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RESULTS OF SURVEY WORKS ON GOLD MINERALIZATION REVALUATION FOR THE ZHUNGAR-BALKHASH FOLD BELT

Abstract. The article contains results of surveys carried out by the authors in a period from 2012 to 2014 under the Grant Project "Analysis of the epithermal gold-silver mineralization of the Zhungar-Balkhash region and allocation of promising areas for discovery of a new type of industrial deposits". Object of research is the epithermal volcanic mineralization of the North-Western, North-Eastern and Southern sectors of Zhungar-Balkhash region. The gold content of almost all 48 objects of research was confirmed through surface litho-chemical testing and classical metallogenetic analysis. Also,the forecast estimate was given to the region's industrial prospects for profitable gold-silver deposits.

Key words: gold, epithermal gold-silver deposits, volcanic-plutonic belts, pre-study, forecast.

In recent decades, in many countries of the world (Russia, the United States, Japan, Brazil, etc.), a breakthrough in the gold mining industry is attributed largely to epithermal gold deposits of volcanic-plutonic belts (VPB) (figure 1) [1-4, etc.]. A new impulse of the increased interest of gold producers to this type of gold mineralization is due to a number of known factors. **Firstly**, this group contains large and unique deposits (USA, Round Mountain - 300 tons Comstock - 266 tons, Papua New Guinea, Porgera - 555 tons, etc.)along with exceptionally wide development of small objects with bonanza nature of mineralization, which allows make work without significant expenditures. **Secondly**, a possibility of using the open cut mining for these objects, involving highly efficient modern ore processing methods (heap and tank leaching, etc.). **Thirdly**, the associated extraction of silver, bismuth, tellurium, mercury and other components. **Fourth**, and most important, finding and involvement in development the deposits with low Au content (up to 1 g/t) with large volumes of ore mass, the so-called large-volume (large-tonnage) objects [3].

The article of V.A. Narseev and V.M. Shashkin [4] states that "the large-volume deposits of squalid concentrations are on a rise and represent new direction of gold mining. According to the US Mountain Bureau, the number of deposits with gold content less than 1 g/t as of January 1, 2007 was as follows: Brazil - 2 objects, 236 tons, cont.= 0.43 g/t; Indonesia - 2 objects, more than 3000 tons, cont. = 0.84 g/t; Chile - 2 objects, 758 tons, cont. = 0.7 g/t; the USA - 7 objects, 557 tons, cont. = 0.44 g/t. The Argentine deposits are close to the abovementioned ones: 1 object, 346 tons, cont. = 1.09 g/t, Peru - 5 objects, 1400 t, cont. = 1.11 g/t. As of January 1, 2012, the number of such facilities has been doubled".

The priorities noted for this type of mineralization are the basis for making an application to the Ministry of Education and Science of the Republic of Kazakhstan in 2011 for the project: **"Analysis of the epithermal gold-silver mineralization of the Zhungar-Balkhash region and allocation of promising areas for discovery of a new type of industrial deposits"** [5].

The authors did not doubt in timeliness of the statement of this topic on Zhungar-Balkhash fold belt (ZBFB), since 75% of its territory is represented by extensive areas of volcanic-plutonic associations of rocks, forming the marginal continental coal and inland continental coal-Permian volcanic-plutonic belts

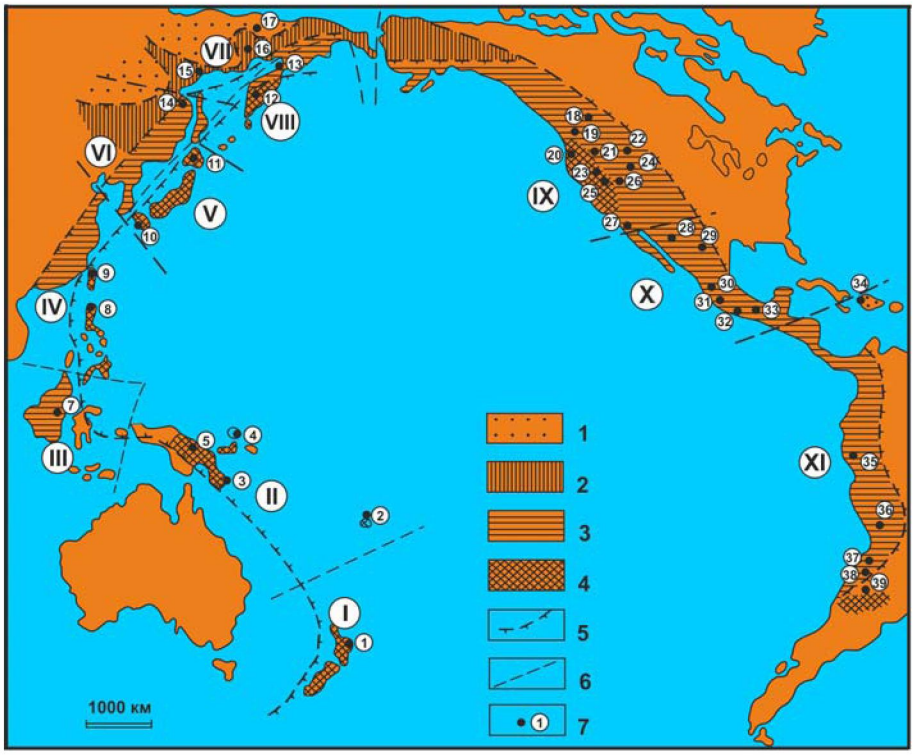


Figure 1 – Placing of large gold-silver deposits in volcanic-plutonic belts of the Pacific ore belt [1].

