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CLASSIFICATION AND CRITERIA FORECASTING OF BOLSHOI ALTAY GOLD DEPOSITS

ҮЛКЕН АЛТАЙДЫҢ АЛТЫН КЕН ОРЫНДАРЫН ЖІКТЕУ ЖӘНЕ БОЛЖАУ ӨЛШЕМДЕРІ

КЛАССИФИКАЦИЯ И КРИТЕРИИ ПРОГНОЗИРОВАНИЯ ЗОЛОТОРУДНЫХ МЕСТОРОЖДЕНИЙ БОЛЬШОГО АЛТАЯ

Abstract. *The result of this research is developing of regional and local criteria of gold deposits. These were also studied their age position; their connection with different geological formations. Zaisan collision zone has length more than 1000 km (NW-SE), and it width is about 20-40 km). It was formed as a result of collision displacement and coupling of lithosphere plates. Some of the most commercially valuable gold deposits of East Kazakhstan are located in several geochronological levels of the Devonian volcano-sedimentary stratigraphic succession. Flank gold ore belt is traced to Russia on the NW and China on the SE.*

Keywords: *Metallogenic, ore belt, gold deposits, Bolshoi Altay, Kazakhstan.*

Аңдатпа. *Бұл зерттеулердің нәтижесі – алтын кен орындарының аймақтық және жергілікті өлшемдерін дамыту. Олар сондай-ақ зерттелді олардың жас жағдайы; олардың әртүрлі геологиялық формациялармен байланысы. Соқтығысу аймағының ұзындығы 1000 км-ден асады (солтүстік-батыс), ал ені 20-40 км-ге жуық). Ол литосфералық плиталардың соқтығысуы мен адгезиясы нәтижесінде пайда болды. Шығыс Қазақстанның кейбір коммерциялық бағалы алтын кен орындары Девон вулканогендік-шөгінді стратиграфиялық реттіліктің бірнеше геохронологиялық деңгейлерінде орналасқан. Қапталдағы алтын кен белдеуі солтүстік-батыста Ресейге және оңтүстік-шығыста Қытайға байқалады.*

Түйін сөздер: *Металлогендік, кенді белдеу, алтын кен орындары, Үлкен Алтай, Қазақстан.*

Аннотация. *Результатом этих исследований является разработка региональных и местных критериев месторождений золота. Они также были изучены их возрастное состояние; их связь с различными геологическими образованиями. Длина зоны столкновения составляет более 1000 км (северо-запад), а ширина-около 20-40 км). Он образовался в результате столкновения и адгезии литосферных плит. Некоторые коммерчески ценные месторождения золота Восточного Казахстана расположены на нескольких геохронологических уровнях девонской вулканогенно-осадочной стратиграфической последовательности. Золоторудный пояс на флангах наблюдается в России на северо-западе и Китае на юго-востоке.*

Ключевые слова: *Металлогенический, рудный пояс, месторождения золота, Большой Алтай, Казахстан.*

Introduction. The considered theory covers geological structures of Bolshoi Altay (BA) located north-west of Central – Asian mobile belt (Rafailovich et al. 2011). According to theoretical mobilism Bolshoi Altay, a single whole geological structure was formed in Hercynian cycle of tectogenesis in the process of collision displacement and coupling of Kazakhstan and Siberian lithosphere plates and degradation of Irtysh-Zaisan paleo embayment (C1-C3) located be-

tween them. The mentioned lithosphere plate's member area matches Zaisan suture zone in the center of which Charsk-Gornostaevsky ophiolitic belt (sutural commissure) has been formed.

BA territory integrates geological structures of Rudniy Altay, Kalba-Narym (in the north-west), Zharma-Saura, and neighbouring regions of Russia and China. Board structures are caledonites of Gorny and Chinese Altay (in the North-East) and Chingiz-Tarbagatay (In the South-West) and the boundaries between them are along Loktevsko-Karairtyshsky and Chingiz Saursky deep-seated faults. Nowadays the total length of the considered territory is more than 1000 km, whereas average width is 300 km [1-2].

