathering horizons.

Gold-bearing weathering crusts are, as a rule, confined to depressions in the relief and are located over primary deposits and gold occurrences. They are often overlapped by Quaternary and PaleogeneNeogene friable sediments.

There are linear and linear-areal weathering crusts according to morphological type. The thickness of gold-bearing weathering crusts varies from 50 to 120 m in linear and linear-areal weathering crusts.

Ore bodies in weathering crusts are of sheetlike, lenticular, and complex irregular shapes.

Ores in weathering crusts are characterized by large amounts of clay material (up to 40% and more). Ore mass consists of quartz, argillaceous and hydrous minerals, iron oxides and hydroxides (goethite and hydrogetite). Free gold is present in iron oxides and hydroxides. Significant amounts of fine gold are associated with clay minerals.

Gold-bearing weathering crusts also include the so-called "iron hats", which are the upper part of pyrite deposits oxidized sulphide ores. "Iron hats" often have high gold and silver content and are developed as gold ore deposits (Akbastau, Kosmurun, Maikain, Sugatovskoye and others). They are formed in the process of chemical weathering and sulphides oxidation.

Gold concentrations range from 1 to 100 g/t. In gold-bearing weathering crusts, gold is present in 3 forms: free (native) gold, finely dispersed gold - in sulphides, iron hydroxides, magnetite, etc. and gold sorbed by clays.

The morphology of native gold is varied. It is found in crystalline, lumpy, wire, film, and other forms. Its color is predominantly golden yellow, which indicates a high gold fineness. Fine gold is concentrated mainly in sulphides, such as pyrite and chalcopyrite, and products of their hypergenic transformation, magnetite, iron oxides and hydroxides. Besides, a significant amount of gold - up to 30% is found in the clay fraction, weathering crusts, where it is probably sorbed by clays. (Airiyants E.V., Zhmodik S.M., Gibsher N.A., 2000: 187).

Gold-bearing weathering crusts are characterized by a close surface position and shallow depth, which determines the possibility of their open mining using efficient heap leaching technology.

Ore zones of the deposit. Four zones of gold-sulphide mineralization are identified within Suzdalskoye deposit - 1, 2, 3 and 4. The zones are crosscutting in relation to host rocks and are represented by strongly fractured, crushed areas, calcareous carbonaceous siltstones and limestones. The fissures are filled with carbonate, quartz, chlorite, and hydromica. Zones are visually identified by increased carbonatization and silicification and sulphide mineralization. Gold-sulphide mineralization zones are delineated by a cutoff grade of 0.1 g/t gold on geological sections and plans. Ore bodies of oxidized and primary ores localized in the zones of gold-sulphide mineralization are identified only by the results of core sampling based on the conditions developed separately for oxidized and primary ores.

Gold ore mineralization zone is located 500 m to the north-west of zone 1. It is traced by mine workings along strike at a distance of 1200 m, down dip at 300-400 m. It has a rather low (40-45 degrees) southeastern dip. In relation to the host rocks, it occupies a crosscutting position. The morphology of the zone is complex, caused by sharp pinches, swells, frequent palpation, and "windows" of barren rocks, the thickness of the zone is up to 40 m. The zone is accompanied by numerous thin dikes of granite-porphyries and aplites, usually beresitized. According to sampling data, the zone is separated by several ore bodies, represented by oxidized and primary ores. The largest objects in the oxidation zone are ore bodies 2 and 2-2. Ore body 2 extends 260 m along strike and 70 m down dip to the lower boundary of the oxidation zone. The body is swollen to 15 to 20 m in thickness and overstretched to 2 to 3 m. The gold grade ranges from 1.5 g/t to 44.4 g/t, averaging 6.4 g/t. (Figure 6).

Ore body 2-2 is in echelon-like positioning in relation to ore body 2. Along the strike it is traced for 100 m, down the dip it is studied at full thickness of the oxidation zone, the average gold grade is 7.1 g/t. Other ore bodies of the oxidation zone are characterized by insignificant size and low gold grades. Oxidized ores of ore zone 2 are also completely exhausted.