1 - Late Jurassic-Early Cretaceous mineralization; 2 - Late Cretaceous mineralization; 3 - Paleogene-Neogene mineralization; 4 - Neogene-Quaternary mineralization; 5 - the boundaries of different age-old metallogenic zones (bergstrich to the age decreasing);6 - boundaries of the Pacific belt segments: I - New Zealand, II - Papua New Guinea, III - Indonesia, IV - Philippine; V - Japanese, VI - Sikhote-Alin, VII - Okhotsk-Chukchi;VIII - Kuril - Kamchatka, IX - North American, X - Mexican, XI - South American;7 - individual deposits (in parentheses the average age of mineralization, million years):1 - Waihi (4.0), 2 - Tavua (4.0), 3 - Mizima (10), 4 - Ladolam (0.3) , 5 - Porgera (6.0), 6 - GunungPongkor (20.0), 7 - Kelian (20.0), 8 - Akupan (1.5), 9 - Chinquashi (1.0), 10 - Hishikari, Kushikino (1,0), 11 - Konomai (10), 12 - Agin (8), 13 - Amethyst (40), 14 - Mnogovershinnoe (65), 15 - Hakanja (71), 16 - Dukat (80), 17 - Kubaka (160), 18 - McDonald (35), 19 - Slipper (23), 20 - McLaughlin (2), 21 - Round Mountain (25), 22 - Cripple Creek (28), 23 - Komstok (13), 24 - Telluride-Silverton (22), 25 - Tonopa (20), 26 - Goldfield (20), 27 - Mesquite (25), 28 - Ocampo, 29 - Parral (30), 30 - Sunset (20), 35 - Yanacocha (15), 36 - Kori-Kollo (20), the United States of America , 37 - La Coipa, 38 - Nevada, 39 - El Indio (10).

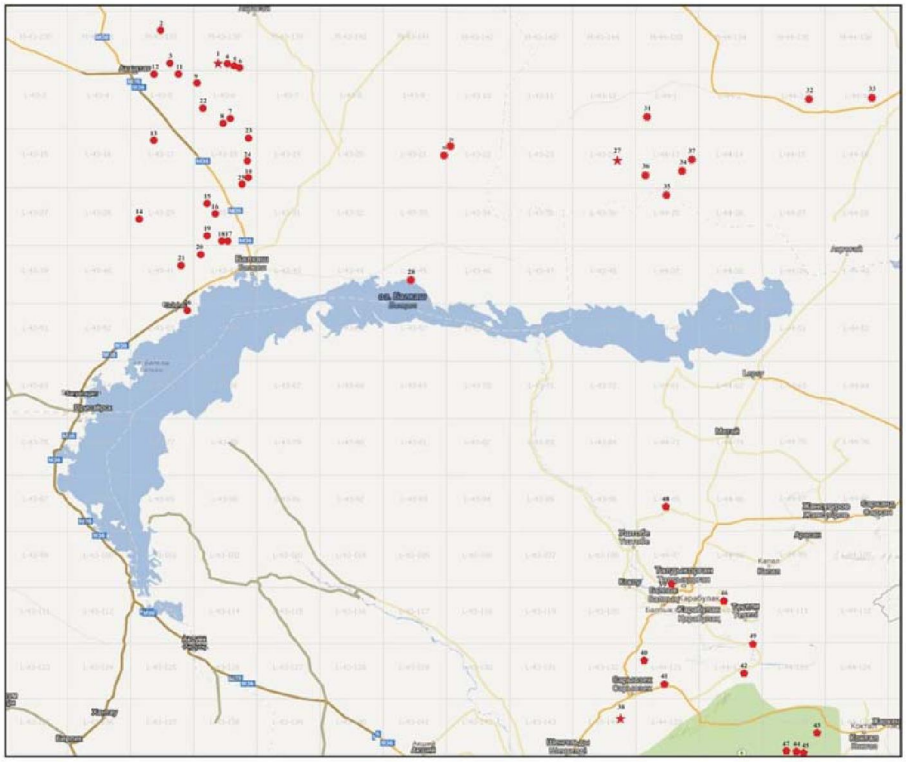
(VPB), which are very promising for studying and searching the deposits of such geologic-industrial type (GIT) [6, etc.].

Recommendations of the predecessors on additional study of the gold content [6-9 and others] and presence of the main ore mineralization factors attributed to the world's known typical epithermal deposits (Wyehi-New Zealand; Cripple Creek, Telluride-Silverton, Goldfield-USA, El-Indio-Chile, Yanacocha-Peru, etc.) [1, 2, 6 other] are the main issues for inclusion of certain objects in the program of works.

For the three years of the Grant Project performance, the workers carried out field work at 48 points of mineralization in the North-West, North-East and Southern sectors of the ZBFB (see figure 2) [5].

In selecting objects for pre-study, first of all, the Map of Prospective Gold-ore spots and areas of ZBFB was used inthe scale 1: 1000000 (figure 3), which was based on the data from the “Registration chart of gold ore occurrences in the south of Central Kazakhstan”, made by results of helicopter searches conducted during the period from 1968 to 1973 by B.S. Zeilik, V.A. Efimenko [10], and the data from Maps of ZBFB gold content of the scale 1: 500000, compiled by E.Y. Seitmuratova, P.K. Zhukov in 1998 [6].

Finally, this map shows about 2000 manifestations and points of gold mineralization, of which, in addition to well-known deposits and ore manifestations, 364 gold mineralization points with a content of 0.01 to 0.1 g/t; 453 points with a gold content of 0.5 to 1.0 g/t; 257 points with gold content from 1.0 g/t to 5.0 g/t and 90 mineralization points with a gold content of more than 5.0 g/t.



North-West sector of Zhungar-Balkhash Region
1. Kuder, 2. Zhilandy, 3. Altynsandyk, 4. Kyra, 5.Oidai, 6. Kosshoky, 7. Kyzyl, 8. Irok, 9. Ktai, 10. Nauryzbai, 11. Zhaumen, 12. Aksengir, 13. Kose, 14. Akshoky West, 15. Shozek, 16. Borly North, 17. Karateke, 18. Karateke West, 19. Karabas, 20. Koskyzyl I and Koskyzyl II, 21. Birksi, 22. Espe Meyerman, 23. Moldybai, 24. Bektau-Ata East, 25. Itlai Uzhtobe, 26. Targyl South.

North-East sector of Zhungar-Balkhash Region
27. Taskora, 28. Orta Deresin, 29. Ulken Tabak Kalkan, 30. Kishkene Tabak Kalkan, 31. Aulie, 32. Altynkazyk, 33. Akshoky East, 34. Kokdala, 35. Uzuntas, 36. Muzbel North, 37. Zhilandy East.

South sector of Zhungar-Balkhash Region
38. Arkharly, 39. Burakoi, 40. Kyzyltogan, 41. Bizhe II, 42. Koturkain, 43. Katutau, 44. Mushketovskoye, 45. Kyzylshoky, 46. Voroshilovskoye, 47. Tashkumyrsai, 48. Akzhide, 49. Konyzdar.

