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MINERALOGENIC POTENTIAL OF SOUTHERN UZBEKISTAN FOR SOLID MINERALS

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Abstract. The article examines the mineralogenic potential of Southern Uzbekistan for both metallic and non-metallic solid minerals based on the zonation of geodynamic structures and tectonic evolution of the region. A comprehensive cartographic database consisting of 20 thematic geological, tectonic, and mineralogical maps was developed to support the research. In addition, a detailed classification of the geological and industrial types of the major solid mineral deposits in Southern Uzbekistan was compiled and used as the basis for constructing mineralogenic and prognostic maps. The study presents a prognostic and prospective assessment of the geodynamic structures with respect to the most economically significant types of mineral resources. The obtained results are intended to improve the efficiency and reliability of regional forecasting and exploration for new mineral deposits within Southern Uzbekistan. Deposits and ore occurrences of metallic and non-metallic minerals are represented by four principal groups: rare metals, base metals, precious metals, and various types of non-metallic raw materials widely used in industry and construction.

Keywords: Southern Uzbekistan, Southwestern Tien Shan, minerals, mineralization, geodynamics, tectonics, zonation, paleo-ocean, microcontinent, geological and industrial types of deposits, ore-controlling factors, cartographic model, cartographic database.

Introduction

Southern Uzbekistan refers to the part of the Southwestern Tien Shan fold system located within the Uzbek state border. Southern Uzbekistan encompasses the western extremities of the Zeravshan and Hissar ranges, the Southwestern Hissar mountain structure, and their adjacent depressions: the Ulus-Dzham, Beshkent, Pashkhurd, and Surkhandarya depressions.

The Southwestern Tien Shan fold system is considered a superterrane and extends from the Sultanuvaiz Mountains, through the Kuldzhuktau and Zirabulak-Ziaetdin hills, to the Zeravshan and Hissar ranges, encompassing the Baysun-Kugitang zone. It includes the Zeravshan ophiolite terrane, the Kuldzhuktau-Chakylkalyan-Hissar terrane, and the Hissar volcanoplutonic belt (VPB). Overall, this superterrane is characterized by an intense imbricate-thrust structure involving Paleozoic sequences that once formed the cover of the pre-Ordovician continental Karakum-Tajik microcontinent.

Figure 1 shows a general administrative map of Southern Uzbekistan with outcropping Paleozoic basement.

The history of geological development of Southern Uzbekistan, geodynamic settings along with their formational and structural characteristics, mineralization, and the distribution patterns of various mineral deposits have been presented in studies by N.I. Dzhantuganov, O.G. Terletsky, A.R. Zakhidov, A.A. Gafurbekov, M.A. Mirusmanov, R.Kh. Mirkamalov, F.K. Divaev, and others [8, 10, 11]. According to their concepts, the structural and material characteristics of Southern Uzbekistan and its metallogenic specialization are related to the composition of the substrate on which they formed and the direction of the evolutionary geodynamic development of the territory.

Another characteristic feature of the geology of Southern Uzbekistan is its heterogeneous structure. The developmental history, spatial position, and zonation of the tectonic structures of

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Southern Uzbekistan, as well as the emergence of fold systems, are explained by the evolution of paleo-oceanic basins and their subsequent transformation into collisional-fold belts [1, 3, 8].

The development of structural and material complexes of the Southwestern Tien Shan and their zonation are considered from the perspective of plate tectonics. The emergence of fold systems is explained by the evolution of oceanic basins and their transformation into fold belts. Their formation is linked to the developmental history of two paleo-oceans: the Paleo-Asian Ocean and the Paleo-Tethys Ocean.

Within the territory of Uzbekistan, the following structures are identified from north to south: the Middle Tien Shan (Kazakh-Kyrgyz) microcontinent, the Turkestan paleo-ocean, the Alai microcontinent, the Zeravshan paleo-ocean, the Afghan-Tajik microcontinent, and the Tethys paleo-ocean proper.

The development of the Turkestan paleo-ocean was accompanied by the subduction of its crust beneath the Middle Tien Shan, which led to the emergence of an Andean-type active margin and its associated Beltau-Kurama volcano-plutonic belt.

