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GEOLOGICAL STRUCTURE OF THE MARJANBULAK ORE FIELD

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Abstract

The article provides a detailed characterization of the geological structure of the Marjanbulak ore field, located at the junction of the Gobduntau and North Nuratau mountains. The stratigraphic features of the silurian-metamorphic formations of the lower Devonian (Marjanbulak formation), as well as the magmatic complexes (Malguzar and South Tien Shan) controlling the distribution of mineralization, have been examined. Particular attention is paid to the structural-tectonic framework of the ore field, including the Southern and Northern fault zones, tectonite types, and their relationship with gold-silver mineralization. Morphological types of ores (venous and vein-spotted) and structural features of the hypergenesis (oxidation) zone have been characterized. The obtained data determine the patterns of ore body localization at the Marjanbulak deposit.

Key words: Marjanbulak ore field, geological structure, sedimentary-metamorphic deposits, tectonites, igneous complexes, rupture faults, gold-quartz formation, oxidation zone, ore bodies.

Introduction

The Marjanbulak ore field occupies an important position in the region's structure, being adjacent to the South Nuratina deep fault. Studying the geological structure, magmatism, and structural features of this ore node is of key importance for understanding the conditions of endogenous mineralization, specifically the gold-quartz low-sulfide formation. Despite the presence of a thick Cenozoic cover on the flanks, the exposed and eroded part of the hill is a complex polyformational complex formed as a result of multi-stage tectono-magmatic and hydrothermal processes. The purpose of this work is to systematize the geological-structural, mineralogical, and lithological data of the Marjanbulak ore field to identify patterns in the placement of industrial gold ore objects.

Materials and Methods

The work is based on detailed geological materials and the results of long-term geological exploration, structural-tectonic, and geophysical research (including the works of P.F. Ivankin, N.I. Nazarova, Z.N. Judalevich, A.N. Norkulov, A.P. Kostenko, O.L. Gentshke, L.P. Shevtsova, and others).

During the study, a comprehensive approach was applied, including:

Geological-structural analysis: detailed mapping of rupture disturbances, tracing of longitudinal and diagonal fracturing zones, study of fracture kinematics and the morphology of ore-controlling intersection nodes.

Litrage-petrographic and mineralogical analysis: studying the material composition of sedimentary-metamorphic strata of the Marjanbulak formation, magmatic complexes (Malguzar and South Tien Shan), and identifying various types of tectonites (breccias, milonites).

Analysis of hypergenesis and oxidation zones: comparing chemical analysis data (ratio of total and sulfide sulfur) with visual observations to determine the thickness, morphology, and depth of oxidation zone development, as well as the nature of gold and silver redistribution in hypergenic conditions.

The Marjanbulak ore field is located on the hillside of the same name between the Gobduntau and North Nuratau mountains. The total area of the ore field, including the buried framing, is approximately 80 km2. Its boundary is conditional and corresponds to the 200-250 m isolation line, which records the depth of the Paleozoic from the modern surface.

In the area of the ore field, Paleozoic sedimentary-metamorphic formations and Cenozoic deposits are developed, forming a thick cover on the flanks ranging from 40-50 to 300-400 m. The entire complex of sedimentary rocks belongs to the Silurian-lower Devonian (Ivankin P.F., Nazarova N.I., 1983) and is represented by sandy-clay deposits of the Marjanbulak formation.

Main part. The most widespread within the ore field (about 90%) are pelite and aleurolite varieties, which constitute blocks and budins of undisturbed rocks and are separated by zones of tectonic disturbances. These are dense, varyingly shale-like, rarely massive rocks of hydroslude-sericite-clay composition containing carbon impurities ranging from 0.5% to 1-2%. The remaining formations (carbon-bearing silicates, quartzite-like "sandstones," and rare carbonate rocks) represent a complex metamorpho-metasomatic complex of rocks formed during dynamometamorphism under the influence of deep fluids that penetrated into dislocated stratified strata and metasomatically replaced them (Ivankin A.F., Nazarova N.I., 1983). [1]

For rocks of this complex, the redistribution of substance during recrystallization is characterized by a spotted-lens-banded pattern. Visually, such rocks are mapped as the interlayering of coal-clay shales with aleurolites and sandstones. The general distribution of rocks in the terrigenous complex is northwestern. The intrusive formations in the ore field are divided into two magmatic complexes: Malguzar and South Tien Shan (Yudalevich Z.N., 1980).

