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NEW NON-SCARN TYPES OF TUNGSTEN MINERALIZATION OF THE KARATUBE-CHAKYLKALYAN ORE REGION

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Abstract
In Uzbekistan, for geological exploration for many years, four geological-industrial types of tungsten deposits have been identified. Until now, the tungsten mineralization of the skarn-scheelite type has been studied in the Karatyuba-Chakylkalyan ore field. To date, tungsten ore mineralization of the gussai type in mineralized granitoids and sarykul type in polycomponent metasomatites broken down by aluminosilicate rocks has been identified in this region. The prospective potential of these two types are estimated. Although these types are more indicative for large deposits, they can be exploited in socio-geographically-economically favorable conditions.

Keywords: gold-tungsten mineralization, Karatube-Chakylkalyan ore region, Yakhton, Chashtepa, Khojadyk, aluminosilicate rocks, metasomatites, Gusai tungsten-ore type, Sarikul tungsten-ore type, skarn-scheelite type, polycomponent metasomatic rocks, geological-industrial types of ores.

The widespread use of tungsten in the production of high–quality steels (as an alloying additive), solid acid-resistant and other special alloys, as well as in electrical engineering (incandescent lamps) and radio electronics, determined the remarkable properties of this element - high melting point and chemical resistance, light output in the kneaded state, increased mechanical strength in hot and cold conditions, the ability to form very solid and wear-resistant joints. Tungsten is one of the main

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profiling metals of Uzbekistan, which has been a well–known tungsten ore province of the world for more than 50 years.

Tungsten ore facilities are concentrated in three mining and economic regions of the republic:

1. Pritashkent (Chatkal ore district, with Sargardon, Barkrak and Chavata-Daikovoe quartz–greisen type deposits);
2. Samarkand (Zirabulak ore district, with deposits Ingichke, Chakylkayansky - Yakhton, Karatyubinsky - Karatyube, North Nurata - Koytash, South Nurata - Lyangar); these skarn-type deposits are confined to granitoids C3–P1 in the Zarafshan–Alai and Zarafshan–Turkistan metallogenic zones of the Southern Tien Shan;
3. Kyzylkum (Turbay ore district with the Sarytau and Sautbay deposits in the South Bukantau zone of the Southern Tien Shan) [2].

The existing classification of tungsten ore formations in Uzbekistan according to the principles of construction are different. M.S. Kuchukova et al (1971) identify as the largest units families of formations associated with certain intrusive phases, with a more detailed division into formations, depending on the depth of the ore-generating granitoids. Classification proposed by V.N. Ushakov (1991), compiled by combining, on the one hand, ore-formational and morphological types, which carry the main target information about objects and determine the main directions of the search methodology, and, on the other hand, ore-generating and associated ore complexes. Ore formation types have a stable set of mineral associations and geological and structural positions, which served as the basis for their taxonomy. For each type, the series of geochemical zoning, the vertical extent of mineralization, as well as the characteristics that determine the composition, nature of distribution and quality of ore are characterized: mineralogical-geochemical type, its variability depending on the level of erosion, specific productivity of mineralization, average grades, areal ore bearing coefficient, associated useful components [3].

Analysis of new information on known classifications of the region allows us to propose a general classification in which four geological and industrial types are identified: skarn and aposkarn-skarnoid strata, feldspar-quartz and quartz-greisen vein-stockwork [2].

The main mineragenic potential for tungsten in the Karatyube–Chakylkalyan ore district for many years was associated with the skarn–scheelite formation, represented by a number of deposits (Yakhton, Chashtepa, Khodzhadyk, Karatyube) and many ore occurrences.

For the Chakylkalyan sector, mineragenic constructions were based on the concept of a two-layer geodynamic section model, typical for areas of development of olistostrome formations and overhangs. The lower layer—autochthon—represents a zonal structural megaunit, developing in the passive continental margin regime and including Paleozoic strata from the Shakhriomon flysch formation of Ordovician age to the Early Carboniferous Pushnovat flysch formation [3].

The upper part of the geodynamic structure formed during the collision stage (C2-3) is represented by various tectonic packages, plates, olistostromes, and "wild" flysch formations, the allochthonous inclusions of which contain many Lower–Middle Paleozoic formations.

The entire volume of skarn ore fields of the Chakylkalyan sector of the region, containing industrial tungsten mineralization, is associated with rocks of the main phase of the Yakhton intrusive complex. Skarn bodies of contact, interlayer, stockwork and cutting morphotypes are formed from various carbonate rocks of the Madmon and Shing formations of the autochthon.