THE SYMBOLS
SITES OF NORTH WEST SECTOR OF ZBR
SITES OF NORTH EAST SECTOR OF ZBR
SITES OF SOUTH SECTOR OF ZBR
STANDARD SECTOR OBJECTS

Figure 2 – Location scheme of the epithermal gold-silver mineralization of the Zhungar-Balkhash region

It should be noted that not only the objects of Au-Ag mineralization were included in the pre-study program, but also volcanogenic Cu-porphyry, Pb-Zn and Pb manifestations, where single significant Au contents were previously noted and their gold content was not specified further (SokurBirksi, Symbhil, Sargul, Kurgantas, Ktay, Akgirek, Kokdala, Bizhe, etc.) [5-10 and others]. Inclusion of not only gold ore occurrences into the study is caused by the fact of existence a number of cases when copper mineralization points (Mystobe, Sambyl, Sokurka, Birksi), polymetals (Zhosabai, Sargul, Akgirek, etc.) and others turned out to be gold ore occurences after additional study. This indicates that the final scale of the gold-bearing nature of the stiffness has not been revealed yet. The noted cases also bear witness to the complex nature of epithermal mineralization.

During the field research of the objects included in the field programs of the next year of work on the project (201-2014), the following tasks had to be solved:

1) mapping of objects with compilation of geological maps: 1: 25000-1: 10000;

2) identification and detailing of the previously and newly identified areas of metasomatically reprocessed rock propagation and conduct of an area litho-geochemical testing.

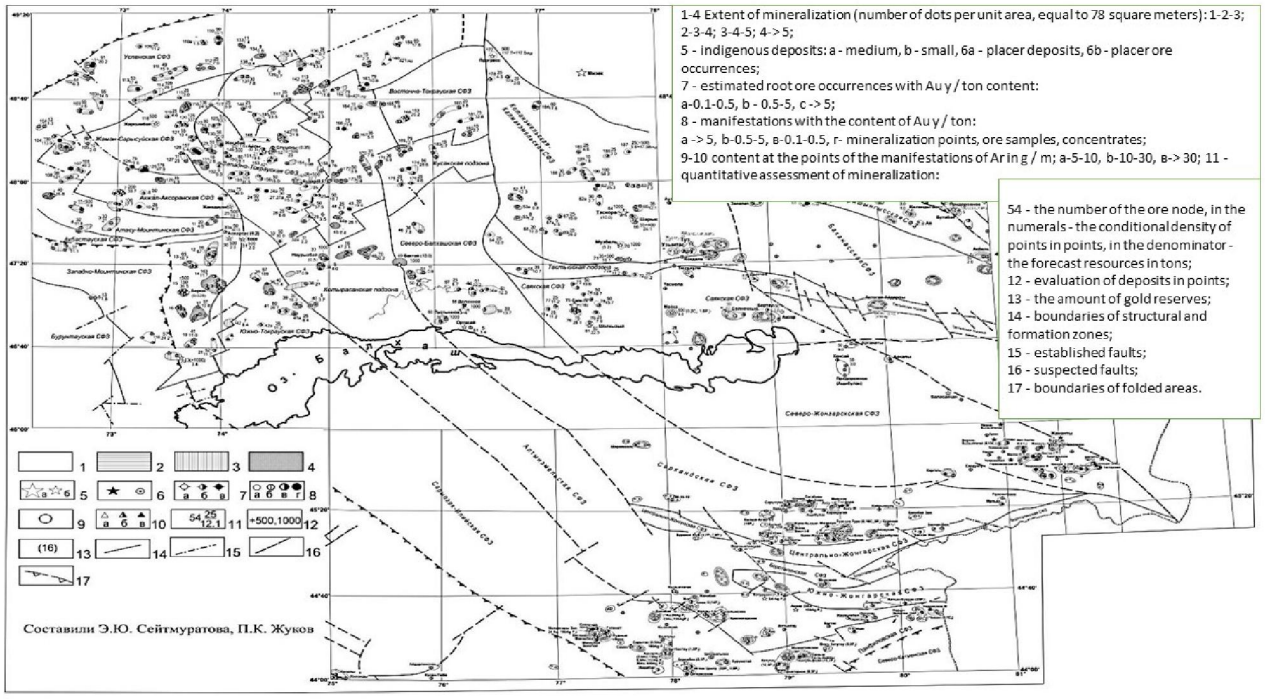


Figure 3 – Map of prospective gold ore spots and areas of the Zhungar-Balkhash fold belt.
Made by: E.Y. Seitmuratova, P.K. Zhukov, F.F. Saidasheva [6]

Areal sampling is due to the fact that this type of mineralization is characterized by an extremely uneven distribution of Au content within ore-bearing areas, which is well illustrated by the drawings of the Silverton-Telluride gold deposits, the USA - 245 tons, Tau-Wua Polo, Fiji Island-120 tons, gold province Kivatin (figure 4a, b, c) [2, 6].

So, the first two large deposits are in common structures of the caldera type with numerous non-industrial manifestations: in the first case - with 37 objects, in the second –with 23 of them [6].

