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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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**GENERAL PATTERNS OF FORMATION AND PLACEMENT
AND FORECASTING-PROSPECTING CRITERIA OF GOLD
ORE DEPOSITS IN THE BLACK SHALE STRATA
OF THE WEST KALBA BELT OF EAST KAZAKHSTAN**

Abstract. The general regularities of the formation and location of gold deposits of the "black shale" type are generalized. The forecasting and search criteria of the West Kalba gold belt are also singled out. Geological criteria include: lithologic - ore-bearing horizons of sandstones, siltstones and shales with an increased content of carbonaceous matter; stratigraphic - occupy the age range from the Precambrian to the Cenozoic; magmatic - relative to the deposits of the black shale type: on the upper ore (the front part of the system), specialized dyke complexes of a variegated composition develop; in the rear zone - diorite-granodiorite and granodiorite-granite-leucogranite massifs with gold mineralization; structural - represented by zones of crushing, boudinage and mylonitization, flexural folds of layers, thrusts; tectonic - gold-bearing areas of carbonaceous rocks are confined to zones of deep faults of long-term development or to systems of extended kulis-like cracks, fixing these faults in the upper structural floor. Mineralogical criteria revealed that the indicators of industrial ores are the presence of arsenic ore pyrite of the cubepentagonal-dodecahedral and pentagonal-decahedral habitus, as well as elongated prismatic and needle crystals, twins, arsenopyrite and terrigenous-carbonaceous carbonate-volcanogenic-carbonaceous formations. The description of geochemical and remote forecasting and search criteria are given.

Key words: patterns of formation and placement, gold ore deposits, black shale strata, forecasting and search criteria.

Introduction. The West Kalba gold belt is located in East Kazakhstan, it is promising in the expansion of gold mining in Kazakhstan. The belt is saturated with gold manifestations in the form of deposits, a large number of ore occurrences and points mineralization points [1, 2]. The most promising are large-volume gold ore deposits in black shale strata, they are characterized by large volumes of ore and large reserves of metals with extremely low contents.

Black shale (carbonaceous) formations are widely distributed within the basic geotectonic structures, occupying the age range from the Precambrian to the Cenozoic. In the structure of the belt, the leading role is played by the carbonaceous-terrigenous formations "sea and land molasses" (figure 1), which served as a litho-geochemical basis for subsequent metamorphic processes that led to the formation of industrial gold-carbon-sulphide deposits. The ore-bearing horizons are sandstones, siltstones and shales with an increased content of carbonaceous matter (2.5-5.5%) [3].

Among **magmatic rocks**, the intrusions of the gabbro-plagiogranite series are most common. In a number of gold ore fields, a gabbro-diorite dike complex is developed, as well as harzburgites, dunites, pyroxenites of the Charsky hyperbasite complex. Concerning the deposits of the black shale type: on the upper ore section (the front part of the system), dyke complexes of a variegated composition specialized for gold are being developed; in the rear zone - diorite-granodiorite and granodiorite-granite-leucogranite massifs with gold and gold-rare metal ores.