According to their composition, skarns are divided into pyroxene, garnet-pyroxene and garnet, with amphibole and epidote. The most favorable condition for the formation of scheelite is the period of formation of hedenbergite skarns, predominantly monomineral, to a lesser extent with a small proportion of garnets. Scheelite is syngenetic and close in time to the deposition of skarn-forming minerals. This is evidenced by the identical crystallization of scheelite, pyroxenes and garnets and the simultaneous recrystallization of scheelite–garnet–hedenbergite aggregates in areas of post-skarn alteration. Also characteristic is the absence of supply cracks with vein minerals to scheelite grains, which indicates its superimposed nature, as well as a decrease in scheelite content in areas of increased sulfidization of skarns, corresponding to the early hydrothermal stage of acid leaching, at which scheelite, along with pyroxenes, becomes an unstable mineral. The skarn stage associated with the formation of scheelite–garnet–pyroxene paragenesis is not accompanied by gold deposits [1].

Early elevated gold concentrations in skarns are associated with the early stages of the acid leaching stage. In the exocontact position at this stage, amphibole–pyrrhotite mineralization develops along monomineral pyroxene varieties, and epidote and epidote–chlorite mineralization develops along garnet-bearing varieties. In the endocontact zone, bleached and pyrrhotinized rocks extend tens of meters deep from the intrusion contact. Plagioclase in such rocks is often completely seritized, and pyrrhotite develops along the primary dark-colored minerals (biotite and amphibole) and is distributed quite evenly in the newly formed rock, making up 3–5% of its volume (rarely up to 10%).

In terms of the time of formation, amphibolization of pyroxenes and replacement of garnets by epidote and chlorite are earlier than pyrrhotinization. Gold of this stage is associated with pyrrhotite and is established in its fine-grained aggregates in the form of dust-like grains, occurring together with base bismuthin and native silver [4].

Amphibolization, epidotization and sulfidization of the initial stages of the acid leaching stage are controlled by zones of post-skarn fine fracturing, covering a vast area of distribution of skarn bodies and creating relatively low, but consistently increased concentrations of gold in them.

The most significant skarn-scheelite manifestation of the Karatyube sector is the Karatyube deposit, the skarn-ore bodies of which are confined to the exocontact of the Sarykul intrusion and are formed along interlayers of carbonate rocks in metamorphic shales, mainly in the form of interstratal deposits. (Fig. 1). The composition of calcareous skarns is dominated by pyroxenes of the diopside–salite–hedenbergite series in association with garnet, vesuvianite and wollastonite. Vesuvian-garnet skarns are the richest in tungsten (72% of these skarns are ore-bearing), garnet-pyroxene skarns are less rich (55% are ore-bearing).

Around the ore bodies of the Karatyube deposit, multi-element halos developed, represented by a set of mono-element halos of W, Be, Mo, Sn, Cu, Zn, P, Ba. The main typomorphic elements of mineralization are W, Be and Sn. They are related to each other spatially and genetically between tungsten, tin and beryllium; beryllium and tin (the latter have a stable positive relationship). The minor indicator elements are molybdenum, zinc, copper, barium and phosphorus.

At the beginning of a new stage of work, the potential of Southern Uzbekistan for tungsten was considered limited, however, geological exploration work carried out by employees of the State Enterprise “South Uzbekistan GSPE” made it possible to identify industrial tungsten mineralization of new ore formation types. The main ones are tungsten-bearing zones of mineralized granitoids (Gussay type) and tungsten-bearing polycomponent metasomatites in aluminosilicate rocks (Sarykul type).