According to metallogenic zoning inside of BA, 4 ore belts are distinguished (Figure 1):

– Rudnoaltaisky copper- polymetallic belt (Fe, Mn, Cu, Pb, Zn, Au, Ag, and others);

– Kalba-Narymsky rare metallic belt (Ta, Nd, Be, Li, Cs, Sn, W).

– West-Kalba gold ore belt (Au, Ag, As, Sb).

– Zharma-Saur multymetallic belt (Cz, Ni, Co, Cu, Au, Hg, Mo, W, TR).

Materials and methods of research. There were field expedition work, different type of sampling such as float sampling, lithogeochemical sampling. Samples and chips were used for making thin rock sections, polished sections. Geochemical researches were carried out. There was studying of the composition of ore minerals with using optical and electronic microscopy. The study of ore minerals and gold (JSM) was carried out in separate grains and in artificial polished sections. There was also used ICP-MS for the chemical composition of ores and minerals studying.

Results and discussion. Due to the complex of geological geophysical data, depth section is characterized by multiplicate earth crust of continental type (thickness up to 50-55 km) that have sharply nonhomogeneous structure of certain geological-geotectonic zones (Rudnoaltaisky, Kalba-Narymsky, Zapadno-Kalbinsky and others). Laminated asthenosphere zones of upper mantle have probably made a great effect on metallogenic specialization of BA geological structure. The considered territory is the unique geologic providing ground where a number of large-scale and unique non-ferrous and gold deposits are concentrated. There are also rare metals ore, rare earths, titanium and other mineral deposits on this territory.