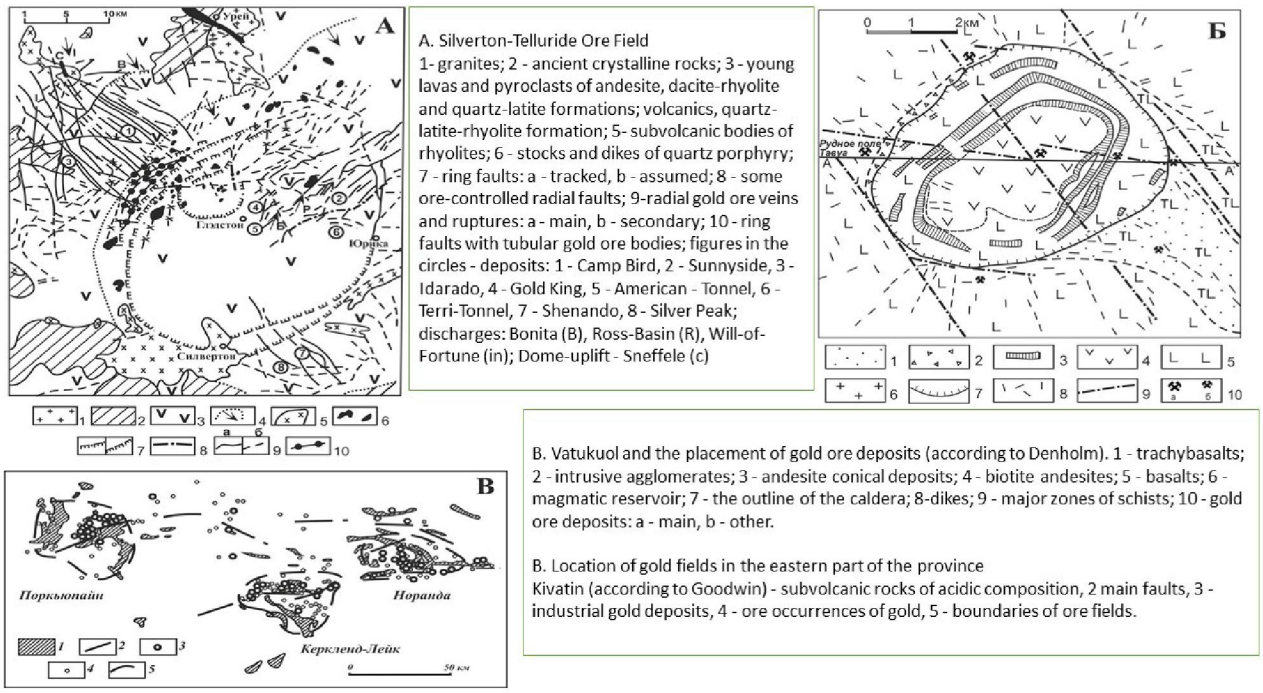


Figure 4 – Examples of uneven distribution of gold mineralization in gold ore structures and fields [6]

Consequently, when searching for epithermal deposits in VPB, there should be no limit to revealing only one or two manifestations that are within a promising ore-bearing structure, but it is necessary to estimate the potential ore-bearing capacity of the entire area that is allocated by hundreds in ZBFB. At the present time, within the framework of the Kargaly volcanic-tectonic structure (VTS), the litho-chemical sampling was carried out on indigenous rocks (G.T.Skublov, 1965-1968), which allowed discover 3 small gold-silver deposits - Slushoky, Ily and Zhosabai and large quantities of mineralization points for gold and silver, which require additional study [6, etc.].

The geological additional study of ZBFB gold ore allows state the following [5] most important results:

- The complex geological structure of all volcanic-tectonic structures revealed during the mapping process, to which the most of the studied gold ore areas are associated (Sokurkoi, Nauryzbai, Kuder-Akgireksk, Sambyl, Sargul, etc.) to, characterized by the complex heterogeneous composition of the basement of these structures and intensively manifested discontinuous tectonics established during interpretation of aerial and cosmic materials (figures 5, 6) [6].

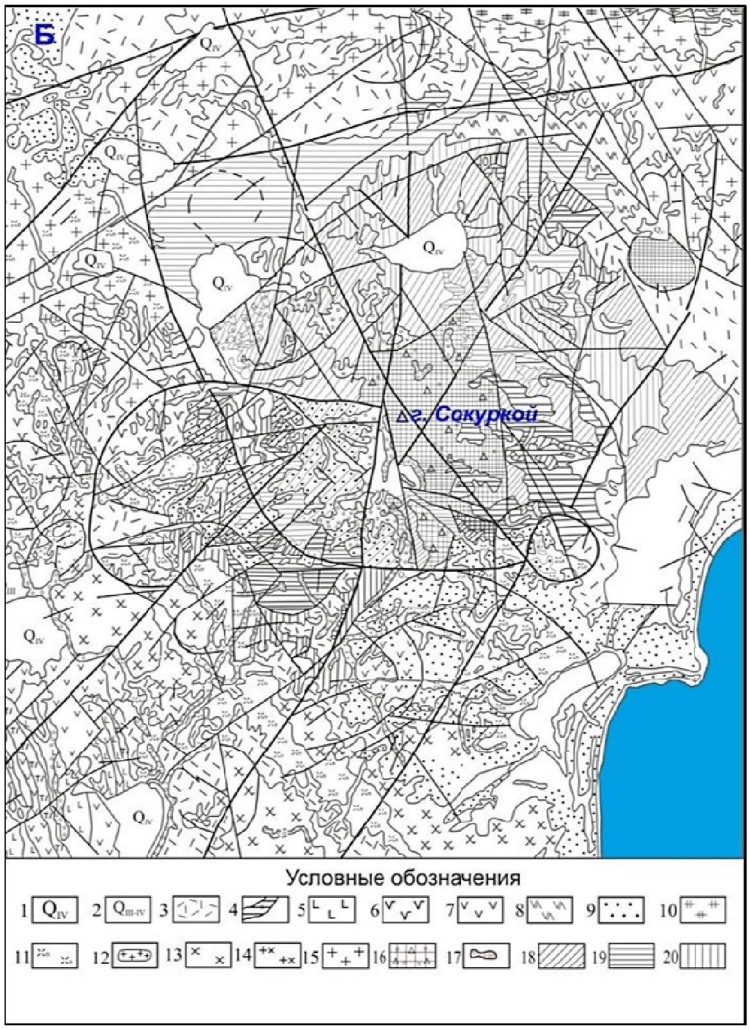


Figure 5 – Geological map of copper-porphyry with gold deposits of Sokurkoi, scale 1:25000.

1 - alluvial and lacustrine-alluvial, dry-type playa; 2 - alluvial-deluvial deposits; 3 - acidic volcanics of the Keregetas suite (C_1b_2-m_1kg); 4 - sub-volcanic intrusion of the Keregetas suite; 5 - basalts of the Kalmakemel suite (C_1s_2-b_1kl); 6 - andesibasalts of the Kalmakemel suite (C_1s_2-b_1kl); 7 - andesites and their tuffs of the Kalmakemel suite (C_1b_2-m_1); 8 - andesidicites of the Kalmakemel suite; 9 - volcanogenic-sedimentary deposits of Silurian; 10 - Proterozoic; 11 - $\gamma\xi\pi P_{1-3}tr$; 12 - granite-felsite-porphyry of the ventral facies of the keregetas suite; 13 - $\mu\gamma\delta P_{1-2}kk$; 14 - $\gamma\delta C_2$; 15 - γD_3ks; 16 - monoquartzites breccia along the vent facies; 17 - the body of monoquartzites; 18 - sericitequartzites; 19 - secondary quartzites with a limonite, sericite-kaolinite-alunite; 20 - secondary kaolinite-dickitequartzites.