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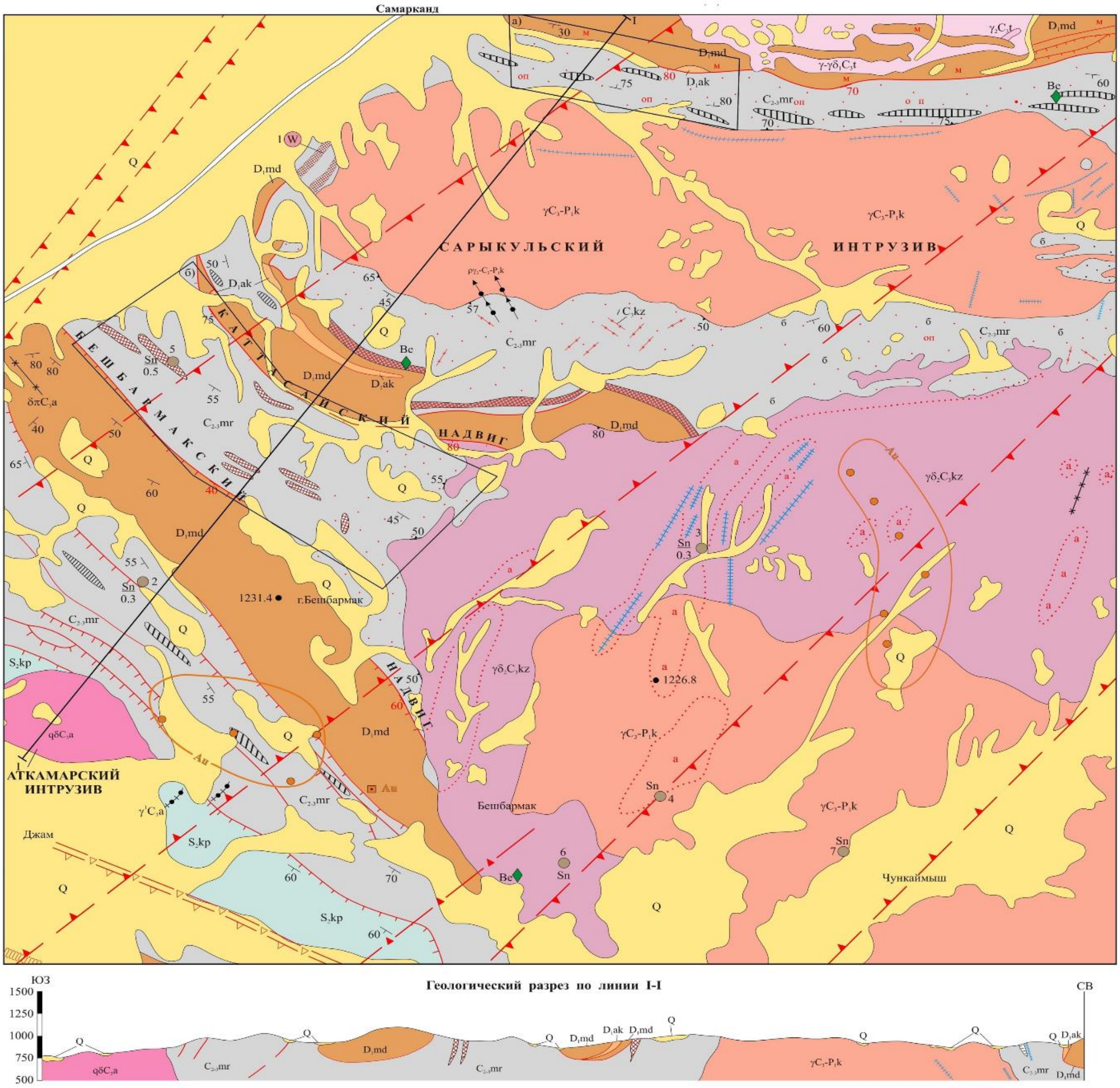

Photo. 1. Schematic geological map of the Karatyubinsky ore field.

The substrate for the formation of ore-bearing metasomatites of the Sarykul type, developed in the Karatyubinsky sector, was the sediments of the matrix of the olistostrome sequence C2-3, deeply transformed by metamorphic processes, attributed in recent years to the Marguzor formation. As a result of regional, contact and dynamometamorphism, primary sedimentary rocks are transformed into various shales, the basis of which is quartz–feldspars–micas (biotite, muscovite, sericite, chlorite) and amphibole.

Post-magmatic processes of hydrothermal impact on the formed metamorphic schists in a tectonically weakened zone of northwestern strike lead to the rearrangement of mineral components and the appearance of new mineral associations that form various rocks of the series: skarnoids–biotite–feldspar–quartz and sericite–chlorite–

quartz–feldspathic metasomatites. The appearance of various formations in this series is possibly associated with the ratio of carbonate, pelitic and psammitic components in the pre-metamorphic substrate and in the continuity of the process from the early metamorphic stages to late metasomatism. Rocks of biotite–feldspar–quartz and sericite–chlorite–quartz–feldspar composition, as well as skarnoids, form a single series of metasomatites with unclear boundaries between them and a large group of vein minerals (quartz, plagioclase, sericite, calcite and possibly amphibole), which give specificity to individual metasomatites.

Mineralization of the Sarykul type is confined to the tectonically weakened zone of the northwestern long-lived fault, expressed by a series of subparallel tectonic sutures; dikes of ultra-acidic granitoids; tectonic packages formed along linear olistoliths of limestones and siliceous shales; linear bodies of metasomatic rocks of various compositions. The main morphotypes of ore bodies of the Sarykul type are plate-like mineralized deposits and various lenses.

Ore bodies are characterized by average tungsten trioxide contents of 0.5-0.8%. Scheelite is the main and only tungsten-containing mineral that determines the practical significance of ores. The typomorphic elements of tungsten mineralization of the Sarykul type are W, Cu, Bi, Sn, Au, Te, Ag.