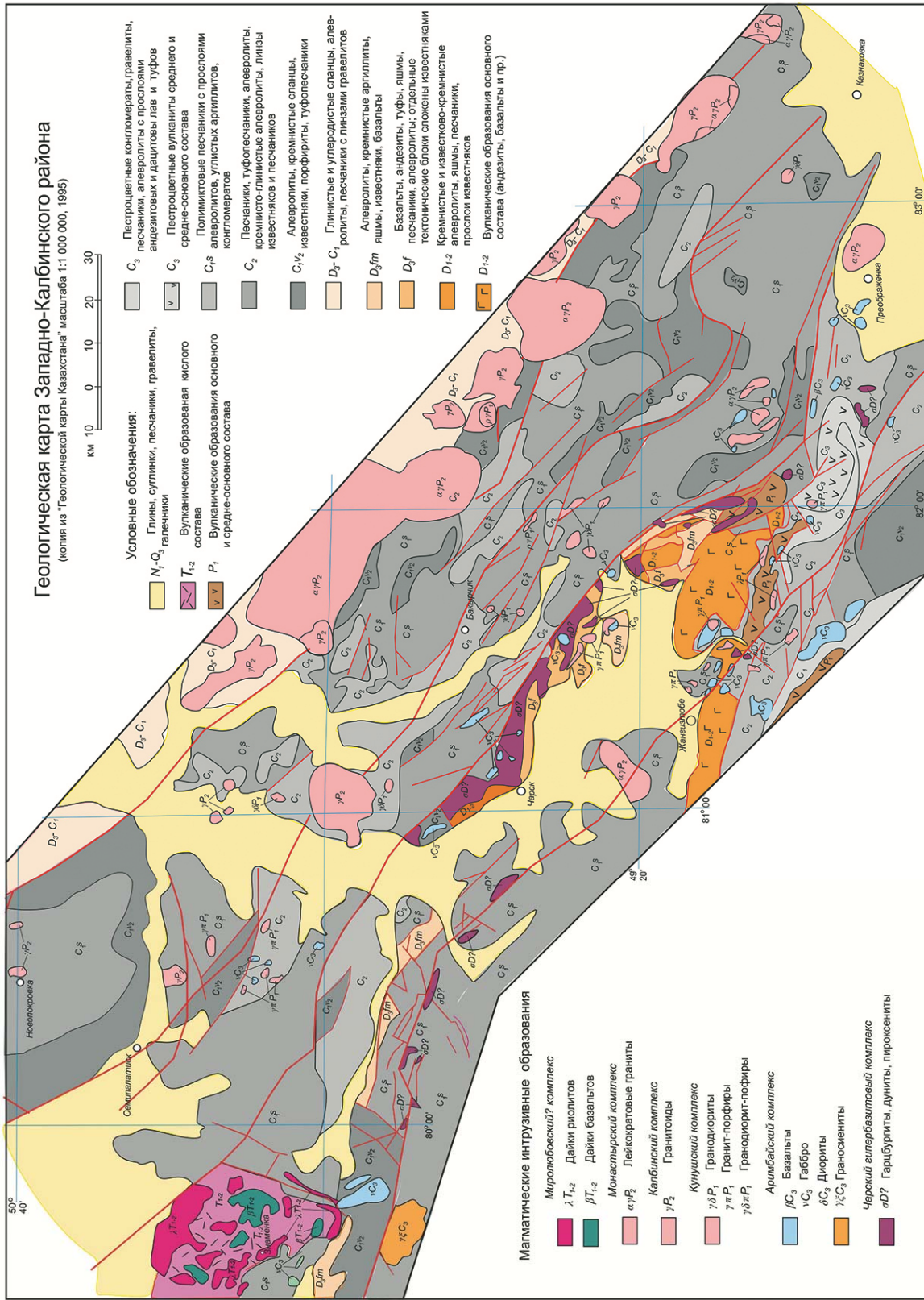


Figure 1 – Geological map of the West Kalba gold belt

Structural position. Deposits have a special frame, represented by zones of crushing, boudinage and mylonitization, flexural folds of layers, thrusts. Such structural combinations ensure the formation of large-volume ore deposits with a vertical extent of up to 1.0-2.0 km and more.

The formation of deposits took place **in conditions of changing geodynamic settings** (marginal continental, rifting, subduction, collisional, post-collisional) with a variety of sources and mechanisms for the concentration of noble metals. The gold ore belt was formed at the end of the carbon at the junction of the Siberian and Kazakhstan paleocontinental massifs [2]. The zone of their connection is the Charsky suture zone, passing in the axial part of the gold ore belt. Gold-bearing areas of carbonaceous rocks are confined to zones of deep faults of long-term development or to systems of extended kulis-like cracks, fixing these faults in the upper structural floor. The length of their first hundreds of kilometers (up to 1000 km), the width of 5-10 km. The most promising areas for the development of carbon-bearing rocks for gold are located in systems of feathering cracks or secant faults, in places of flexural breaks of deep faults, at the intersections of deep faults.

The gold specialization of the belt was determined: 1 - the formation of high-carbon flysch and molasse formations, which possess favorable ore-generating properties; 2 - complex of gabbro-diorite-plagiogranite small intrusions with which postmagmatic hydrothermal mineralization processes are associated; 3 - development along the ore-controlling disturbances of dynamometamorphic transformations stimulating mobilization and redeposition of petro- and oreogenic components on favorable geotectonic barriers.

Mineral associations are native gold, platinum. For large deposits, the general stages are indicative: the pre-production stage is pyrite-pyrrhotite-marcasite-nickel-cobalt-gersdorffite; ore-gold-rare metal (native gold, scheelite, molybdenite, bismuthite, chalcopyrite, tellurides, possibly minerals of the platinum group), gold-pyrite or gold-pyrite-arsenopyrite (with platinoids), gold-silver-quartz-sulphosalts-paleopolymetallic (with platinoids); the final post-ore quartz-carbonate-marcasite-antimonite-tetrahedrite (with fine gold, Sr, Hg, Ba minerals).

Morphology of ore bodies and the form of finding gold in the West Kalba belt. Gold ore bodies are divided into: quartz megastockwork; linear zones of sulfidization (Bakyrchik, Suzdal); combined form deposits.

In the ores of deposits such as mineralized zones, there is an exceptional **variety of gold forms**: 1 - native visible and invisible microscopic gold in veins and ore minerals; 2 - colloidal native and ionic gold in rocks; 3 - native micro- and nanosized gold in pyrite and arsenopyrite; 4 - native gold in carbonaceous material in the form of metallofullerenes (intensively sublimated from 600° C); 5 - native gold micro- and nanosized in solid carbonaceous matter (it is opened only when plasma combustion of carbonaceous material); 6 - organometallic compounds of gold in liquid hydrocarbons and bitumen (sublimated from temperatures of 60-80°C); 7 - intermetallic compounds of gold with Ag, Pt, Pd, Cu, Zn, Fe, Co, Ti in the form of microparticles in a carbonaceous material; 8 - chemical compounds of gold with oxygen, sulfur, arsenic and antimony in carbonaceous material and in sulphides; 9 - ion sorbed gold on the surface of particles of clay and carbonaceous material [1].

In the West Kalba gold belt, **five gold ore regions** have been identified: Suzdal-Mukur, Akzhal-Daubai-Baladzhal, Zhanan-Zhaima, Bakyrchik, Sentash-Kuludzhun [1]. They gravitate toward certain structures along the boundaries of blocks of the earth's crust of various types, deep faults, thrust zones, island arc structures, etc.

In general, the following **gold ore formations** [4] are distinguished for the West Kalba gold belt: gold-carbon-sulfide with types of gold-sulphide deposits in mineralized zones and gold-sulfide-quartz deposits; gold-berysite-listvenite; wretched sulphide gold-quartz.

The vast majority of gold ore objects of the West Kalba region belong to the deposits of fine gold in the carbonaceous strata of folded regions. According to genesis, gold deposits of the belt belong to polygenic: volcanogenic-hydrothermal-sedimentary; hydrothermal-metasomatic; in weathering crusts.

Typical representatives of developed in the region **industrial types of gold mineralization** are:

Bakyrchik industrial type of deposits formed in the collision stage refers to gold-arsenic-carbonaceous mineralized rocks and zones of veining silicification. Gold mineralization is associated with granitoids of the Kunush complex C₃, and also the Kyzylovsky fault system with zones of schist formation, brecciation, favorable for filtration of fluids on carbonaceous-siltstone rocks (Bakyrchik, Bolshevik, Gluboky Log, etc.).