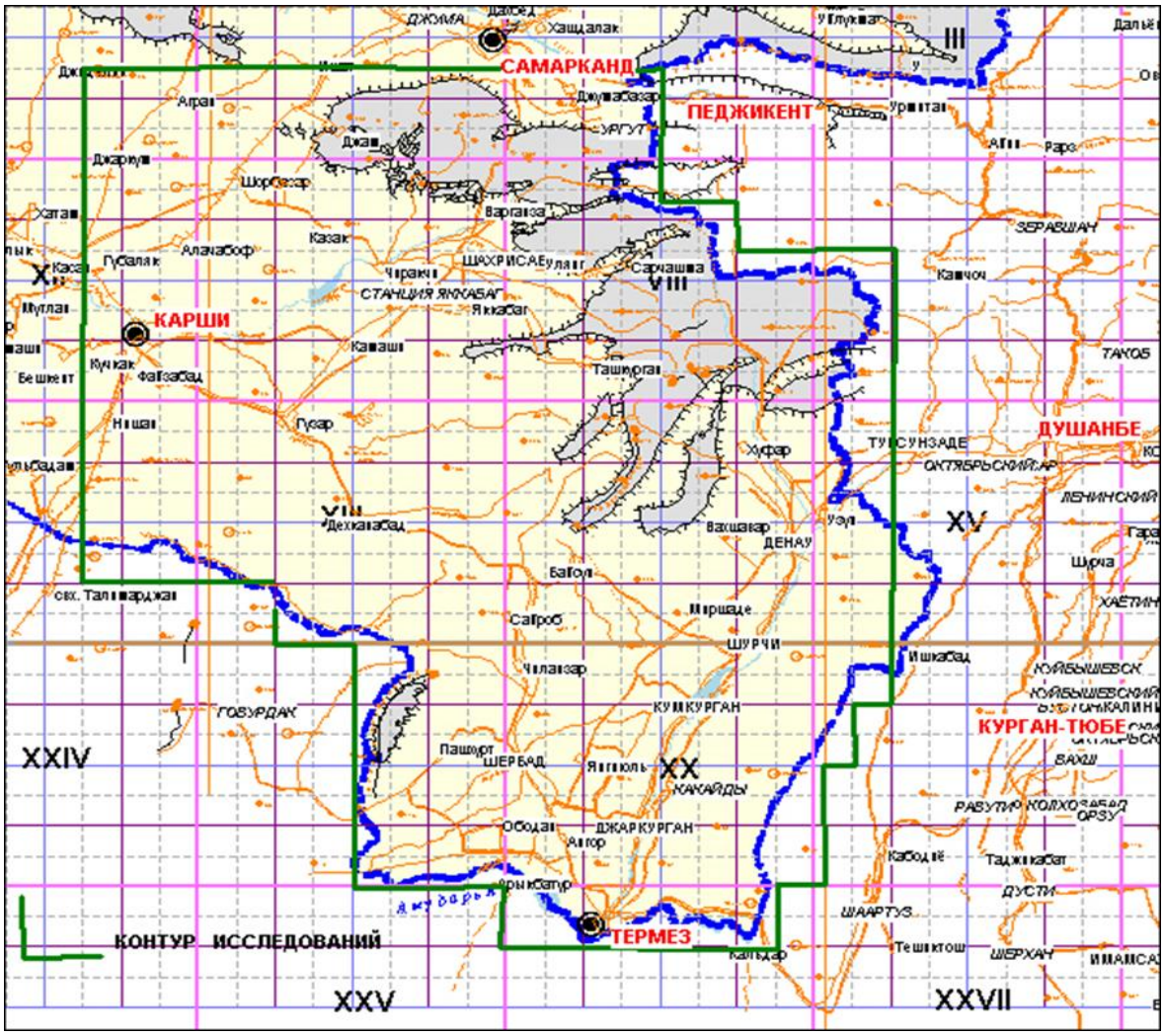

Figure 1. Overview administrative map of Southern Uzbekistan with outcropping Paleozoic basement

The crust of the Zeravshan paleo-ocean subducted southward beneath the Afghan-Tajik microcontinent, triggering the opening of the South Hissar riftogenic suboceanic basin. During the Late Paleozoic collision, the South Hissar-Bukhara volcano-plutonic belt was formed at the margin of the microcontinent. The convergence of the Kazakh-Kyrgyz and Afghan-Tajik microcontinents

predetermined the closure of the Turkestan and Zeravshan paleo-oceans, contributing to the formation of the nappe-fold system of the Southern Tien Shan.