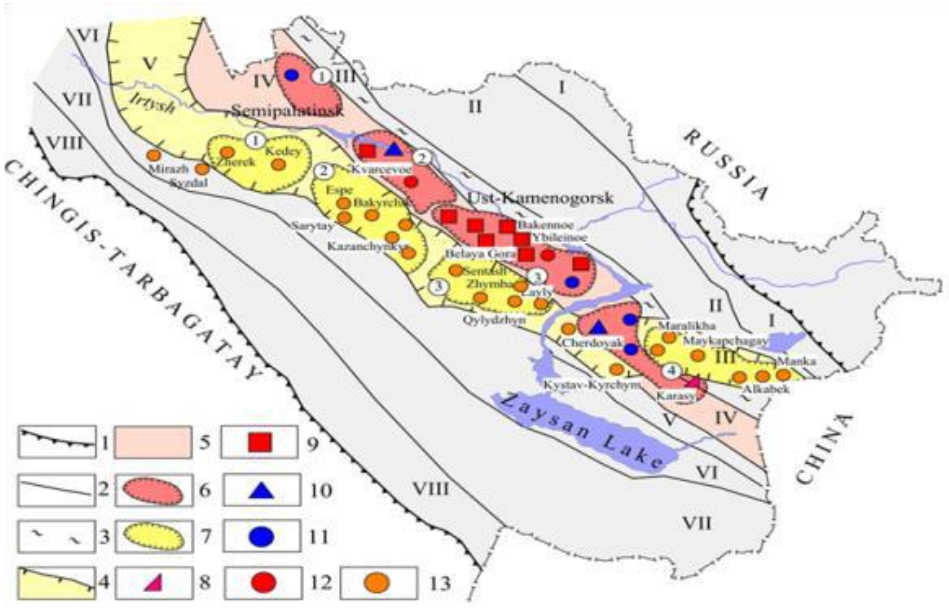

Figure 1. Scheme of placement of rare metal and gold-ore belts: 1 – The boundaries of the Greater Altai and 2 – metallogenic zones; 3 – Irtysh crush zone; 4 – East Kazakhstan gold ore, and 5 – Kalba-Narym rare metal belt; 6 – rare metal ore regions (1 – Shulbinsk; 2 – North-West-Kalba; 3 – Central-Kalba; 4 – Narym); (7) gold ore regions(1 – Mukursky; 2 – Bakyrchik; 3 – Kuludjun; 4, South Altai); (8–13) types of deposits: 8 – albitite-greisen (Sn, Ta); 9 – rare metal pegmatites (Ta, Nb, Be, Li, etc.); 10 – greisen-quartz-vein (Sn, W); 11 – quartz vein tin (Sn, W); 12 – tungsten; 13 – gold ore deposits. Metallogenic zones (I – Beloubinsko Sarymsaktinskaya; II – Rudy Altai; III – Irtysh; IV – Kalba-Narym; V – West-Kalba; VI – Charsk; VII – Zharma-Saurs; VIII – Syrektas-Sarsazan). Deposits of the Kalba-Narym zone: 1 – quartz; 2 – Bakennoye; 3 – Jubilee; 4 – Belaya Gora; 5 – Cherdoyak; 6 – Karasu. Deposits of the West Kalba zone: 1 – Kazanchunchur; 2 – Kuludjun; 3 – Layla; 4 – Kystav-Kurchum; 5 – Maralikha; 6 – Maykapchagay; 7 – Alkabek; 8 – Manka

Gold ore and gold-containing deposits were formed in various geodynamic conditions and due to consanguinity with ore-forming geologic formations of different compound and age [3-4].

The following four geological-commercial gold ore deposits can be distinguished: Gold-copper-polymetallic type is represented by gold containing sulphide complex deposits of BA (Figure 2).

It is characterized by many large-scale commercial deposits of copper, lead and zinc where gold as well as silver, cadmium, platinum, selenium and other elements are the associate component of copper-sulphide and sulphide complex deposits.

a-Rudny Altai cupper-polymetallic belt 1 - boundary of metallogenic zones; 2 - ore district; 3 - ore zone; 4 - ore node; 5 - 12 - ore formations: 5 - epimagmatic; 6 - skarn; 7 - greisen-quartz-vein; 8 - quartz vein golden; 9 - gold-quartz berezitic; 10 - pyrite-polymetallic; 11 - volcanogenic-sedimentary iron-manganese; 12 - metamorphogenic (golden); b – mineral associations, Ridder-Sokolnoye deposit; c - native gold in the copper-pyrite ores of Ridder-Sokolnoye deposit (G.D. Ganzhenko)

The deposits formed in rifting and island-arc geodynamic conditions of Hercynian conditions of tectogenesis. They genetically relate to the group of differentiated basalt- andesine- rhyolitic formations (D1-3). The system of activated mantle-crust deep-seated faults had ore- control meaning and they determined length of volcanicity and mineralization. Multistage of formation and multiple-deck distribution of mineralization on several stratolevels with vertical range of ores up to 1000-1500 m are determined for a number of large deposits. (Ridder-Sokolnoye, Tishinskoye, Maleyevskoye, Orlovskoye, Artemyevskoye and others) [2-5].