Suzdal industrial type - gold-carbon-sulphide type of mineralized zones in terrigenous-carbonate rocks (Suzdal, Mirage, Babur, etc.);

The *Kulujun industrial type* of deposits belongs to the gold-quartz-vein type among terrigenous-carbonaceous rocks. Spatially, they are located in the low-carbon grauwacke deposits of the inter-arc deflections of C1, are genetically related to small intrusions of granitoids and dikes of the Kunush complex C3. This industrial type in West Kalba includes Kulujun, Sentash, Dzhumba, Laila, and others;

The *Baladzhai industrial type* of deposits refers to the gold-quartz-vein and stockwork gold-sulphide type of mineralized zones in hydrothermally altered rocks among magmatic intrusion (beresites, listvenites). This industrial type also includes the fields of West Kalba - Baladzhai, Skak, Kedey, Zherek, etc.;

The *Zhanan industrial type* of deposits is localized in variegated and gray-colored volcanic-sedimentary carbonaceous complexes C₂₋₃, has tectonic control, refers to a gold-sulfide-quartz formation with a gold-bearing weathering crust. This industrial type in West Kalba includes the deposits Zhanan, Mukur, Kedey, Kempyr, and others [5];

Akzhai industrial type, within which more than 195 gold-quartz veins and about 10 zones of vein-disseminated gold mineralization are established in magmatic and terrigenous-carbonaceous rocks;

The *Daubai-Ashaly industrial type* is a gold-carbon-sulphide type of mineralized zones in terrigenous-sedimentary rocks, gravitating toward the tectonic zone of the Daubai fault.

Forecasting and search criteria of gold mineralization of the West Kalba belt:

Mineralogical criteria. *Search crystal morphology. Native gold.* Visible gold is present only in quartz-veined ore bodies - up to 90% of the total amount of metal. It forms irregular small separations in the interstices of quartz grains, in microcracks, in the walls of the cavities of sulfide leaching. The dimensions of the golds vary from a few hundredths of a millimeter to 0.5-1.0 mm. With depth, the size of the golds decreases [6].

The forms of gold are quite diverse. Most often they have irregular contours with an uneven surface, with bizarre branches, corners, wire-like formations, scales, hooked individuals with capricious jagged edges. Usually they inherit the space occupied. Gold often bears the imprint of facet or other surfaces of neighboring minerals. Recrystallized formations with unclearly expressed faces of the cube, covered with lines of layered growth. Very rarely there are cubic crystals with a weakly developed octahedron facet. The color of gold is golden yellow, from light to bright yellow. Sometimes there is a greenish tinge. The presence of gold in the concentrates of eluvium, deluvium or crushed samples of rocks from the core of wells and mine workings clearly indicates the presence of gold-quartz veins. All veins in the region are accompanied by placers of gold.

"Invisible" gold". In disseminated and vein-disseminated ores of mineralized zones, gold is submicroscopically finely dispersed in pyrite, arsenopyrite, and carbonaceous matter.

Pyrite is the most abundant mineral of ore bodies and near ore metasomatites, localized in mineralization zones among carbonaceous sedimentary rocks. Their placement in area determines the endogenous zoning of ore fields and deposits. Four types of pyrite are distinguished. For the deposits of the West Kalba gold belt: diagenetic-metamorphic (I), metasomatic (II), ore (III) and post-ore (IV) [6-10].

Diagenetic-metamorphogenic pyrite I is widespread in the sandy-shale deposits of the carbon outside the ore bodies, manifests itself in the form of fine-grained aggregates emphasizing the stratification of rocks, or is released in the form of nodules and concretions. It is characterized by a fibroidal non-uniformly granular structure. Under regional metamorphism, the cryptocrystalline aggregates of diagenetic pyrite undergo recrystallization - there appear cubic crystals.

In vein-disseminated metasomatic ores, pyrite II is distributed in sandy-shale rocks in the form of a thin uneven impregnation of cubic, cube-pentagonal-dodecahedral, pentagonal-decahedral crystals measuring 0.01-1 mm, less often up to 2-2.5 mm. The content of gold in it varies from 0.2 to 0.8 g/t.

Ore pyrite III is found in all structural-morphological types of ores and manifests itself in the form of uneven dissemination more often in cubic and pentagonal-dodecahedral crystals. Quartz veins often contain granular and drain aggregates of the mineral. The size of the crystals is 0.1-1 mm and more. In association with pyrite III, arsenopyrite is constantly found, less often chalcopyrite, sphalerite, galena, faded ore, native gold. The content of gold in pyrite III varies from 0.1 to 16 g/t.

Post-ore pyrite IV originated in the final stages of the formation of deposits in quartz-calcite and calcite veins, which sequester all previously formed mineral associations. Its crystals usually do not

exceed 1 mm and are represented by well-formed cubes with shiny faces covered with a thin layered growth hatching.

Indicators of industrial ores are a large number of morphological types of pyrite crystals, the presence of arsenic ore pyrite of cube pentagonal dodecahedral and pentagonal dodecahedral habitus.

The spatial location of the sites of localized gold mineralization is controlled by fields of arsenopyrite development. For most ore bodies, a small number (1-3) of morphological types of arsenopyrite crystals is characteristic. On gold enriched sites, a wide variety of morphological types of crystals is observed, due to the appearance of underdeveloped faces of the pinacoid and the faces of the prism of the second and third kinds. They also have elongated prismatic and acicular crystals, as well as twins, tees and complex splices. This sign serves as an indicator of "rich" gold ores. The ratio of short-prismatic and elongated prismatic to the depth of ore-metasomatic columns of crystals naturally changes. Short-prismatic crystals predominate in quartz-veined ores, and in stockwork-lengthened prisms.

Carbonaceous matter. The most gold-bearing ones are terrigenous-carbonaceous and carbonate-volcanogenic-carbonaceous formations. It is to this type of formation that the carbonaceous sandy-shale sequences are located, within which the largest gold deposits are located.

When prospecting and evaluating works on gold ore deposits of the West Kalba belt, attention should be paid to the areas with the largest accumulations of carbonaceous matter and the presence of sulfides and quartz in it. With great attention to the monomineral accumulations of hydrocarbons in the form of lenses, concretions, tendons that are characteristic for the apical part of ore bodies, and for the admixture of carbonaceous matter in metasomatites (the most gold-bearing beresites and sericite-quartz metasomatites enriched with disseminated hydrocarbons). It is necessary to pay attention to the intensity of light, the character of hardness, electrical conductivity, anisotropy of microhardness - they vary from the position in the ore horizon.