In Southern Uzbekistan, four groups of metallic and non-metallic minerals belonging to 61 ore-formation types have been identified: base metals (copper, lead, zinc, aluminum); precious metals (gold, silver, platinum group metals); rare metals (tungsten, tin, molybdenum, antimony, mercury, cerium, ytterbium, yttrium, tantalum, niobium, lithium, beryllium, cesium, rubidim); and non-metallic raw materials (barite, celestine, fluorite, native sulfur, rock salt, potash salt, coal, oil shale, agrochemical ores). A mineral resource base has been established here for the following solid minerals: gold (Akba, Kizilturuk, Shirotnoye deposits), polymetals (Khandiza, Chakchar deposits), tungsten (Yakhton, Gussay deposits), and others.

Further expansion of mineral exploration in the region depends on identifying its prospective potential using new advanced analytical methods.

Materials and methods

For geodynamic and minerogenic regionalization, a digital database of cartographic information for Southern Uzbekistan has been created in ArcGis format. A total of more than 20 cards have been converted to electronic format.

The set of regional cartographic materials included in the electronic database is selected in such a way that it reflects the region's geology from various perspectives - mineral resources, stratigraphy, tectonics, geodynamics, structures, magmatism, metamorphism, and the state of the mineral resource base.

The electronic database of computer maps of Southern Uzbekistan includes: a geological map; a mineral resources map; geochemical maps of indicator elements for gold, polymetallic, and rare-metal mineralization; an anomalous magnetic field map of Southern Uzbekistan; a geodynamic map of Southern Uzbekistan (featuring fragments of Late Paleozoic geodynamic setting assemblages); a lineament and ring structure map of Southern Uzbekistan; a magmatic complex map of Southern Uzbekistan; a pre-Mesozoic basement map of Southern Uzbekistan; a drilling density map of the pre-Mesozoic basement of Southern Uzbekistan; a schematic map of mineralogical-geochemical indicators of mineralization and metasomatic processes in pre-Mesozoic formations of covered areas in Southern Uzbekistan; and a map of tectonic stress field distribution in the structures of pre-Mesozoic formations of the Southern Tien Shan.

Results and Discussion

Based on the concept of the evolutionary geodynamic development of Pre-Mesozoic structures, a tectonic zonation of the territory of Uzbekistan was performed, wherein each geodynamic structure is characterized by its inherent tectonic and magmatic manifestations that, in one way or another, determine its metallogenic character [2].

Figure 2 shows a geodynamic zonation scheme of Southern Uzbekistan.

The scheme illustrates the following geodynamic structures:

1. The Zeravshan-Alai back-arc zone of the carbonate shelf of the volcano-plutonic belt;

2. The South Hissar axial zone of the volcano-plutonic belt at the active margin of the Afghan-Tajik microcontinent;

3. The Bukhara-Khiva structure — an isolated intracontinental basin with fragments of metamorphic complexes of the continental crust;