The Malguzar complex (C_{2-3}-R) is represented by a homodromic series of formations of gabbro-diorite-granodiorite-granite composition, formed during the orogenic stage of development.

In the early orogenic stage (C_{2-3}), a gabbroid formation emerged, represented by dikes of diabases and diabasic porphyrites, which are widely distributed throughout the entire ore field. The dikes are grouped, forming northwesterly belts that fix early-formation fault zones. Their length is up to 500 m, thickness is 1-10 m, and the contacts are clear.

Intermediate series dikes (diorites, diorite porphyrites, granodiorites, lamprophyres) are characteristic of the transition period to the granitization stage. These dikes control the main ore bodies and quartz vein zones. They are widespread in all ore-bearing areas. Its length reaches 170 m, and its thickness reaches the first meters.

The late orogenic stage of development (C_3-P_1) concluded with the introduction of small granitoid intrusions forming small rod-shaped bodies observed in the North West and Salyn areas. According to geophysicists (Norkulov A.N. et al., 1982), the existence of a granitoid massif is hypothesized on the southeastern buried flank of the Marjanbulak ore field.

A common feature of the daisies of the Malguzar complex is their consonant and subconsonant positions within the surrounding structures. They account for 80-90% of all igneous rocks in the ore field. The penetration of dikes occurred during the orogenic stage of activation and, in relation to ore processes, they are pre-ore. During the process of ore formation and the manifestation of later tectonic movements in fault zones, they were broken into small blocks, metasomatically transformed, quartzed, and sometimes contain gold-bearing mineralization.

The South Tien Shan complex of the post-consolidation activation stage (P2-T) is represented by an antidrome series, which includes dikes of alkaline siyenite-porphyres and alkaline lamprophyres. Alkaline siyenite-porphyres (P2-T) were isolated only in the Salyn area. The dikes form sub-latitudinal fractures. The maximum length of the dikes is up to 700 m, and the thickness is up to 4 m. Alkaline lampreys (T) complete the magmatic cycle. They are developed throughout the entire ore field and are confined to the secant zones of sublatitudinal and northeastern extent. In relation to the ore, the dikes of the South Tien Shan complex are post-strudine.

The position of the Marzhanbulak ore field in regional structures is determined by its proximity to the South Nuratina deep fault, which is traceable in the northwestern direction along the northern foothills of Karakchatov, and in the southeastern direction extending into the Malgozor Mountains (Shmakov Yu.V. et al. 1989). The main structural elements of the ore field are the Northern and Southern Marzhanbulak zones, which are branches of the South Nuratina deep fault. The general direction of the structures is northwestern. In addition to these main zones, the Marjan-Bulak ore field also includes the Intermediate, Intermontane, and Eastern Karakchatov zones. The southern zone has been studied most comprehensively, as it encompasses all known industrial gold-bearing objects. Its internal structure is extremely complex due to the duration of its formation. It is characterized by a striped-lensed structural plan, due to the formation of a complex multi-seam framework of breaches formed by tectonites and their surroundings by lens- and wedge-shaped blocks of differently dislocated terrigenous rocks (budins).

Ivankin P.F. and Nazarova N.I. identified 3 types of tectonites:

1. Type 1 tectonites are dense rocks with a brecciated and shale-like texture, formed during the initial stages of deformation. Characteristic of peripheral zones. Carbon content less than 1%.

2. Type II tectonites are black-colored rocks with abundant carbon content (Stv~ 3%) and a breccia texture, consisting of the chaotic distribution of flint fragments, band rocks, and vein quartz in blastomylonite sericite-graphite cement with a distinct slate-like texture and variously oriented sliding mirrors. The cement content is 50-70%, containing quartz veins and scattered sulfide inclusions. They are very widespread. The presence of gold mineralization is not characteristic of siliceous breccias; however, in areas of intensive tectonic movements, they contain highly silvery ores. The preferred association of silver with these rocks is evidently related to the increased reduction capacity of these rocks due to their high content of carbon and pyrite.