Metasomatic criteria. Yu.A. Ananiev and A.F. Korobeinikov [6] gave a complete description of the metasomatites of the West Kalba gold belt, their role as a search and evaluation criterion is shown. In general, four metasomatic formations have been established: albite-amphibole (metadiorites, I), quartz-feldspar (alkaline, II), propylitic (III) and listvenite-beresite (IV). Within the individual formations, facies are distinguished, differing in mineral composition.

I Albit-amphibole metasomatites (metadiorites) are shown in the deposits Baladzhal, Akzhal, Bizhan's ore manifestation, in contacts of gabbrod stocks with volcanogenic-sedimentary rocks of the carbon. Metasomatites are similar to normal magmatic diorites, but differ from them by structures and accessory mineralization. They form bodies of irregular shape, developed both in intrusive and in volcanogenic-sedimentary rocks. Metasomatites have a grayish color, heterogeneous textures, fine-grained structures. Amphibole is represented by two varieties - ordinary hornblende and ferro-actinolite. In metadiorites there is always a thin rash of ilmenite, secondary chlorite, epidote, in unaltered gabbroids of zircon is absent. The upper age limit for the formation of metadiorites is determined by the presence of their xenoliths in the gabbroids of the endocontact. Fragments of metasomatites do not bear traces of hornfels. Similar metasomatic changes are characteristic for gabbro-diorite-granodiorite massifs, which are usually interpreted as the result of the effect of intermagmatic fluids on the host rocks of the basic composition.

II Quartz-feldspar metasomatites are widely distributed in the apical parts of the Baladzhal and Akzhal massifs and do not extend beyond intrusives. They form vein-like bodies with a length of 10-30 m at a power of up to 3-5 m. In the autometasomatic process, potassium-sodium feldspars and quartz appeared in the form of pegmatoid coarse-grained rocks of pink and meat-red color of massive texture. Their outer zone is represented by slightly modified rocks, with newly formed pink albite and apatite; intermediate - differs from the outer by larger albite grains in nest-shaped separations between which quartz is developed; the inner zone is a typical pink quartz-albite metasomatite (albite - 65-70%, quartz 30-35%, apatite 2-3%). The pink color of the albite is due to an admixture of hematite. The process is characterized by the addition of SiO_2 , Na_2O , P_2O_5 and the removal of TiO_2 , Fe_2O_3 , FeO , MgO .

III Propylitic metasomatites are divided into 4 facies: actinolite-epidote-albite, feldspar-calcite-epidote, epidote-albite with calcite and epidote.

IV Listvenite-beresitic metasomatites accompany vein, stockwork and vein-disseminated ores, and also form independent vein-like bodies, are controlled by disruptive disturbances and zones of fracturing.

The detection of the products of the local alkaline metasomatism (albite-amphibole, quartz-feldspar, propylitic metasomatites) serve as a criterion for the forecast of mineralization, and the presence of beresite-lisvenites as products of the acid leaching stage of the postmagmatic process is a search sign for productive mineralization.

Geochemical criteria. Geochemical prospecting of the indigenous gold ore deposits in the West Kalba gold ore belt was carried out within the Suzdal-Mukur ore region (the Suzdal, Mirazh, Jherek, Mukur and others deposits) and the Kyzylovsky crushing zone (the deposits Bakyrchik, Bolshevik, Zagadka, Promezhutochnoye, etc.) [11]. The areas are characterized by steppe landscapes with a low hill topography. The exploratory area has developed rocks of high-carbon flysch and molasses formations.

Geochemical searches revealed a number of Au-As and Au-As-Sb anomalies ranging in size from 50 to 150 km². A common element of geochemical abnormalities is As. It forms stable high-contrast halos that are consistent in content and size, corresponding to the position of known deposits and ore occurrences.

At the Jherek and Central Mukur deposits (figure 2), a generalized Au-As anomaly with an As content of 100 g/t is established, covering an area of 98 km². Within its limits, four local maxim with an area of 1-4 km² with an As content of 500-1000 g/t are clearly distinguished, with which Au halos of intensity 200-900 mg/t and Sb up to 10 g/t are spatially conjugated. Despite the high degree of geological study of the Jherek-Mukur area, there is still a high likelihood of discovering new ore deposits, as indicated by the high gold and arsenic content in the halos. Since the site is characterized by a hilly relief with pronounced drain valleys, the epicenters of the geochemical anomalies can be displaced up to 300 m relative to the indigenous source.

The Ahmet anomaly is represented by a complex Au-As halo measuring 25x5-7 km, oriented in the north-north-east direction - chain anomalies Au of intensity 30-100, up to 300 mg/ton (in gray concentrates). Content As 70-200 g/t characterize the central and north-eastern part of the halo field. Gray, dark gray calcareous sandstones and siltstones of the Middle Carboniferous age are exposed on the anomaly area, abundant eluvium of quartz veins is noted. The study of polished sections from the detrital fraction of geochemical samples made it possible to establish, within the anomaly, the presence of two types of native gold: 1-dusty, finely dispersed (less than 3 μm), bound to pyrite pseudomorphs of limonite, and 2-finelyinterstitial (10-60 μm) in quartz fragments, in association with carbonates, chlorite and oxidized sulphides.