4. The Baysun-Kugitang collisional structure of the orogenic uplift with rift fragments.

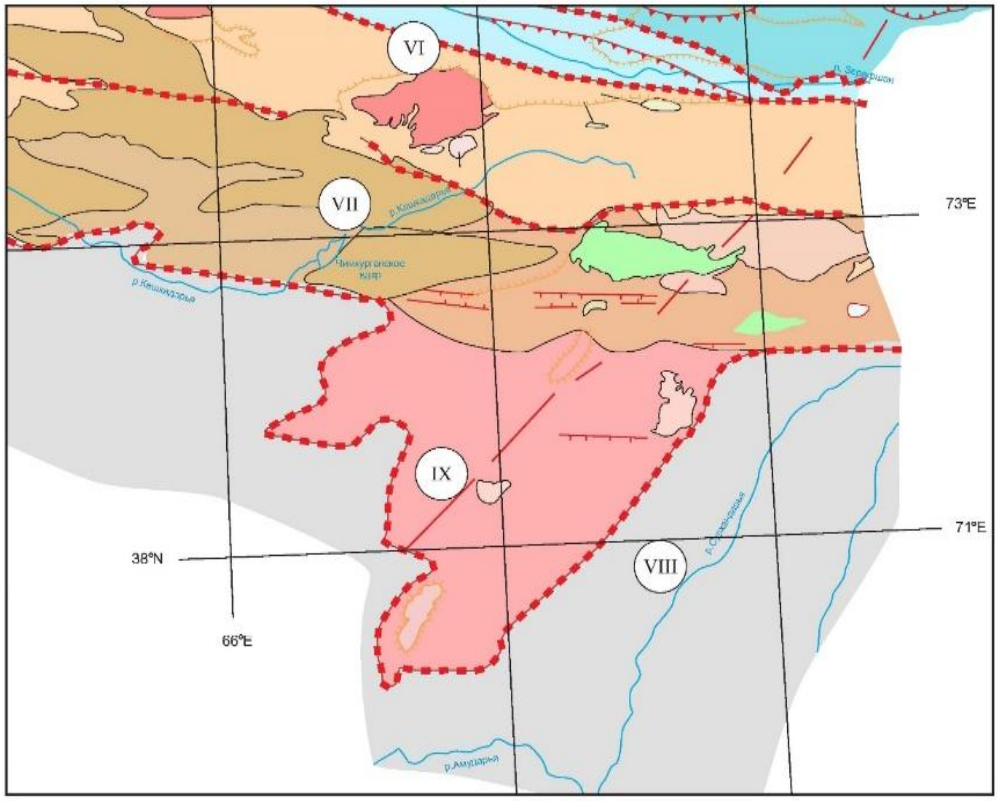

Figure 2. Geodynamic zonation scheme of Southern Uzbekistan. Legend (Roman numerals in circles)

VI — the Zeravshan-Alai back-arc zone of the carbonate shelf of the volcano-plutonic belt; VII — the South Hissar axial zone of the volcano-plutonic belt at the active margin of the Afghan-Tajik microcontinent; VIII — the Bukhara-Khiva zone featuring an isolated intracontinental basin with fragments of metamorphic complexes of the continental crust; IX — the Baysun-Kugitang collisional structure of the orogenic uplift with rift fragments.

The performed mineralogenic zonation of Southern Uzbekistan confirmed the zonal nature of the region's mineralization [7]. Four zones were identified, coinciding with the boundaries of the geodynamic structures in Figure 2, each possessing its own metallogenic profile (Table 1).

The Zeravshan-Alai mineralogenic zone is characterized by a specific rare-metal specialization. The main scheelite-bearing deposits and ore bodies, such as Yakhton, are represented by the skarn type and are confined to the contacts and immediate exocontacts (up to 50–100 m) of intrusions belonging to the (C_3–P_1) granodiorite-adamellite formation. The skarn process occurred under conditions of high plasticity of carbonate rocks, resulting in the formation of exfoliations and layer-contraction fractures within the near-contact zone of the cooling intrusion. Concurrently, the formation of skarn bodies was rigidly controlled by fluid migration (the orientation of the ore-distributing system). The factor of pull-apart opening of skarn-localizing surfaces during strike-slip faulting, which created zones with stagnant hydrothermal conditions, played a dominant role [12].

The ore process occurred at lower temperatures against a background of increasing brittle deformation in marbles and the development of radial contraction fractures in granitoids. During the activation of submeridional longitudinal northeastern strike-slip faults, crushing of skarns and the formation of an exokinetic fracture system in granites took place.

Table 1. Mineralogenic zonation of pre-Mesozoic formations in Southern Uzbekistan (Southwestern Tien Shan)

Mineralogenic zone No.	Name of the minerogenic zone	Geodynamic structure	Mineralogenic specialization; main formation types of deposits
1	2	3	4
VI	Zeravshan-Alai	Back-arc zone of the carbonate shelf of the volcano-plutonic belt	W, Mo, Ta, Nb, Mg; W, Mo – skarn type, Ta-Nb – pegmatite type, Ta-Nb – albitite type, Mn – oxide type
VII	South Hissar	Axial zone of the volcano-plutonic belt at the active margin of the Afghan-Tajik microcontinent	Au, Cu, Zn, Pb, Ag; Au- sulfide-quartz type, Cu-Zn-Pb volcanogenic massive sulfide type, Au-Ag
VIII	Bukhara-Khiva	Isolated intracontinental basin	Deeply buried Paleozoic basement with undefined mineralization
IX	Baysun-Kugitang	Collisional structure of the orogenic uplift	Pb, Zn, Cu, Au, Ag, Sn. Pb; Zn- volcanogenic massive sulfide type, Au- sulfide-quartz type, W-Sn- skarn and greisen types

Tungsten mineralization in skarns was largely determined by the orientation of ore-concentrating structures. Concurrently, alongside the factor of the pull-apart opening of low-angle surfaces, subvertical fracturing gained significance, contributing to a local decrease in pressure.

