Role of faults and tectonic blocks in the Daugiztau gold deposit, Uzbekistan

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Abstract: This article delves into the comprehensive study of geodynamics concerning ore formation within the local area of gold ore mineralization in the central KyzylKum province. The primary focus lies in understanding the influential role of faults and tectonic blocks in the distribution of gold mineralization at the Daugyztau ore field. Geodynamics, as a significant factor in ore formation processes, is driven by external forces and prominently characterized by the dynamic activity of faults and blocks. The central KyzylKum province is renowned for its rich gold deposits, and exploring the underlying geodynamic processes is crucial for deciphering the mechanisms behind the formation and distribution of these valuable mineral resources. The study aims to shed light on the relationship between geodynamic phenomena and gold mineralization within the Daugyztau ore field. One of the key aspects under investigation is the role of faults, which are fractures or discontinuities in the Earth's crust, in controlling the migration and concentration of gold-bearing fluids. These faults act as pathways and conduits for the transportation of hydrothermal fluids, facilitating the deposition of gold and other associated minerals. By analyzing the spatial distribution and characteristics of faults in the area, researchers can gain insights into the geological processes responsible for gold mineralization.

1 Introduction

The rapid development of the economy of Uzbekistan, the emergence of new industrial sectors, requires the strengthening and expansion of the mineral resource base of the republic. This includes mining provinces, where production facilities for the processing of mineral raw materials operate. One such mining province is the Central Kyzylkum, where the limit of surface and near surface deposits has been exhausted [1, 2].

In solving the problem of the mineral resource base of the province, the main way is to search for new objects, as well as predictive and prospecting work on the flanks of known and developed deposits. The latter include the Daugyztau ore field with gold deposits Daugyztau, Asaukak, Amantaytau, Vyysokovoltnoe (Au/Ag) and others. Many researchers have shown that structural factors and their dynamics play a large role in the processes of formation and distribution of hydrothermal gold mineralization in the objects.

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of the Central KyzylKum. These factors determine the migration routes of hydrothermal solutions, the spatial position of ore bodies, and also their morphology.

To date, huge work has been carried out to study the genesis, patterns of formation and geological and structural conditions for the formation of gold ore manifestations and the placement of gold mineralization in their spaces within the Central KyzylKum. However, the increase in geological research and geological prospecting does not lead to a corresponding increase in the list of gold deposits in the province, hence the strengthening of the mineral resource base of gold.

In this situation, the study of tectonic tension and deformation of the area of manifestation of endogenous mineralization, modeling their structures on the basis of the principles of tectonophysical studies by M.V. Gzovsky, is of great importance. At the same time, the most important thing is that the results of geological and structural studies are the basis for studying (modeling) the tectonophysical features of the structures of ore objects. The results of these works, in combination with data from studying the geological and structural conditions for the formation and placement of endogenous mineralization, are the basis of a new method for deciphering the geodynamic situation of local ore-bearing areas: ore provinces, ore fields and deposits.

2 Materials and methods

The Daugyztau ore field, which includes the Daugyztau, Asaukak, Vysokovoltnoye, and other gold deposits, occupies almost the entire territory of the Beltau Mountains. Its tectonic feature, as indicated by researchers such as I.Kh. Khamrabaev, L.P. Zonenshayn, N.N. Usmanov, T.N. Dalimova, P.A. Mukhin, Yu.S. Savchuk, I.M. Golovanov, R.Kh. Mirkamalov, and others, is the restriction from the east by a large ore-controlling (ore-distributing according to A.V. Korolev) fault structure of northeast extension, as well as its block structure determined by systems of northeast and latitudinal faults. These are the main tectonic structures involved in the ore formation process and determine the internal geodynamics of the Beltau Mountains and, consequently, the Daugyztau ore field.

According to the mentioned researchers, I.Kh. Khamrabaev, L.P. Zonenshayn, N.N. Usmanov, T.N. Dalimova, P.A. Mukhin, Yu.S. Savchuk, I.M. Golovanov, R.Kh. Mirkamalov, and others, the tectonics and geodynamics of the Hercynian metallogenic epoch of the Central Kyzylkum are determined by the tectonics of the lithospheric plates, with a predominance of horizontal movements. This has had an impact on the structural framework and geodynamics of the ore field. It is confirmed by the results of experiments modeling tectonic stresses and deformation in the structures of the ore field.