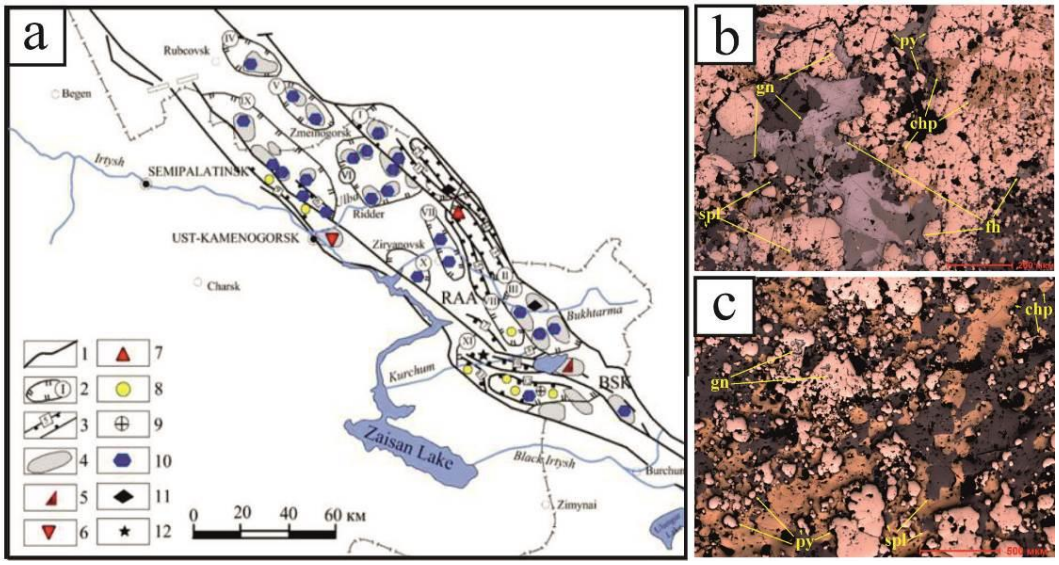

Figure 2. Gold-containing base metal deposits of Rudny Altai

Ore-bearing structures are volcanic domes, synvolcanogenic faults, intersection nodes of disjunctives, horizons of carbon-bearing-clayed and calcareous shale and others. Gold is related to the main ore-forming process corresponding to formation of commercial copper-polymetallic ores. It often develops concentrates (ore chutes) on the late ore-forming stages in the form of the system of crosscutting gold- bearing, silica-sulphide and barium sulphide veins.

Average gold content in sulphide-polymetallic ores is about 0,8 g/t. When mined it is extracted occasionally and makes considerable share in balance reserves of the region and the whole Kazakhstan.

Characteristics of gold deposits

Properly gold ore deposits were formed in collision geodynamic conditions (in Zaisan suture zone) and are located in West-Kalba gold ore belt and Irtysh shear zone [2,4]. The following ore types are distinguished.

Gold-listvenite type occurs in Irtysh zone (Maraliha deposit). Crystalline schist and amphibolites including serpentinite lenslike mass, dikes of diabase porphyrites and plagiogranite-porphyrites are ore – hosting. Gold-bearing ores were formed in the process of infolded-thrust deformations of collision stage and is fixed in ore fold silica–listvenite zones (gold sulphide ore is associated with amphibolite shale). Ore is vein-disseminated, basic ore minerals are pyrites, arsenic pyrites and gold. Chalcopyrite, sphalerite, galenite and fahlore refer to affluent ore minerals. Free and fine-grained gold is in pyrite, arsenic pyrite and magnetic iron ore. It is a commercial deposit.

Gold-sulphide vein-disseminated type refers to unconventional type of gold ore spacely associated with island-arc, volcanogenic-carbonate- terrigenous formation C1v2-3 (Suzdalskoye, Mirazh, Akzhal and others). Geological-genetic model of ore formation is defined as hydrothermal- metasomatic and determined by formation of gold-bearing crushed vein and jasperoids in tectonically fractured carbonate- terrigenous rocks. Ore parent strata were formed due to minor intrusions, plagiogranit dikes and granodiorites (kunushsky complex C3). Ore bodies are represented by crushed veins, interlacing veins, and quartzitic veins with pyrites, arsenic pyrite, rare with antimonite. Free gold is fine and submicroscopic (average content is 8-10 g/t) (Figure 3). Ores are related to Karlin-Trenda deposit according to basic characteristics. These deposits

are being developed as they are of commercial meaning [4,5].

Gold- quartzitic type is characterized by gold-quartzitic-vein deposits widely represented in West-Kalba zone (Laily, Kuludzhun, Sentash, Kazan-Chunkur and others). They are spacely located in low carbon graywacke sediments (aganaktinskaya suite C1S). Ore is controlled by faulting and is genetically associated with minor intrusions and kunushsky complex dikes (C3). Ores are characterized by great variety: pyrite, arsenic pyrite, gold, chalcopyrite, sphalerite, fahlores, antimonite, scheelit and others(Figure 3). Gold is free in polysulfide and stibial assemblages. The deposits refer to small ones by scale of ore. These deposits are being developed. Besides they are the source of placer gold.