The rare-metallic geological-industrial type with tantalum, niobium, lithium, tin, and beryllium (Bayankara, Mangit, Sulatsay) manifests as pegmatites [6]. Pegmatites are plate-like, veined, and chisel-shaped bodies that are weakly, moderately, and completely differentiated in C_3-P_1 granite intrusions and their nearest exocontates. The content of the most important metals, tantalum pentaoxide and niobium, varies in pegmatites (%) from 0.016–0.018 and 0.014–0.016 respectively. The economic viability of mining these objects can only be achieved through the comprehensive extraction of all useful ore components, namely quartz, mica, feldspars, tantalum, niobium, lithium, tin, and beryllium.

The South Hissar mineralogenic zone is identified within the geodynamic zone of the same name, which is saturated with volcanogenic and intrusive formations. This is the axial zone of the volcano-plutonic belt of Middle Carboniferous–Permian age. No commercial deposits have been discovered within this zone inside the territory of Uzbekistan, although fluorite deposits are concentrated within the same zone in neighboring Tajikistan.

The metallogenic character of the zone is determined by fluorite and rare-metal occurrences, and to a lesser extent, by base metals. The most promising occurrence is Kuldara, which hosts copper-zinc massive sulfide (VMS) mineralization within metavolcanics of basalt-rhyolite composition. Recently, the gold potential of the South Hissar mineralogenic zone has attracted particular attention.

The Bukhara-Khiva mineralogenic zone is identified within the geodynamic zone of the same name and is entirely covered by Mesozoic and Cenozoic sediments. It represents a potentially promising mineralogenic zone for metallic minerals.

The Baysun-Kugitang mineralogenic zone is located within the geodynamic zone of the same name. It consists of two subzones: the northern Baysun subzone and the southern Kugitang subzone. The Baysun subzone is characterized by active Early-Middle Carboniferous volcanism, which was accompanied by the formation of massive sulfide polymetallic mineralization (Khandiza, Chakchar,

South Karasan, etc.). In the distribution of mineralization, the leading role belongs to Early Carboniferous ring volcanotectonic structures. There are indications of gold mineralization, which is localized not only in Paleozoic but also in Upper Triassic sediments (Yangoklyk).

The Kugitang subzone exhibits a substantially plutonic (granitoid) evolutionary profile in the Late Paleozoic. Its metallogenic character is determined by poorly studied occurrences of fluorite, tin, lead, zinc, and mercury. Of particular interest is that a portion of the lead-zinc, mercury, and fluorite mineralization is of Mesozoic age. The presence of gold associated with sulfides has been established in quartz veinlets within the basal Jurassic layers.

Conclusions

Southern Uzbekistan stands as one of the country's most promising ore regions for the discovery of new solid mineral deposits. Four geodynamic zones, which serve as the foundation for corresponding mineralogenic zones, have been identified within the territory of Southern Uzbekistan:The Zeravshan-Alai back-arc zone of the South Hissar volcano-plutonic belt (W, Mo, Ta-Nb, Be, Mn);The South Hissar axial zone of the volcano-plutonic belt at the active margin of the Afghan-Tajik microcontinent (Au, Cu, Zn, Pb, Ag);The Bukhara-Khiva zone of an isolated intracontinental basin (deeply buried Paleozoic basement with undefined mineralization);The Baysun-Kugitang collisional structure of the orogenic uplift (Pb, Zn, Cu, Au, Ag, Sn).

Based on the created digital cartographic information base, a comprehensive cartographic model of Southern Uzbekistan was created. Geodynamic and mineralogical zoning of the territory was conducted, with the determination of the metallogenic profile.