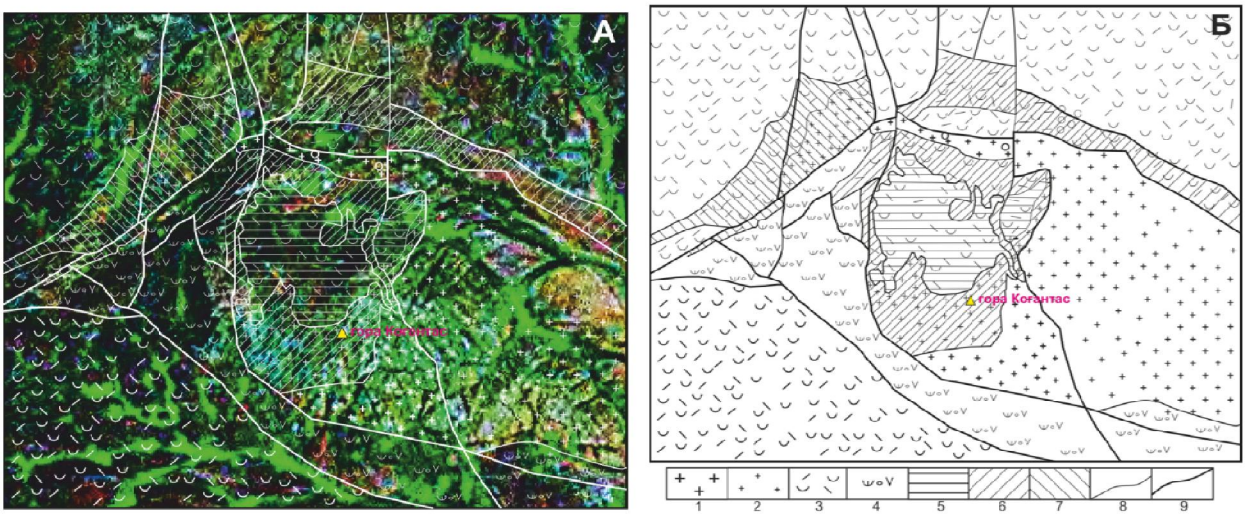


Figure 6 – The cosmogeological map (A) and the geological map (B) of the copper-gold ore manifestation Korgantas [5].
1 - fine-grained leucogranites (P); 2 - granite-porphyry (C); 3 - tuffs of the acid composition of the Keregetas suite (C2kg); 4 - tuff-conglomerates, sandstones, siltstones, sills of andesites of the Kalmakemel suite (C1-C2kl); 5 - andalusite-quartz metasomatites; 6 - metasomatitesandalusite-quartz-sericite and kaolin-quartz; 7-metasomatites quartz-sericite and quartz-kaolinic; 7- geological and facies boundaries; 8-breaking disorders

- **Distribution break down formetasomatic formations**, which form extensive fields in all areas studied, which were previously identified by a number of geologists, and definition of their facial varieties. The largest number of metasomatites facies was established on the Kuder-Akgirek area (figure 7). These are secondary quartzites of the following mineral types: monocrystal, quartz-sericite, quartz-sericite-dickite, quartz-hematite-kaolinite, alunite-kaolinite, quartz-dickite-zunite, jarosite-kaolinite.

- **Confirmation** of a previously noted fact of widespread distribution of the secondary quartzite metasomatic formation, to which the most of the epithermal gold-silver mineralization is associated to.

- **Also identification of the dependence** of ore content of the secondary-quartzite metasomatic formation of its structural position. In the case when it is manifested in the center of the volcanic construction, fixed by the products of the muzzle and prichargalfacies, the probability of revealing relatively large ore objects is most significant [4, 5, 10].

- It has also been confirmed, that peripheral zones of volcanic structures, radial and annular faults are no less **favorable for the ore deposition**.

- After processing the results of analytical studies, it was revealed that the **elements-indicators of gold mineralization** in ZBFB are Pb, Cu, Mo, Bi, and the subphonic elements are as follows: Co, Ni, V, Sn, and they are characterized by negative correlation ratios to the gold.

Schemes of geochemical haloes made on all areas and geologico-geochemical sections by profiles also allowed reveal:

1) geochemical specialization for each area;

2) close positive correlation between Au- Pb-Mo-Bi-Ag-Cu;

3) According to the correlation analysis, a productive geochemical association of elements (Au, Ag, Pb, Cu) is determined, which is supplemented with bismuth at the upper ore and ore levels, and Bi occupies the position of Mo in the positions of remotely-peri-ore and lateral wedging.

Data on the geological structure, spectral and atomic absorption analyzes allowed the authors to compute the predicted schemes for a number of gold ore areas studied (Symbhil, Akgirek, Sargul, Nauryzbai, etc.), with allocation of sites according to the prospects degree as the primary and secondary (figure 8 A, B, C). On the basis of the same data, the gold reserves were estimated at a depth of 10 m, for a number of studied gold ore deposits which may be interesting for investors.

According to the analysis of these data, the following gold-ore areas and objects are promising: Sokurkoi-61,074 tons, Symbhil-38,066 tons, Kuder-Akgirek-86.814 tons, Akshoky-10.639 tons, Kosshoky-18.096 tons, etc. [5].