3 Results

A comparative analysis of the second and third variants of the experiment (Figures 1 and 2) revealed a sharp difference in the geodynamic and tectonophysical features of the Beltau territory in the pre- and ore stages of development. The pre-ore stage is characterized by contrasting stress distribution along the element, simulating a transverse structure. It is caused by horizontal displacement (shear) of the fault sides and displacement of tectonic blocks in the direction of this structure. The contrast in stress distribution is also observed in the tectonic blocks themselves. In the direction of their displacement, tectonic stresses migrated and concentrated in areas of local compression (fault junctions).

There was an uneven distribution of stress and deformation of the rocks. The most important local extension zones for the manifestation of geological processes formed in the south and...
north-west (closed area) of Beltau, occupying about 20% of the territory. This indicates that the south and north-west of Beltau, even in the pre-ore stage, were tectonophysically and geodynamically prepared for the manifestation of various geological, tectonomagmatic and ore-magmatic processes here. With the activity of deep faults, sharp changes occurred in the stress-strain state of the Beltau area and its ore-controlling structures.

Values of maximum tangential stresses ($\tau_{max}$): 1–absence of tangential stresses; 2, 3–weak voltage fields; 4, 5–moderate voltage fields; 6, 7–strong stress fields; 8–lines of faults and directions of displacement along them; 9–directions of active displacements; 10–boundary of the Paleozoic basement.

Fig. 1. Map of tectonic stress distribution in the structures of the Daugyztau ore field.

Option I. Having determined the tectonophysical position of Daugyztau in province stress fields, we began to study the Daugyztau tension on a scale of 1:50000. Experiments were carried out in 3 variants. Each option corresponds to a certain stage in the development of Daugyztau Square. Their structural and tectonic foundations are built taking into account the sequence of formation of the main ore-controlling structures. The greatest interest is the third version of the experiment, where the structural-tectonic basis of the model of Daugyztau structures consists of faults formed before ore formation and where the geodynamic situation corresponds to the stage of ore deposition. The structural-tectonic basis includes a transverse fault extending in the north-northeast direction, as well as northeastern and sublatitudinal ore-controlling structures that divides Daugyztau into bloc (Figure 3).
Thus, more than 90% of gold occurrences were formed in areas with minimal tectonic tension and deformation of the host rocks, which is an important fact when predicting and searching for gold mineralization within Beltau and adjacent closed areas.

4 Discussion

The geodynamic setting of the ore field during the ore-forming period is characterized by the fact that the tectonic forces activated its fault structures. The activity of northeast faults (boundary elements of the blocks) caused movement of the block's relative to each other. The morphology of the blocks and their spatial arrangement in the structural network...
of the ore field greatly influence the character of their movements, as well as the stress and deformation. In the area of the ore field, seven blocks are conditionally distinguished (Fig. 4). The first two small blocks occupy the northern part of the ore field. It is characteristic for these blocks to concentrate stresses with increased deformation along the zone of the eastern boundary fault. The concentration of stresses here is due to the following geodynamic setting: forces applied to the model act on the block from the north, and forces resulting from the local displacement of the eastern boundary structure of the ore field act from the south. The nature and opposite direction of movements along the eastern boundary fault have caused the migration of tangential stresses in these blocks and their concentration along the eastern boundary of the ore field, leading to increased deformation of rocks and the formation of compression local deformation zones.

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8 – directions of active displacements;  
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Fig. 3. Scheme of tectonic stress distribution in the structures of the Daugyztau ore field.

Option III. Block 3 has the following geodynamics: its boundary faults have been activated due to the displacement of northern blocks in the southeast direction. This displacement is determined by the activity of boundary faults and the morphology of the northern blocks. Local extension...
deformation zones with decreasing stress were formed; the southern territory of the block is influenced by moderate and high magnitudes of tangential stresses, where several local compression deformation zones are observed. They are located along the block boundaries and indicate that the nature of their formation is closely related to the tectonic activity of boundary faults. This block is characterized by the manifestation of different directional local displacements of its individual sections. The northern territory shifts in the southeast direction. In the center of the block, a powerful zone of local extension deformation has formed, from which extension occurs in the southeast and northeast directions.