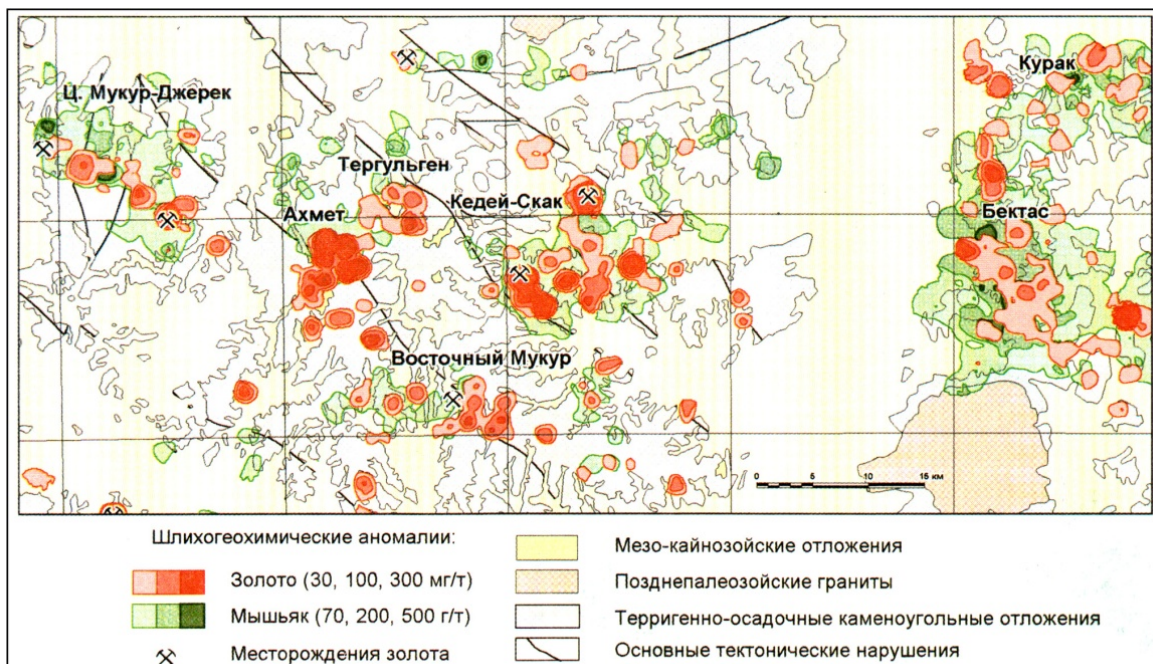


Figure 2 – Anomalies of gold and arsenic, identified by geochemical testing (Mukur-Bektas anomalous zone) [13]

The anomaly of Ahmet Yuzhnyi is located 6 km to the south-east from the anomaly of Ahmet. Its central part is fixed by a small (1.5 km²) aureole Au 220-552 mg/t, on the whole, the aureole Au occupies an area of 8-9 km² at concentrations from 30 mg/ton to 1.39 g/ton. The contents of As_m = 37-39 g/t, Sb_m = 2.3-5.8 g/t. Mineralogical researches on the anomaly have established numerous signs of gold I in cement artificial polished sections and in association with hydromicas, in some cases there is a large gold II (0.01-0.5 mm) and spongy collomorphic gold III (10x20 μm).

As can be seen from the map (figure 2), all other gold ore objects of this ore field are clearly delineated by geochemical halos over Au and As. Two new promising areas were also established.

Anomaly Bektas is located in the eastern part of the study area (figure 2). The Delbegei granite massif and adjacent coal rocks carry quartz veins. In the center of the complex Au-As-Sb halo, the Uytas and Karashoki granite rods are located. By the works of Charaltyn LLP [12], the anomaly of Bektas was transferred from the discharge of the independent Bektas ore field.

Kurak anomaly is located northeast of the Bektas anomaly (figure 2). It represents a long (more than 7 km) aureole of meridional strike with high Au contents of 4.6-10.0 g/t, controlled by the zone of the regional Terekty fault. The content of As in the same samples is 60-1800 g/t. The host rocks are represented by a stratum of carbonaceous-argillaceous siltstones and sandstones containing dikes and quartz veins. The anomaly is clearly recorded by geophysical methods, coinciding with the zone of gradients of the magnetic and gravitational fields. The anomaly bears signs of large-scale gold mineralization, has been poorly studied.

In the Bakyrchik ore field (figure 3), 850 geochemical samples were taken on an area of about 800 km² and a large anomaly of latitudinal strike corresponding to the deposits localized in the Kyzylovsky crushing zone was identified. A group of similar Au-As anomalies are located south of the Kyzylovsky zone, it is not accompanied by known gold deposits and deserves further study.