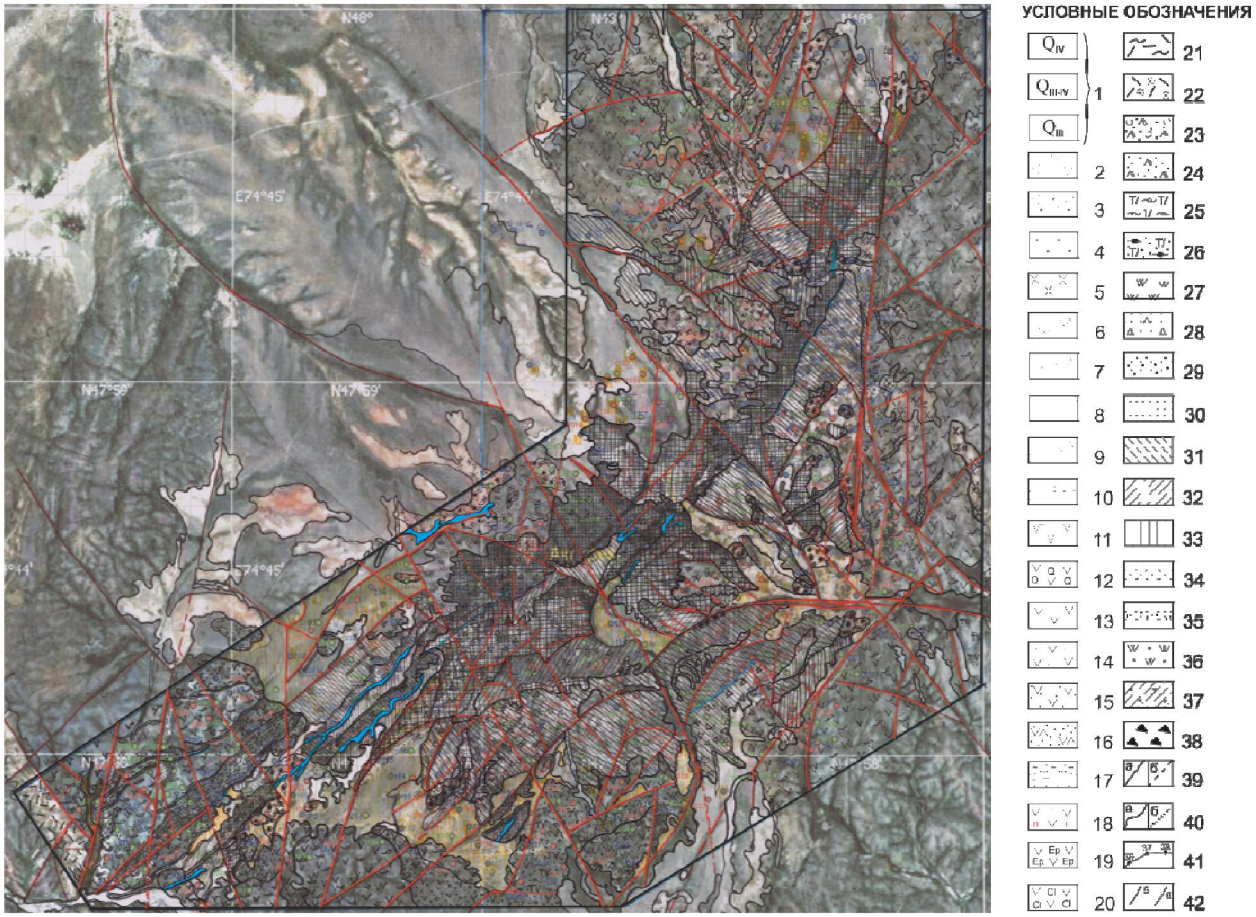


Figure 7 – Cosmogeological map of prospective gold-ore area Akgirek, the scale 1: 10000.

1 - quaternarysediments (dry-type playa, white alkali, alluvial deposits); 2 - paleogeneclays with fragments of rocks (rolledan-dacute); 3 - "iron hats" with fragments of rocks – red-colored paleogene clays with fragments of secondary quartzite; 4 - "iron hats" without fragments of rocks; 5 - intrusive bodies type of porphyritic granosienites; 6 - dykes of granosienitporphyry; 8 - dykes of rhyolite porphyry and felsite porphyry; 9 - dykes of diabases; 10 - quartz vein; 11 - andesi-basalts; 12 - quartz-bearing andesites; 13 - andesites (aphyric and porphyritic); 14 - automagmatic breccia of andesite composition; 15 - lithic-crystal tuff of andesite composition; 16 - crystallotuff of andesite-dacite composition; 17 - a pack of volcanic sedimentary rocks; 18 - propylitizedandesites; 19 - epidotizedandesites; 20 - chloritizedandesites; 21 - fluid lavas of rhyolite composition; 22 - spheriolite lavas of rhyolite composition; 23 - ash crystallotuff of rhyodacite composition; 24 - caked tuff of rhyodacite composition; 25 - ignispumites of trachyriolite composition; 26 - ignimbrites of trachyriolite composition; 27 - polymineral secondary quartzites with unindentified facial associations; 28 - monoquartzites on brecciated rocks; 29 - monoquartzites granular; 30 - monoquartzites secondary quartzites "sound" for pressure (aphyric); 31 - quartz-sericite-diccite(kaolinite secondary quartzites).

Thus, the conducted studies showed a high prospectivity of the studied areas and manifestations of epithermal Au-Ag mineralization. It has also been established that some of them can be considered as large-scale deposits with poor ores that have been successfully developed in many countries by the open cut mining method, using new technologies for extracting gold (heap, vat leaching, etc.) [3, 4, etc.].The works carried out at the first stage of search for epithermal Au-Ag manifestations in ZBFB convincingly substantiate the high prospects and the extreme necessity of setting up detailed prospecting and appraisal works to verify the manifestations to the depth and recommending conduct further exploration and subsequent extraction.

The authors are grateful to the Ministry of Education of the Republic of Kazakhstan for support of the grant 0520 for 2012-2014, results of which again confirm the prospects for the epithermal gold-silver mineralization of the Zhungar-Balkhash fold belt.