Gold-arsenic- carbon-bearing type. This type is presented by larger deposits in gold reserves (Bakyrchik, Bolshevik, Gluboky Log and others) formed on middle-Hercynian collision ore-bearing level (C2-C3). Subaerial grey molasses, potamo limnic and swampy carbon-bearing black – shale lithofacies (bukon suite (C2-3)), subjected to intensive dynamometamorphic and hydrothermal- metasomatic changes (zone of Kyzylovsky deep-seated fault), and to the influence of deep seated (3-5 km) rock bodies. Geological-genetic model of Bakyrchik deposit is considered as remobilization, hydrothermal with primary accumulation of aqueous-diagenetic gold in sediments and with income hydrothermal solutions with juvenile gold from magmatic source. Multiple-stage concentration of gold contributed to formation of very large deposit.

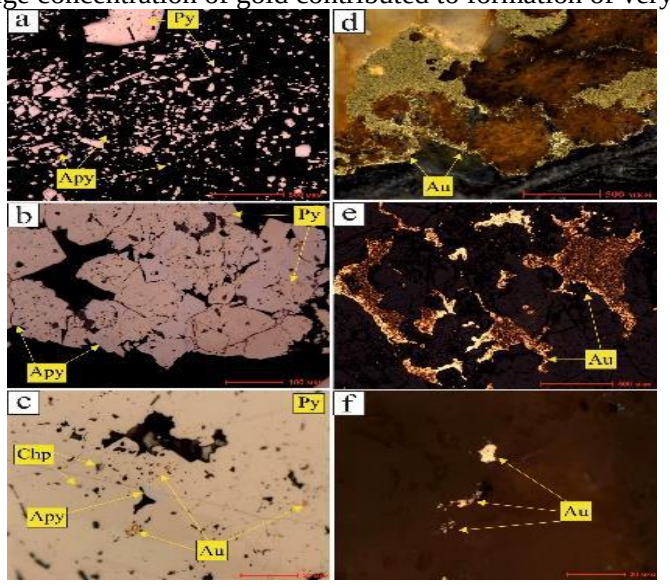

Figure. 3. Mineralization of the Akzhal deposit (a, b, c) and Sentash deposit (d, e, f)
(chp – chalcopyrite, py – pyrite, apy – arsenopyrite, au - gold)

Ore bodies are represented by phacoidal and taenioid deposits with abundant impregnation of gold-bearing pyrite and arsenic pyrite. The thickness is 0.6-20 m, flat deposits are 1700 m to the dip. Basic ore minerals – pyrite, arsenic pyrite and gold, secondary minerals are antimonite, pyrrhotite, marcasite, chalcopyrite, galenite and others. Gold is hard to recover and its content ranges from o.2 to 60 g/t, average is 8-9 g/t. Considerable part of gold is in carbon compounds. Fullerene and fullerene-shaped precipitates, micro- and nanoparticles, nanotubes containing Au, Ag, Pt, Pd, W, Mo, Sn, Y, Yb, Ta and other elements were determined by using scanning election microscope. The considered type is leading in prospected reserves and forecast resources among gold ore deposits of Kazakhstan [6-8].

Conclusions. Lithologic-and-stratigraphic factor is of great importance in defining gold control with distinguishing geochronological levels and sediments of increased carbonaceousness that are favourable for sedimentation and concentration of gold. All ore fields and deposits have magmatic control of gold ore that is genetically related to hypabyssal minor size intrusions and dikes of collision geodynamic conditions. Geological-structural, geophysical and mineralogical-geochemical, prognostic-prospecting criteria and results of geological-genetic modelling of ore objects were taken into account, and on their basis the evaluation of the studied region perspectives was carried out.

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