The new ore-formational type of gold-tungsten mineralization for the North Chakylkalyan zone (Gussai) is associated with late (in relation to the Yakhton intrusive complex productive on skarns) tectonic zones of northeastern strike, and is manifested in the Chashtepa and Yakhton ore fields.

What these ore fields have in common is the formation of telescoped type mineralization, with spatial combination of skarn–scheelite (with gold) and hydrothermal–metasomatic gold–tungsten mineralization.

The substrate for the formation of ore-bearing metasomatites of the Gussay type are granodiorites and quartz diorites of the Yakhton complex. The ore-bearing rocks are albite-quartz metasomatites with orthoclase, chlorite, carbonates and polysulfide mineralization (pyrite, marcasite, pyrrhotite, arsenopyrite, molybdenite, fahlores).

Ore bodies are localized in discontinuous structures in northeastern and latitudinal directions in the Chashtepa ore field and in northeastern and submeridional directions in the Yakhton ore field [2].

The morphology of ore bodies for the Gussay type of mineralization directly depends on the nature of the ore-localizing structures. The main morphotypes for ore bodies are lens-shaped bodies in the linear parts of discontinuities and ore columns that form in the intersection zones of northeastern, latitudinal and submeridional disjuncts, under a screen of rocks of siliceous-carbonate strata.

In ore columns, mainly developed in the Chashtepa ore field, rich ores (with a WO_3 content of 1.5-2% or more) are formed, confined to quartz-hematite and hematite-quartz breccias, with superimposed sulfide mineralization.

The main tungsten-containing mineral in ores of the Gussay type is scheelite, which forms mainly fine dissemination, less often fine aggregate accumulations. In addition to it, the ores contain tungstite, meimakite, ferritungstite and hydrotungstite. In the oxidation zone, hydroxide forms are more common. In addition to the described tungsten minerals in the ores, the presence of reservoirs of tungsten-containing substances in an unknown mineral form, deposited on iron oxide minerals, is assumed.

The geochemistry of the Gussay type mineralization is clearly determined by the multistage nature of the ore process. To analyze the distribution of ore elements, the intensity coefficients of accumulation of elements in ores were calculated relative to their clarke in the earth's crust. As a result, the following series of coefficients (clarks) - concentrations - was obtained:

Bi-Te-Au-W-Sb-As-Mo-Ag-Se-Cu-Sn (for the Chashtepa ore field);

Bi-W- (Ag, Te) -Sb-As-Au-Pb (for the lower tier of the Yakhton ore field).

A comparison of these series indicates a significant role of Te and Bi in the formation of the Gussay type gold-tungsten mineralization.

Based on the results of the correlation analysis, to a first approximation, it is possible to identify a number of geochemical parageneses that determine the spatial locations of increased gold concentrations. The most important of them: Au-W, Au-As, Au-Te – determine the typomorphic elements of the Gussay type gold-tungsten mineralization (Au, W, Bi, As and presumably Te).

At the level of ore columns, a combination (telescoping) of geochemical parageneses is planned, mainly in positions of screening of mineralized zones developed in granodiorites by siliceous-carbonate strata.

The upper ore level of the ore zones is recorded, presumably, in the form of a series of thin quartz veinlets with a northeast strike and accompanied by elevated gold contents, correlated with antimony, silver, lead and arsenic. The presence of various gold parageneses associated with the discrete nature of the development of the ore process allows us to observe their combination in telescoping areas and assume possible spatial separation with the formation of gold-tungsten and actually gold and tungsten mineral associations.

The post-collision age of the Gussay-type gold-tungsten mineralization determines its association with late deformation structures superimposed both on collision granodiorites and on dikes of the Almalysay complex of Permo-Triassic age, cutting

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the entire pre-Mesozoic section, Upper Paleozoic granitoid complexes and, in many cases, thrust – canopy structures.

The preliminary estimated potential of tungsten trioxide at objects of new ore formation types in the Karatyube-Chakylkalyan ore region allows it to be mined using both open and underground methods.

Primary ores of the Gussay and Sarykul types are technologically simple and their flotation processing scheme is not fundamentally different from the schemes previously effectively used at mining enterprises with similar ores (Ingichke, Koitash).

For oxidized ores of the Gussay type, the State Enterprise "Ingichka Experimental and Technological Expedition" has developed methods for alkaline leaching of ore, allowing for the extraction of 85–90% of tungsten trioxide into the solution.

Thus, from the above it follows that for tungsten deposits the main potential-industrial types of the republic are skarn and apakoskarn-skarnoid: Gumbiet and, especially, greisen types, which are of great indicator importance for large deposits, although in the socio-geographical-economical under favorable conditions they can be exploited. The republic's recorded tungsten reserves, taking into account redemption, are estimated quite highly. The forecast resources are twice as large.

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