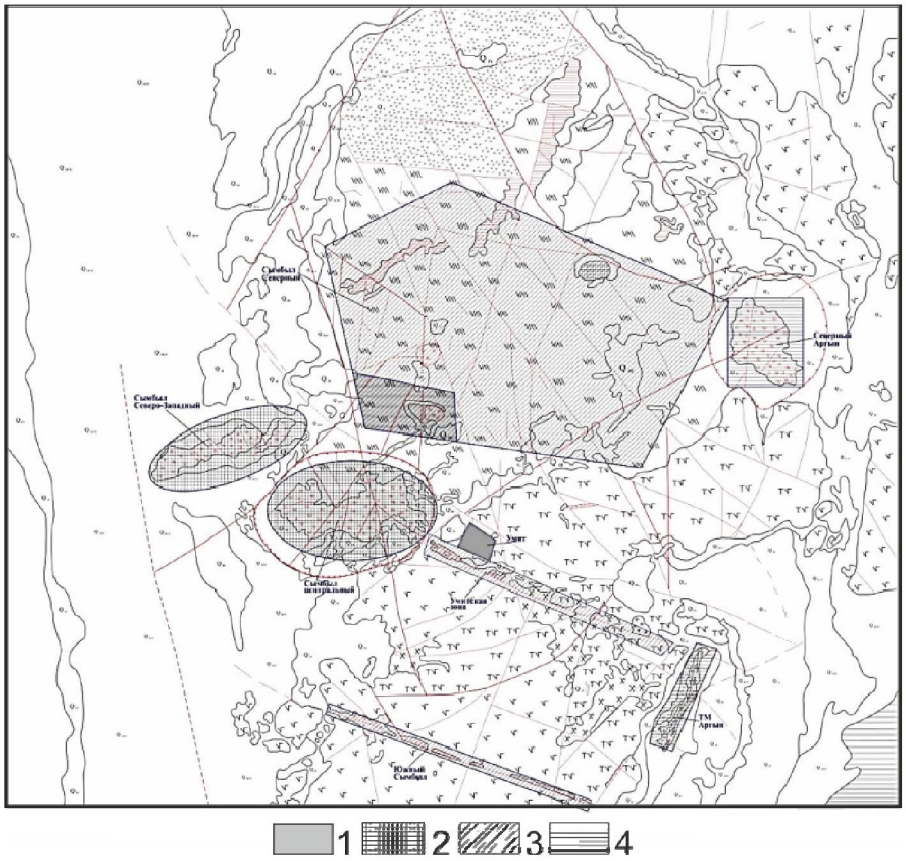


Figure 8A – Forecast scheme for the gold ore area Symbyl, the scale1: 25000.
1 - known deposit, 2- primary prospect sites, 3 - prospect secondary sites, 4 - prospect third turn sites

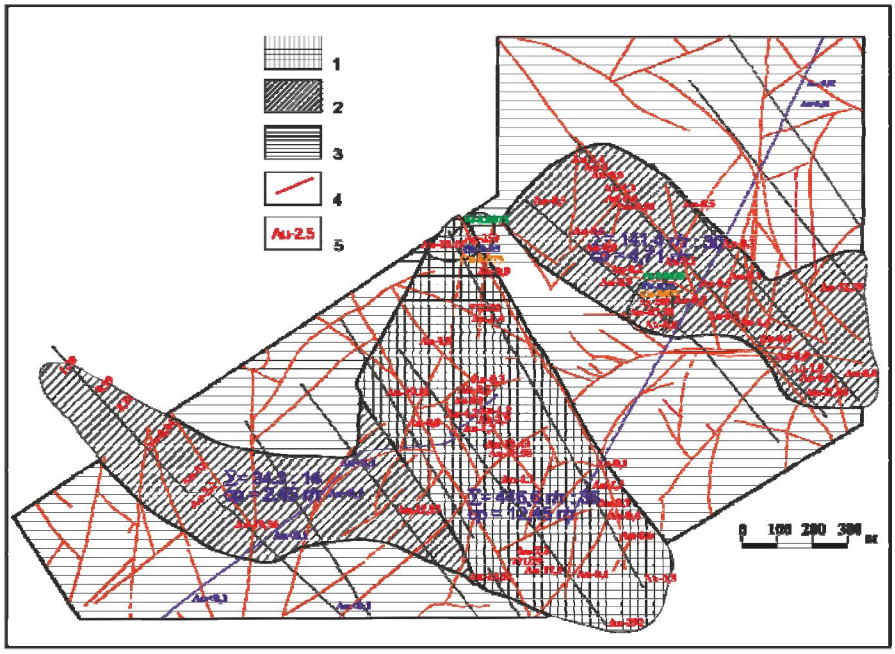


Figure 8B – Forecast scheme for the Akgirek prospective gold-ore area.
1 - primary prospect site, 2 - secondary prospect site,
3 - third turn prospect site, 4 – faults, 5 - points with significant Au content