One of the central blocks of the ore field, Block 4, differs in its geodynamics from other blocks. Here, the geodynamic setting is passive. The stress intensity is very low, with numerous zones of local extension deformation. The northern section, which has a wedge-shaped form, is displaced in the southeast direction. The activity of the block's boundary faults is of a local nature. The passivity of the faults is apparently determined by the position of the block in the center of the structural network of the ore field and the limitation from the south and north by latitudinal faults, which are perpendicular to the direction of the applied compressive forces penetrating the model.

Block 5 is one of the active structures of the ore field. Its activity is determined by the combined influence of the dynamics of the northeast faults and the Daugyztaus deep structure. The wedge-shaped segment of the northern territory of the block, formed by the junction of the northeast and Daugyztaus faults, extends southward, resulting in the formation of a zone of local extensional deformation with a decrease in stress to zero. The process of wedging leads to the migration and concentration of stresses, with enhanced deformation in the northern part of the Asaukak fault junction with the Daugyztaus deep structure. Along the western boundary structure of the block, a zone of local extensional deformation was formed. The southern territory of the block is characterized by geodynamic passivity, despite the active phase of movement of the northeast faults. I attribute this phenomenon to the presence of a latitudinal fault that bounds the block from the south.

Block 6 is also one of the active structures in geodynamics. It is bounded by the northeast controlling faults from the northwest and southeast, a sublatitudinal fault from the south, and the Daugyztaus deep structure from the east. Under the influence of provincial tectonic forces, the geodynamics of the entire block and its surrounding structures are characterized by active movement. The northern and southwest sections of the block, which have a wedge shape, have shown activity in the form of displacement, respectively in the southern and northeast directions. In these same directions, there is a migration of shear stresses and their concentration in the eastern part of the block, in the junction zone of the northeast fault with the Daugyztaus deep structure. The concentration of shear stresses is accompanied by enhanced deformation, leading to the formation of a zone of local compressional deformation against the background of provincial deformation. The importance of deformation and its consequences, especially local extensional deformation caused by provincial compressional deformation, have been noted by A.V. Korolev and P.A. Shekhtman, A.V. Korolev, Kh.A. Akbarov, M.K. Turaev, and others [1, 4, 6].

L.I. Lukin, F.I. Wolfson, and others note that the study of the deposit's structure can be considered primarily as an investigation of the genesis of its form (stereogenesis) with all the complications associated with deformations and movements in ore-forming processes. The geodynamics of wedge-shaped segments in Block 6 contributed to the formation of local zones of extensional deformation, which naturally affected stress, reducing it to a minimum. The stress reduction is accompanied by the migration of shear forces from the zone of the local extension, releasing energy from provincial compression. The process of energy release affects the structure of the host medium, forming zones of fracturing and rock fragmentation.
The wedge-shaped area of the northern territory of the block, formed by the conjugation of the northeastern and Daugyztaus faults, is thrust southward, resulting in the formation of a zone of local extension deformation with a decrease in stress intensity to zero. The wedging process leads to the migration and concentration of stresses, with an intensification of deformation in the northern part of the Asaukak fault conjugation with the Daugyztaus deep structure. A zone of local extension deformation was formed along the western boundary structure of the block. The southern territory of the block is characterized by geodynamic passivity, despite the active phase of movement of the northeastern faults. The reason for this phenomenon is attributed to the presence of a latitudinal fault that bounds the block from the south.

Block 6 is also one of the active structures in geodynamics. It is bounded by the northeastern ore-controlling faults from the northwest and southeast, by a sub latitudinal fault from the south, and by the Daugyztaus deep structure from the east. Under the influence of tectonic forces, the geodynamics of the entire block and its surrounding structures are characterized by active movement. The northern and southwest parts of the block, which have a wedge-shaped form, exhibit displacement activity in the southern and northeastern directions, respectively. In these same directions, there is the migration of tangential stresses and their concentration in the eastern part of the block, in the zone of the conjugation of the northeastern fault with the Daugyztaus deep structure. The concentration of tangential stresses is accompanied by an intensification of deformation, leading to the formation of a zone of local compression deformation against the background of provincial deformation.