In Southern Uzbekistan, 4 groups of metallic and non-metallic minerals belonging to the ore-formation type are identified: non-metallic minerals—copper, lead, zinc, aluminum; precious metals—gold, silver, platinum group metals; rare ones— tungsten, tin, molybdenum, antimony, mercury, cerium, itterbia, ittrium, tantalum, niobium, lithium, beryllium, cesium, and rubidium; and non-metallic raw materials—barite, selestine, fluorite, native sulfur, rock and potassium salts, coal, combustible shales, and agro-ores.

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ӨЗБЕКСТАННЫҢ ОҢТҮСТІГІНДЕГІ ҚАТТЫ ПАЙДАЛЫ ҚАЗБАЛАРДЫҢ МИНЕРАЛОГИЯЛЫҚ ӘЛЕУЕТІ

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Аңдатпа. Мақалада геодинамикалық құрылымдардың аудандастырылуына және аймақтың тектоникалық эволюциясына негізделген өзбекстанның Оңтүстігіндегі металл және металл емес қатты минералдар үшін минералогиялық әлеуеті қарастырылады. Зерттеуді қолдау үшін 20 тақырыптық геологиялық, тектоникалық және минералогиялық карталардан тұратын кешенді картографиялық мәліметтер базасы жасалды. Сонымен қатар, өзбекстанның Оңтүстігіндегі негізгі қатты пайдалы қазбалар кен орындарының геологиялық және өнеркәсіптік түрлерінің егжей-тегжейлі классификациясы жасалып, минералогиялық және болжамдық карталарды құру үшін негіз ретінде пайдаланылды. Зерттеу барысында геодинамикалық құрылымдардың минералды ресурстардың экономикалық маңызды түрлеріне қатысты болжамды және перспективалық бағасы ұсынылған. Алынған нәтижелер өзбекстанның Оңтүстігіндегі жаңа пайдалы қазбалар кен орындарын аймақтық болжау мен барлаудың тиімділігі мен сенімділігін арттыруға бағытталған. Металл және металл емес пайдалы қазбалардың кен орындары мен кен орындары төрт негізгі топқа бөлінеді: сирек металдар, негізгі металдар, бағалы металдар және өнеркәсіпте және құрылыста кеңінен қолданылатын металл емес шикізаттың әртүрлі түрлері.

Түйін сөздер: Өзбекстанның Оңтүстігі, Тянь-Шаньның Оңтүстік-Батысы, пайдалы қазбалар, минералдану, геодинамика, тектоника, зоналау, палео-мұхит, микроконтинент, кен орындарының геологиялық және өнеркәсіптік түрлері, кенді бақылау факторлары, картографиялық модель, картографиялық мәліметтер базасы.

МИНЕРАЛОГИЧЕСКИЙ ПОТЕНЦИАЛ ТВЕРДЫХ ПОЛЕЗНЫХ ИСКОПАЕМЫХ ЮГА УЗБЕКИСТАНА

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Аннотация. В статье рассматривается минералогический потенциал Юга Узбекистана как в отношении металлических, так и неметаллических твердых полезных ископаемых на основе зональности геодинамических структур и тектонической эволюции региона. Для поддержки исследований была разработана обширная картографическая база данных, состоящая из 20 тематических геологических, тектонических и минералогических карт. Кроме того, была составлена подробная классификация геологических и промышленных типов основных месторождений твердых полезных ископаемых на юге Узбекистана, которая была использована в качестве основы для построения минералогических и прогностических карт. В исследовании представлена прогностическая и перспективная оценка геодинамических структур в отношении наиболее экономически значимых видов минеральных ресурсов. Полученные результаты призваны повысить эффективность и надежность регионального прогнозирования и разведки новых месторождений полезных ископаемых на Юге Узбекистана. Месторождения и рудопроявления металлических и неметаллических полезных ископаемых представлены четырьмя основными группами: редкие металлы, неблагородные металлы, драгоценные металлы и различные виды неметаллического сырья, широко используемого в промышленности и строительстве.

Ключевые слова: Южный Узбекистан, Юго-Западный Тянь-Шань, полезные ископаемые, минерализация, геодинамика, тектоника, зональность, палеоокеан, микроконтинент, геологические и промышленные типы месторождений, рудорегулирующие факторы, картографическая модель, картографическая база данных.