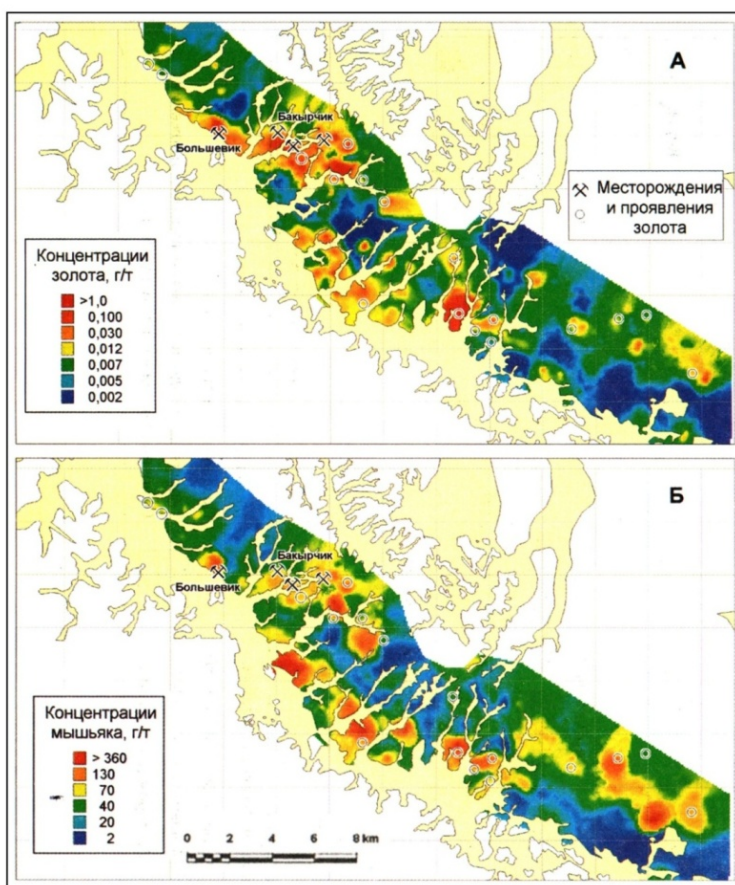
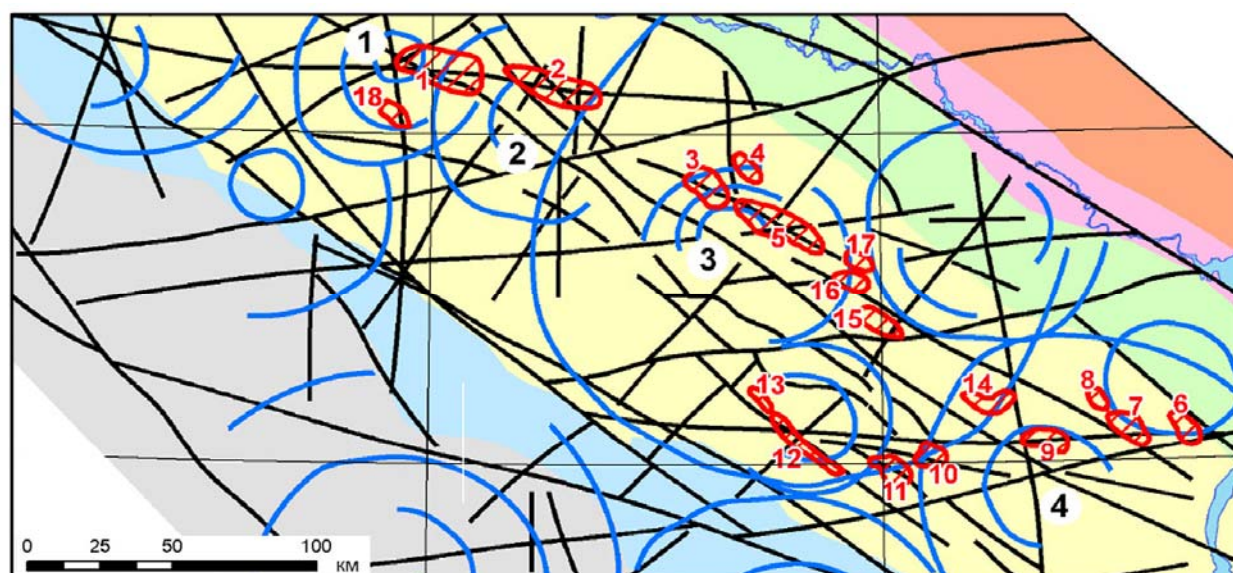


Figure 3 – Distribution of gold (A) and arsenic (B) in the area of the Kyzylovsky crushing zone (the Bakyrchik and Bolshevik deposits), based on the results of chemical testing [13]

Remote (aerospace) criteria. The first and so far the only studies in this direction within the Western Kalbinsk gold belt have been carried out by researchers of the Tomsk Polytechnic University [14]. Materials of multispectral space imagery Modis and Landsat ETM + were used. Studies have shown that in West Kalba, the cosmostructures of linear and circular (arc) morphology are clearly manifested.

On the basis of combinations of linear and circular (arc) structures, four focal structures have been identified (figure 4) – Jherek-Suzdal, Kedey, Kyzylovsky and Dzhumba. The Jherek-Suzdal focal structure is formed by conjugation of linear (northwestern, latitudinal, meridional and northeastern) and telescopic ring structures with diameters of 53, 35 and 15 km. The Kedey focal structure is formed by the conjugation of linear (northwestern, latitudinal, meridional and northeastern) and telescopic ring structures with diameters of 64 and 28 km. The Kyzylovsky focal structure is formed by the conjugation of linear (northwestern, latitudinal, meridional and northeastern) and telescopic ring structures with diameters of 162, 53, 36 and 21 km. The Jumba focal structure is formed by conjugation of linear (northwestern, latitudinal and meridional) and telescopic ring structures with diameters of 105 and 38 km. Taking into account the data on the deep structure of the study area [3], the levels of embedding of focal structures have been determined: Kyzylovsky and Dzhumba - upper mantle-lower crust (active upper mantle - section M), Jherek-Suzdal and Kedey- medium-crustal (section of the sialic and granulite-basite complex).



Металлогенические зоны Зайсанской складчатой системы










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|  | Жарма-Саурская |
|  | Чингиз-Тарбогатайские каледонские структуры обрамлениям |
|  | Частные колцевые и дуговые структуры |
|  | Частные линеаменты |
|  | Рудные поля и их номера: 1) Джерекское, 2) Кедейское, 3) Эспинское, 4) Миалинское, 5) Бакырчикское, 6) Лайлинское, 7) Кулуджунское, 8) Теректинское, 9) Джумбинское, 10) Баладжальское, 11) Ашалы-Даубайское, 12) Боко-Васильевское, 13) Акжальское, 14) Сенташское, 15) Жантасское, 16) Казанчункурское, 17) Канайское, 18) Суздальское |
| 4 | Очаговые структуры Западно-Калбинской металлогенической зоны
1) Джерек-Суздальская, 2) Кедейская, 3) Кызыловская, 4) Джумбинская |

Figure 4 – Cosmo-structural model of the West Kalba metallogenic zone and adjacent territories (based on the results of decoding space images Modis) [17]

Kyzylovsky and Dzhumba focal structures reflect the deflection of the M surface, the Jherek-Suzdal and Kedey - Semipalatinsk uplift of the asthenosphere. The development of focal structures was pulsating. Maximum energy effects fall on the main seismic boundaries - the surface of M, the partition of the sialic and granulite-basite complex, the partition of the granite and diorite layers, the section of the sedimentary and granite layers. In the focus structures, the ore fields are controlled by the areas of conjugation of linear (more often, north-western) and concentric elements with diameters of 28-38 km [2, 15, 16].

The use of Landsat data made it possible to reveal patterns of location of deposits within the Kyzylovsky (Bakyrchik), Boko-Vasilievsky and Suzdal gold fields.