Type III tectonites are loose, sooty-black, finely shale-like, and highly carbonated (Stv~ 10%). The fragments contained within the milonit are very small and exhibit signs of repeated rubbing. Quantitatively, this type is the least widespread, consisting of longitudinal relatively weak cords within the thick zones of I and II-type tectonites, along which subsequent repeated movements were implemented. The high content of carbon matter in milonites indicates its repeated introduction during renewed movements.

Milonites often contain quartz ore veins and budins of vein-spotted ores. In addition to the spatial relationship, a genetic one is also noted, expressed in the metasomatic change and enrichment of the edge parts of terrigenous rock blocks with gold and silver upon contact with milonites. The latter unambiguously indicates the migration of ore-generating solutions within milonitic joints as the most permeable structures.

Geological-structural analysis of fracture zones (Kostenko A.P., 1986) showed that they represent the interaction of various types of tectonites: siliceous breccias with adjacent shale zones and milonites of suture structures. [2]

Siliceous breccias and schist formation zones are elements of the Narvan shift zone and extend in a northwesterly direction along an azimuth of 300-320o. Seam fractures are a manifestation of the Karakchatov-Marjanbulak branch of the deep fault, extending sub-latitudinally (280-290º). The intersection nodes of the northwestern and sublatitudinal zones are extremely complex areas. All ore areas of the Marjanbulak ore field are located within such nodes.

The subsidence of the southern zone is subvertical, with a thickness of about 600-800 m. The North Marjanbulak fault zone is practically unstudied due to its overlap with a thick cover of loose sediments. Its existence has been confirmed by geophysical data (Norkulov A.N. et al., 1982). Two wells drilled at different times revealed tectonites similar to those in the Southern Zone. The slope of the zone is steep southern, with a thickness of approximately 600-700 m.

As a result of comprehensive geophysical work (Norkulov A.N. et al., 1982), the continuation of the Southern and Northern zones was traced on the northwestern buried flank of the ore field, their junction was established, and a sublatitudinal fault was identified, forming a tectonic trough along the northern edge of the hill with displacement amplitudes up to 450 m. The nature of the fault is regional, typically representing an uplift-slip type. Its extension is 280-300°, and the angle of incidence is 45-80°.

In addition to the characterized large branches of the South Nurata Deep Fault, a number of secondary longitudinal and diagonal faults are mapped on the ore field. The latter are well deciphered on aerial and space photographs. In the exposed part of the upland, they represent a plane of sliding and a system of secant fissures, sometimes formed by igneous rocks of later phases. Usually, diagonal disturbances of northwestern (320-350o) and northeastern (10-40o) extent are characterized by low thickness, simple composition, low displacement amplitudes, and small length, splitting the linearly elongated structures of the ore field into individual blocks. The Marjanbulak deposit covers the southwestern slopes of the eponymous plateau and structurally corresponds to the Southern fault zone, where areas with industrial gold content are located. Thus, the boundaries of the deposit are determined by the position of the Salyn, Saryk-Bel, Ukrainian, Western, Tangi, Eastern, Kuchumsay, and Gumsay sections.

The deposit possesses all the main features of geological structure noted for the ore field. At the same time, the role of fault disruptions increases significantly, which is explained by the deposit's location directly within the Southern fault zone.

The southern fault zone has a complex band-lens-block structure, due to the alternation of tectonites with relatively undisturbed rock blocks. The rocks of the zone have been altered to varying degrees by carbon-sulfide-carbonate and carbon-albite-quartz metasomatic processes.

The ore-bearing zones are represented by fragments of a west-north-west stretch formed by the intersection of northwestern elements of the Southern mineralized zone with suture structures of a sublatitudinal stretch.

In the structure of the deposit, the Saryk-Bel and Tangin ore zones are distinguished, converging at an acute angle in a northwesterly direction. The first includes the Saryk-Bel, Ukrainian, and Western sections, while the second includes the Tangi, Kuchumsay, and Gumsay sections.

The study of the oxidation zone, weathering crust, and hypergenic processes at the Marjanbulak deposit was conducted by O.L. Gentshke and L.P. Shevtsova (1982).

The oxidation zone of the deposit is a fragment of the general system of Mesozoic linear weathering crusts. Her age is that of an Apte Senoman. As a result of modern denudation processes within the upland, extensive weathering crusts have been completely destroyed, and the upper part of the oxidation of mineralized structures has been significantly eroded.