The importance of deformation and its consequences, especially local extension deformation resulting from provincial compression deformation, has been noted by A.V. Korolev and P.A. Shekhtman, A.V. Korolev, Kh.A. Akbarov, M.K. Turapov, and others [1, 2, 3, 7]. L.I. Lukin, F.I. Wolfson, and others point out that the study of the structure of a deposit can be considered crucial in understanding its genesis and the formation of its shape (steroidogenesis) with all the complications associated with deformations and movements in ore-forming processes. The consequences of geodynamics in wedge-shaped areas, expressed in the formation of new structures such as rock fracturing and fracturing, play an important role in the localization of ore mineralization and serve as structural exploration indicators and predictive criteria.

The consequences of geodynamics in wedge-shaped areas, expressed in the formation of new structures such as rock fracturing and fracturing, play an important role in the formation of ore bodies and the localization of endogenous mineralization. On the other hand, it should be noted that when modeling stresses in the structures of the Daugyztau ore field, the formation of a zone of opening along the edges of the northeastern and Daugyztau faults is typical for this wedge-shaped area of the block. In nature, these zones serve as channels for the circulation of hot fluid ore-bearing solutions. The zone of opening along the fault edges could serve as such a channel, as the Daugyztau deposit is spatially associated with this zone. A similar structural position is also observed in the Asaukak deposit.

An increase in permeability is one of the main factors promoting the circulation of ore-bearing solutions from the depths of the Earth and, under certain physical and chemical conditions, the precipitation of chemical elements from them, forming a mineral deposit. With multidirectional displacement of sections of tectonic blocks, favorable permeable zones can form in the central parts of the blocks. Thus, the geodynamics of Daugyztau during the ore development period are based on horizontal movements and tectonic stress. The Amantaytau deposit, like Daugyztau and Asaukak, is controlled by a wedge-shaped structure, but its position is determined not by the junction zone of faults but by a zone of local extensional deformation formed in the center of the wedge-shaped structures.
Block 7, the smallest in terms of area, is located in the southeastern part of the ore field. It differs from other blocks in terms of its morphology (triangle shape) and geodynamic setting. Its geodynamic setting during the period of ore formation is characterized by the activity of all its boundary faults, although this activity is local. Along the Daugyztaus fault, in its northern section, slight movement is observed. A displacement in the southern direction is observed along the western edge of the fault, while a displacement in the northern direction is observed along the eastern edge.
is observed along the opposite edge of the fault. Local movements directed against each other, identified in the section on morphological changes of the fault, concentrate tangential stresses and enhance rock deformation along the western edge of the Daugyztaus structure. The northeastern and sub latitudinal boundary faults exhibit a reverse pattern. Here, the activity of the faults is directed from their center toward their junction with the Daugyztaus rupture. These phenomena have led to the formation of local extensional deformation zones within Block 7. Based on the migration and concentration of tangential stresses, as well as changes in deformation, Block 7 can be divided into two parts that move in opposite directions relative to each other: the eastern part, associated with the Daugyztaus fault, moves in the northeast direction, while the western part moves in the southwest direction. Under such geodynamics, theoretically, northwest-oriented extension fractures should be formed in the local extensional deformation zones. In the natural analog of this block, a system of northwest-oriented faults is observed, which controlled the gold-silver mineralization bodies of the Vysokovoltnoye deposit. Another reason that could have led to the formation of northwest-oriented ore-controlling faults in Block 7 is the boundary fault of structural-formational zones, which runs along the south of Beltau, delimiting it. This fault separates the Zeravshan-Turkestan structural-formational zone from the Zeravshan-Alai zone, specifically the Central Kyzylkum subzone that includes Beltau, from the Zeravshan subzone (A.K. Bukharin, 1985). This major provinceal structure was in an active phase of development during the ore formation process, as indicated by the formation of northwest-oriented ore-controlling structures in the Auminzatay deposit.

5 Conclusions

In general, the geodynamic setting of the Beltau Mountains (Daugyztaus ore field) during the ore-forming period was determined by the influence of external provincial tectonic forces. The internal geodynamic setting of the Beltau Mountains, and consequently the Daugyztaus ore field, was determined not only by the influence of external forces but also by their structural-tectonic framework. The key tectonic elements in this framework are the northeastern, latitudinal, and sub-latitudinal faults and blocks, which were activated under the influence of provincial tectonic forces. They created structural positions favorable for the formation of gold deposits and ore occurrences and the localization of endogenous gold mineralization within them.

References