There are 6 ore bodies among primary ore bodies of zone 2. The largest of these is ore body 21, which is an extension at the depth of ore body 2-2 identified in the oxidation zone. Ore body 2-1 is traced by drill holes in a distance of 700 m, down dip of 250 m, the thickness of the ore body varies from 1.0 to 13.5 m, averaging 4.8 m. Ore body mode of occurrence is defined by the nature of orebearing structure in ore-bearing zone No. 2. The main mineral bearing gold is pyrite, its crystals contain finely dispersed gold. The gold content in the ore body varies from 2.2 g/t to 13.1 g/t, averaging 6.7 g/t.

Ore bodies 2-3, 2-4 are identified by several holes, the distance between the bodies is from 5 to 15 m. Ore bodies 2-3, 2-4 of primary ores are connected with ore bodies of oxidized ores in subsurface part. Ore bodies extension down dip is 100 - 160 m, along strike extension is 450 m, thickness varies from 1.0 to 11.3 m. Mineralization is represented by pyrite with finely disseminated gold. The gold grade ranges from 3.4 g/t to 13.1 g/t, averaging 6.4; 10.6 g/t.

The remaining ore bodies are smaller in size, their position is within the ore-bearing zone No. 2, the nature of gold distribution, and its content are shown in the graphical appendices and in the reserve estimation tables.

Gold mineralization zone 3 is located 200 m southeast of ore zone 1. It is traced 700 m along the strike, its thickness of 10-100 m, and reaches its maximum thickness in the central part. Only oxidized ores are identified within the zone. They are represented by the main ore body and a number of smaller lenses. The main ore body along the strike has been studied on 550 m. (Cindy L. 2000: 13).

The shape of the ore body is complex due to swells up to 15 m in thickness and pitches, and there are apophysises represented by poorer ores. The dip of the ore body is steep (76-60 degrees) southeast. The gold content varies from 1.5 to 106 g/t, with an average of 16.2 g/t.

Such minerals obtained as by-product during the development of Suzdalskoye gold deposit (construction materials (sand, clay, limestone), rock dumps containing gold, sulfur, arsenic) and contained in sulfide gold-bearing minerals will be of primary importance.

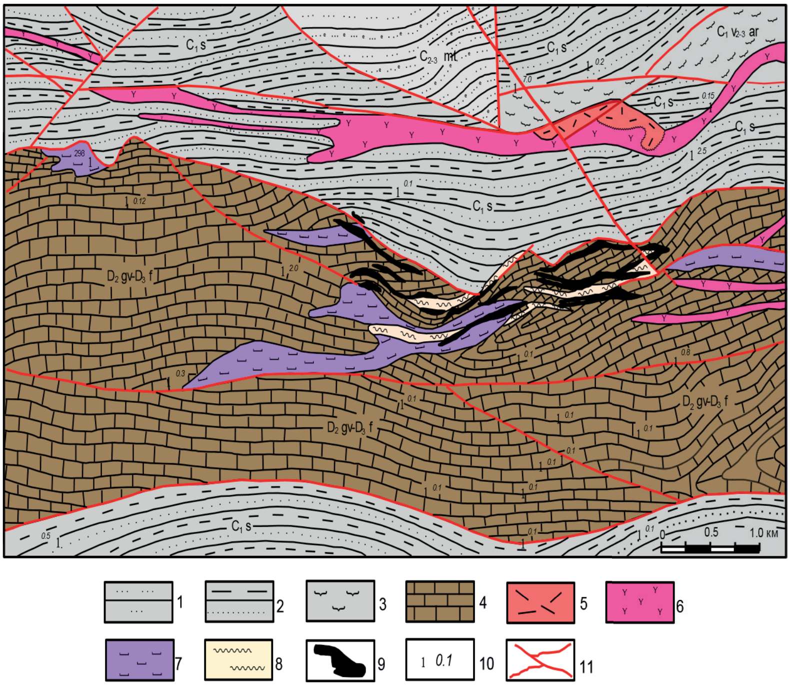
Significant gold reserves of the deposit, large size of ore zones, irregular distribution of gold in the ore bodies allow us to classify the deposit according to the complexity of geological structure into the 2nd group.