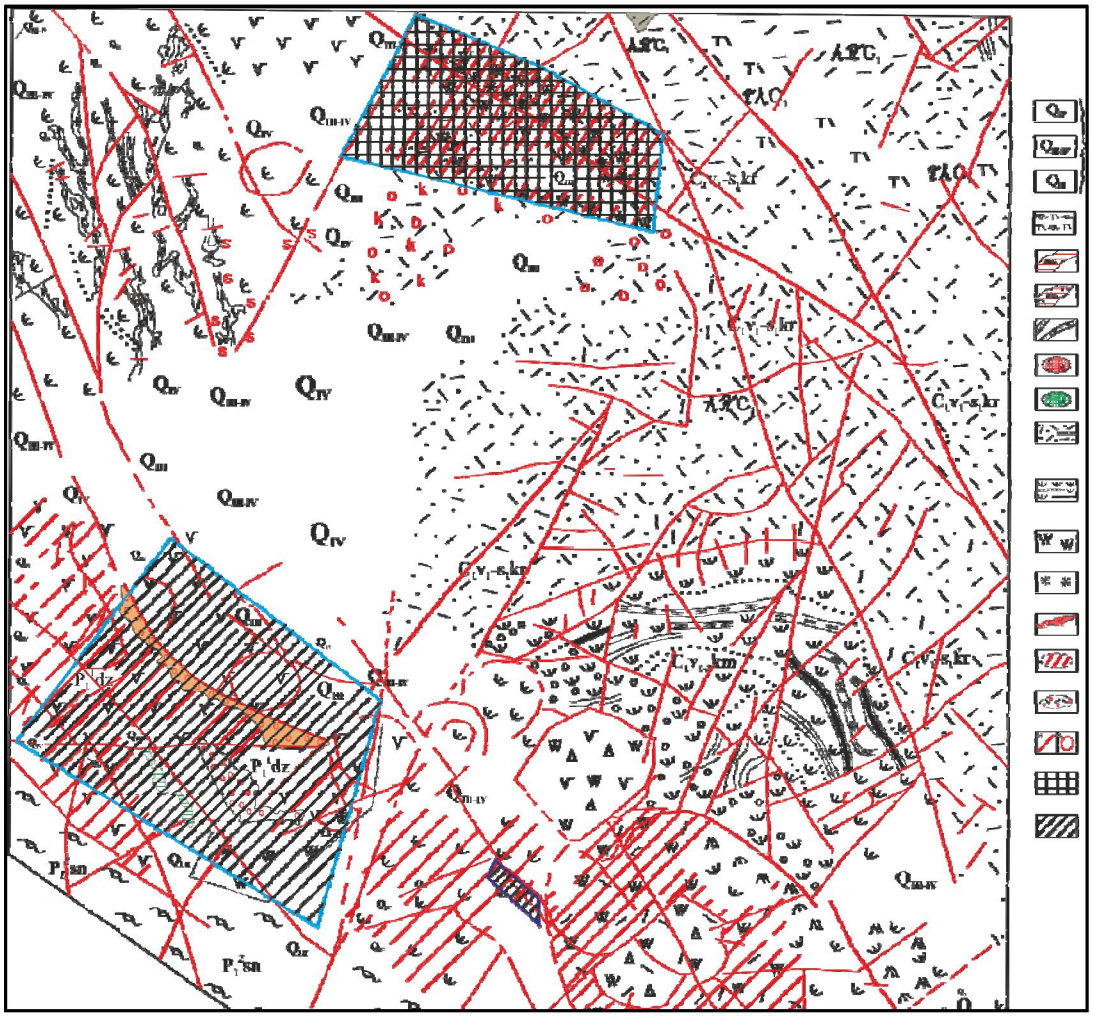


Figure 8B – Forecast scheme for the Sargul prospective gold ore area.

1 – quaternarysediments (dry-typeplaya, whitealkali, alluvialdeposits), 2 - shangelbay suite – ignimbrite-ignispumite series of the trachyrhyolite composition, 3 - sub-volcanic intrusion of the rhyolite porphyry of the karkarala suite(C_1v_2-$s_1$kr), 4 - sub-volcanic intrusion of the rhyolite porphyry of the karkarala suite(C_1v_2-$s_1$kr),5 - dykes of the microgranite-rhyolite- and felsite-porhyry of early carboniferous, 6 - heterochronouspersilicic volcanic neck, 7 - heterochronoussubsilicic and medium volcanic neck, 8 - the karkarala suit(C_1v_2-$s_1$kr)lithocrystalloclastic tuff of rhyolite composition with rare interbed of tuffites, tuffaceous sandstone,9 - the kemelbek suit (C_1v_2-$s_1$km) – volcanogenic-sedimentary series of andesite basalt, andesite, rhyodacite with interbed of tuffites, tuffaceous sandstone, limestones, ferruginous quartzites, carbonaceous-argillaceous aleurolite and coal, 10 - secondary quartzites, not dissected into mineral facies, developed in the Early Carboniferous rocks of the karkarala and kemelbek suites, 11 - ferruginization zone, 12 - quartz vein,13 – crust of weathering of quartz-kaolin profile, 14 – quartzous and sericitized volcanic rock, 15 – faults: a) linear of variety order, b) ring and arcuate, 16 – primaryprospectsite, 17 – secondaryprospectsite

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ЖОҢҒАР-БАЛХАШ ҚАТПАРЛЫ ЖҮЙЕСІНІҢ АЛТЫНКЕНДІЛІГІН ҚАЙТА БАҒАЛАУ БОЙЫНША ЖҮРГІЗІЛГЕН ҚОЛДАНБАЛЫ ҒЫЛЫМИ-ЗЕРТТЕУ ЖҰМЫСТАРЫНЫҢ НӘТИЖЕЛЕРІ ЖӨНІНІДЕ

Аннотация. Мақалада 2012–2014 жылдары аралығында орындалған «Жоңғар-Балқаш аймағындағы эпитермальды алтын-күміс кенорындарын талдау және жаңа типті өнеркәсіптік кенорындарын табу үшін перспективалық аймақтарды бөлу» гранттық жоба авторларының жүргізген зерттеу жұмыстарының нәтижелері келтірілген. Зерттеу нысаны Жоңғар-Балхаш аймағының Солтүстік-Батыс, Солтүстік-Шығыс және Оңтүстік бөліктеріндегі эпитермальды вулканогенді кендену аймақтары болып табылды. Аралық литохимиялық сынамалау мен классикалық металлогендік талдаудың нәтижелеріне сүйене отырып, зерттелінген

барлық 48 нысанның алтынкенділігі дәлелденді және эпитермальды алтын-күміс кенорындарын өндіру үшін өнеркәсіптік перспективалы аймақтарға болжамдық баға берілді.

Түйін сөздер: алтын, эпитермальды алтын-күміс кенорындары, жанартау-плутондық белдем, қосымша зерттеу, болжам.

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О РЕЗУЛЬТАТАХ ПРОВЕДЕНИЯ ПРИКЛАДНЫХ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИХ РАБОТ ПО ПЕРЕОЦЕНКЕ ЗОЛОТОНОСНОСТИ ЖОНГАРО-БАЛХАШСКОЙ СКЛАДЧАТОЙ СИСТЕМЫ

Аннотация. В статье изложены результаты исследований, проведенных авторами в 2012–2014 гг. по грантовому проекту «Анализ эпитермального золото-серебряного оруденения Жонгаро-Балхашского региона и выделение перспективных площадей для обнаружения промышленных месторождений нового типа». Объектом исследований явилось эпитермальное вулканогенное оруденение Северо-Западного, Северо-Восточного и Южного секторов Жонгаро-Балхашского региона. На основе результатов площадного литохимического опробования и классического металлогенического анализа была подтверждена золотоносность почти всех 48 исследованных объектов и дана прогнозная оценка промышленных перспектив региона на обнаружение рентабельных для отработки эпитермальных золото-серебряных месторождений.

Ключевые слова: золото, эпитермальные золото-серебряные месторождения, вулкано-плутонические пояса, доизучение, прогноз.

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