The Marjanbulak ore field is characterized by a linear type of weathering crust, which is developed along tectonic disturbance zones. Their extent is controlled by the main structures of the ore field. Geomorphologically, this is expressed by the lowering of the relief. [1]

Rocks in the weathering crust are usually disintegrated and represent an unstructured bleached mass. The thickness of the weathering crust ranges from several centimeters to the first meters.

Exogenous processes related to the oxidation of primary rocks and ores are much wider and deeper in the deposit.

Factors influencing the composition, size, and morphology of the oxidation zone include the composition and quantity of the ore mass, the nature and morphology of ore bodies, and the lithological composition of primary rocks. The zones of tectonically developed rocks are most fully oxidized, including the surrounding areas of aleuropellites. To a lesser extent, dikes and mica-albite-quartz metasomatites are susceptible to oxidation, while quartz metasomatites (sandstones) and quartz veins are almost not oxidized significantly. [2]

The characteristic features of the oxidation zone are the clarification and limonitization of the rocks. Fields of clarified and limonitized rocks are located along the main ore-bearing structures. The breeds are grayish-white with the inclusion of brown, purple, and cherry colors. Their composition is predominantly hydro-slurry-kaolinite (40-60%), with a large amount of iron and manganese hydroxides present. Primary minerals are not preserved, with the exception of quartz. The carbon-containing substance burns out completely.

In dikes, changes are less developed, which is due to their higher density. In the oxidation zone, hydroslude, carbonate, and kaolinite develop along plagioclase, while chlorite, nontronite, and iron hydroxides develop along dark-colored ones. The main mass is a mixture of clay-carbonate composition impregnated unevenly with iron hydroxides.

The rocks of the oxidation zone are characterized by low strength due to the replacement of primary materials with clay and increased cracking. Limonitized rocks are characterized by a fine-porous texture due to the formation of voids from sulfide leaching.

The most important feature of the oxidation zone is the behavior of gold within it. In the oxidation zone, an increase in the total amount of visible gold is observed due to the partial release of early fine-dispersed gold during the process of hypergenic destruction of rocks, the enlargement of gold particles occurs due to the growth of released gold into hypergenic gold, and gold fineness increases to 905-955.

In addition, the migration of gold to lateral rocks occurs due to its "flowing" with iron and manganese hydroxides. The thickness of ore bodies increases compared to the unoxidized part, while the average gold content decreases. However, the spreading process does not extend beyond the ore-bearing zone, as the surrounding undisturbed rocks are less permeable.

The depth of development of the oxidation zone depends on the destruction and permeability of the rocks. Within tectonically weakened and mineralized structures, the thickness of the oxidation zone increases.

The fluctuations of the oxidation zone boundary level range from 50 to 150 m. The boundaries of the oxidation zone are uneven, characterized by protrusions and depressions.

The boundary between oxidized and primary rocks is clearly visible and is based on field observations and chemical analysis results based on the ratio of total sulfur to sulfate and sulfide sulfur (data from preliminary and detailed exploration of the Saryk-Bel and Zapadny areas were used - B.D. Klimenko, V.D. Oskin, 1985,1988, L.N. Grigorieva, 2008) [1].

CONCLUSION

Two morphological types of ores are widespread at the Marjanbulak deposit: veined and veined-spotted, often closely associated with one another.

For vein-spotted ores, it is characteristic that they are located at the contact points of rigid terrigenous rock blocks with tectonic zones. They are represented by steep-sloping zones of intensely cracked, sometimes brekched rocks with superimposed carbonate-quartz-sulfide mineralization. By material composition, they correspond to low-silver ores formed in the early stages of ore formation.

Venous ores are represented by quartz veins or lenses with superimposed polysulfide mineralization and are associated with quartz-venous zones in abundant carbonate milonites. In terms of material composition, they correspond to high-silver ores, the formation of which occurred in the final stages of ore formation.

The ores of the Marjanbulak deposit belong to the gold-quartz formation and are low-sulfide (sulfide content 1-5%).

The ore bodies of the study objects of the Saryk-Bel group are represented by steeply descending linear-stretched zones of fracturing, vein-like quartzation, and brekching in the sandy-clayey rocks of Siluradevon (West, Saryk-Bel, and New areas) and in the position of the plagiosienite stock of the Malguzar complex (Northern West area).

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