Mirazh deposit. Mirazh deposit is located to the west of Semeytau, within the eastern side of the Gornostaevsky ophiolitic belt. Hosting rocks are olystostromic complex limestones of CharskoGornostaevsky belt.

Ore belongs to the gold-sulfide-quartz formation, the upper horizons are oxidized. Disseminated ore mineralization is represented by gold and mercury, accompanied by halos of As, Sb, Hg, fuchsite, brainerite, pyrite, arsenopyrite, and antimonite.

Gold mineralization is revealed in the melange zone, at the contact of serpentinized protrusions of ultrabasites and limestones of the olystostromic complex. Productive weathering crusts with Au grades up to 5-73 g/t are developed up to a depth of 40-60 m. A total of seven ore-bearing zones (50600m long), 1-35m thick, with an average gold grade of 1.46 g/t and a maximum value of 29.8 g/t, are identified. Disseminated ore mineralization is represented by gold and mercury, emphasized by halos of As, Sb, Hg. Pyrite, arsenopyrite, antimonite, fuchsite and brainerite are indicated in the ores. Productive weathering crusts with Au content up to 5-73 g/t are developed 40-60 m deep.

The geological situation and the nature of mineralization indicate the proximity of the mineralization to the Suzdal type. According to “Vostkaznedra” territorial directorate data, inferred gold resources in primary ores are about 2.5 tonnes, in oxidized ores - 3.5 tonnes. According to the experience of gold-bearing weathering crusts development at Zhanan, Suzdal and Mukur sites, the geological and economic assessment of the Mirazh deposit is positive. (Figure 8).



1 - sandstones, gravelites, tuffs of Maytubinsk suite average composition (C3mt); 2 - sandstones, siltstones, limestones of the Serpukhovian (C1 s); 3 - limestones with siltstones and tuff-sandstones interlayers of Arkalyk suite (C1 v2-3 ar); 4 - limestones with bitumine varieties interlayers and the Givetian- Frasnian siltstones (D2gv - D3f); 5 - rhyolitoid dikes and 6 - quartz syenites (C3); 7 - serpentinites, birbirite (PR1); 8 - secondary quartzites; 9 - gold ore zones; 10 - ore points with gold grade (g/t); 11 - tectonic disturbances.

Figure 8. Schematic geological map of Mirazh deposit

Conclusion

Conclusions. In the course of these studies the spatial confinement of many gold deposits and ore occurrences to carbonate and carbonate-bearing formations of East Kazakhstan has been outlined. The analysis shows that the most significant gold occurrences are spatially associated with carbonateterrigenous formations of D3-C1 island-arc type. One of the potential deposits is Baybura ore occurrence, located in the promising ore-concentrating structure (West-Kalba gold belt), in the Bolshaya Bukon riverheads in Kokpekty district of East Kazakhstan region, 37 km from Bazanbay village, and it is confined to superintrusive zone of the hidden granitoid massif. Such a favorable geological and structural position is one of the leading criteria for the discovery of a new gold ore deposit in this area.

Gold-bearing zones are represented by hydrothermally altered and skarnified rocks formed by limestones in the process of ferric-siliceous metasomatism.

It is recommended to continue target study of island-arc type carbonate strata in other promising areas of Zaisan sutural zone (Semipalatinsk Priirtyshie and other areas).

The obtained preliminary results confirm sufficiently high prospects of discovering unconventional types of deposits with fine and free gold in carbonate formations of the region, which may be of industrial importance. «This research has been/was/is funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (Grant No. AP1488941500000)».

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