The space-structural position of the Bakyrchik ore field (figure 5) is determined by the fact that it is localized in the inner part of the arch structure with a diameter of 31.5 km of a complex internal structure. The structure is confined to the junction of large disruptive disturbances of the northwestern, northeastern and sublatitudinal strike. In the inner part of the structure several systems of telescopic ring structures with radii from 1.5 to 13 km have been identified. It is precisely these telescopic ring structures, "strung" into linear latitudinal or northwestern, that control the position of the main deposits of the ore field - Bakyrchik, Bolshevik, Kostobe, and others. The areas of occurrence of vein-disseminated and interspersed mineralization are spatially combined with the developmental regions of ring structures with diameters of 1.5-3.2 km, whereas the areas of predominantly veined mineralization are characterized by the development of ring structures with diameters of 2.7-9 km.

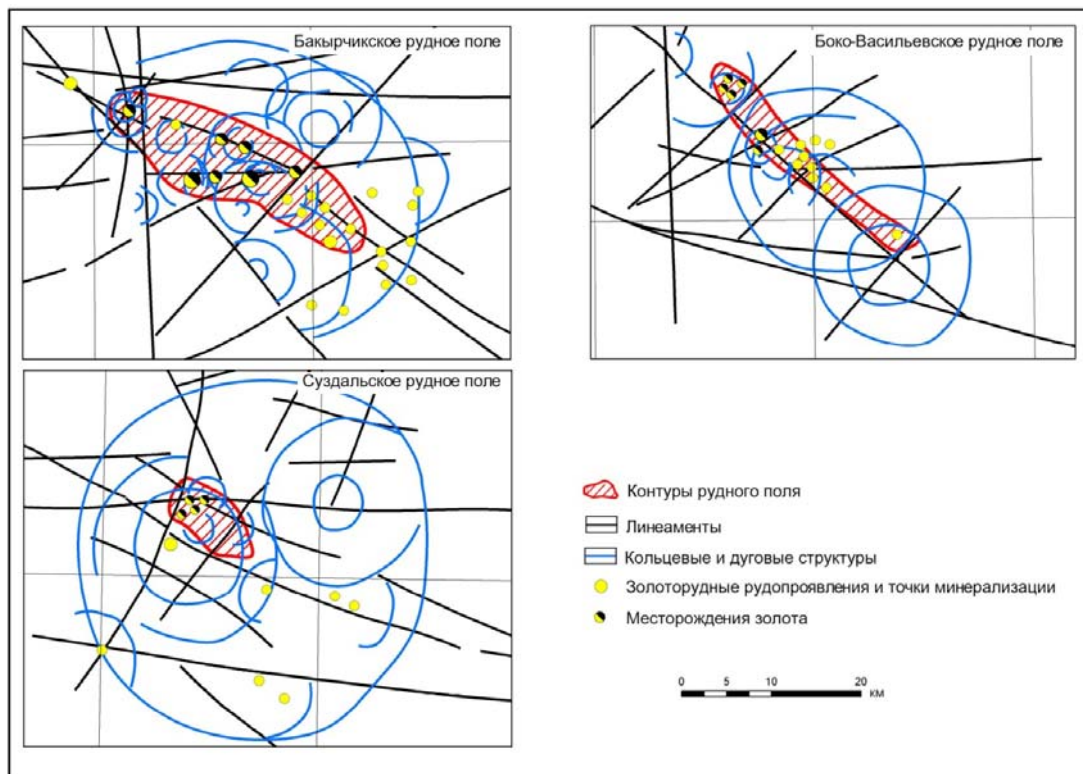


Figure 5- Cosmo-structural models of ore fields [17]

In a cosmostructural relationship, the Boko-Vasilievsky ore field (figure 5) is located in the inner parts of a series of ring structures with diameters of 17-18.5 km, which are confined to the conjugation site by a large linear structure of the northwest strike with less extended linear structures of the northeasterly direction. Systems of telescopic ring structures of high orders are installed in the inner parts of large ring structures. The mineralization of various morphological types is localized at the nodes of conjugation of the northwestern discontinuous disturbance with northeastern and latitudinal. Disseminated and vein-disseminated mineralization is spatially associated with ring structures 2.5-3.2 km in diameter, vein-like - located in the inner parts of ring structures with a diameter of 6.3-12 km.

Suzdal ore field (figure 5) is located in the inner part of the ring structure with a diameter of 36 km of complex structure. The structure is confined to the conjugation of northwestern, sublatitudinal and northeast lineaments. In this ring structure, the structures of smaller diameter are naturally "nested", forming telescopic systems. Mineralization is controlled by the sites of conjugation of northwestern, northeastern and latitudinal linear structures. The manifestations of stockwork and disseminated mineralization are spatially associated with ring structures with a diameter of 2.9-4.2 km, while vein is associated with ring structures with a diameter of 6.6-9.2 km.

The study of the real composition of the surface of the studied ore fields by the spectral angle method showed that the central parts of ring structures with a diameter of 1.5-4.2 km are characterized by elevated concentrations of calcite and dolomite. The obtained regularities of the material composition fully correspond to the metasomatic mapping of surface mine workings and core wells [6].

Summarizing, the authors of [18, 19] note the following advantages of remote space exploration of the territory: 1 - The West Kalba gold belt is characterized by a wide development of linear and ring structures; 2 - the location of the largest ring and arc structures is associated with a deep energy source, which are the main seismic boundaries: the surface of M, the partition of the sialic and granulite-basite complexes, the partition of the granite and diorite layers, the section of the sedimentary and granite layers; 3 - on the combination of linear and circular (arc) structures, four focal structures are distinguished, in the contours of which the main ore fields are located; 4 - within the ore fields, the relationship between deposits and ore occurrences is established with cosmostructures of a higher order: vein-disseminated and interspersed mineralization is controlled by conjugation of linear different strike and ring structures 1.5-4.5 km in diameter, while quartz veins are conjugated with linear different stretch and ring structures with diameters of 6.2-9.5 km.

Thus, the use of remote methods seems very promising as forecasting and search criteria for gold ore fields and deposits within the West Kalba belt.

Geophysical criteria. The distinctive features of the physical fields of gold deposits of West Kalba are: 1 - ore-bearing zones have electrical conductivity due to carbonaceous matter and sulphides, and they are distinguished by geophysical methods within the perspective areas; 2 - hydrothermal metamorphism - sericitization, pyritization, silicification, kalistanisation - was manifested in the ore-bearing zones, which led to a significant change in the various physical properties of the rocks; 3 - mineralization is controlled by disruptive disturbances, within which the physical properties of the rocks, primarily the electrical conductivity, differ from those of the surrounding rocks; 4-mineralization is often accompanied by small intrusions and dikes of the gabbro-diorite-granodiorite series, which have increased magnetization and excess density.

In **conclusion**, it should be noted that deposits of fine gold in carbonaceous terrigenous and terrigenous-carbonate strata become the leading type of commercial gold deposits. In the medium term, these ore objects will be one of the main sources of gold [20].

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**ШЫҒЫС ҚАЗАҚСТАН БАТЫС-ҚАЛБА БЕЛДЕУІНІҢ
АЛТЫНКЕНДІ КЕН ОРЫНДАРЫНДАҒЫ ҚАРА ТАҚТАТАСТЫҢ
ҚАБАТЫНЫҢ ҚАЛЫҢДЫҒЫНЫҢ ЖАЛПЫ ЗАҢДЫЛЫҚТАРЫН ҚАЛЫПТАСТЫРУ МЕН
ОРНАЛАСТЫРУ ЖӘНЕ БОЛЖАМДЫҚ-ІЗДЕУ КРИТЕРИЙЛЕРІ**

Аннотация. «Қара тақтатасты» типтегі алтын кенорнының жалпы заңдылықтарын қалыптастыру және орналастыру қорытындысы. Батыс-Қалба алтын белдеуінің болжамдық-іздеу критерийлері бөлінген. Геологиялық критерийлері мыналарды қамтиды: литологиялық - кендену болып табылады құмды көкжиег, алевролитті және тақтатасты жоғары мөлшерлі көміртекті заттар; стратиграфиялық - үлкейу диапазоны докембрия дан кайнозойға дейін; магматикалық - қара тақтатасты типке қатысты шоғырлары: алдыңғы бөлігіндегі кескін (жүйенің алдыңғы бөлігі), мамандандырылған алтын дайкті кешендерінің түрлі түсті құрамы дамуда; тыл аймағында - диорит-гранодиоритті және гранодиорит-гранит-лейкогранитті массивтер алтынның кенденуімен; құрылымдық - ұсынылған аймақтар қысылуы, будинажа және милонитизация, қабаттың флексурлы майысуы, жылжымалы; тектоникалық – тиімді алтын учаскелері көміртекті құрамды жыныстардың орайластырылған аймақтарда терең сынықтардың ұзақ дамуы немесе жүйелеріне ықтырмалы жарықтар ұзақтығы, бұл сынықтарды жоғарғы құрылымдық қабатта белгілеу. Индикаторлары өнеркәсіп кен болып табылатын қатысушы мышьяқты кенді пирит кубентагондодекаэдритті және пентагондодекаэдритті габитустардың минералогиялық критерийлерін анықтадық, сондай-ақ призматикалық ұзындық және инелі кристалдар, екеулік, үштіктер арсенопирит және терригенді-көміртекті, карбонатты-вулканогендік-көміртекті формация. Геохимиялық және қашықтықтан болжамдық-ізвестіру критерийлеріне сипаттау берілді.

Түйін сөздер: заңдылықтары қалыптастыру және орналастыру, алтын кенорындары, қара тақтатастың қабатының қалыңдығы, болжамдық-іздеу критерийлері.

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**ОБЩИЕ ЗАКОНОМЕРНОСТИ ФОРМИРОВАНИЯ И РАЗМЕЩЕНИЯ
И ПРОГНОЗНО-ПОИСКОВЫЕ КРИТЕРИИ ЗОЛОТОРУДНЫХ МЕСТОРОЖДЕНИЙ
В ЧЕРНОСЛАНЦЕВЫХ ТОЛЩАХ ЗАПАДНО-КАЛБИНСКОГО ПОЯСА
ВОСТОЧНОГО КАЗАХСТАНА**

Аннотация. Обобщены общие закономерности формирования и размещения месторождений золота «черносланцевого» типа. Выделены и прогноз-поисковые критерии Западно-Калбинского золоторудного пояса. Геологические критерии включают: литологические - рудоносными являются горизонты песчаников, алевролитов и сланцев с повышенным содержанием углистого вещества; стратиграфические - занимают возрастной диапазон от докембрия до кайнозоя; магматические - относительно залежей черносланцевого типа: на верхнерудном срезе (фронтальная часть системы), развиваются специализированные на золото дайковые комплексы пестрого состава; в тыловой зоне - диорит-гранодиоритовые и гранодиорит-гранит-лейкогранитовые массивы с золотым оруденением; структурные - представлены зонами смятия, будинажа и милонитизации, флексурными перегибами слоев, надвигами; тектонические - продуктивные на золото участки углеродсодержащих пород приурочены к зонам глубинных разломов длительного развития или к системам протяженных кулисообразных трещин, фиксирующие эти разломы в верхнем структурном этаже. Минералогические критерии выявили, что индикаторами промышленных руд являются присутствие мышьяковистого рудного пирита кубпентагондодекаэдрического и пентагондодекаэдрического габитусов, а также удлиненнопризматические и игольчатые кристаллы, двойники, тройники арсенопирита и терригенно-углеродистые, карбонатно-вулканогенно-углеродистые формации. Дано описание геохимических и дистанционных прогноз-поисковых критериев.

Ключевые слова: закономерности формирования и размещения, золоторудные месторождения, черносланцевые толщи, прогноз-поисковые критерии.

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