

FEATURES OF FORMATION AND PLACEMENT REGULARITY OF GOLD MINERALIZATION AT PISTALI DEPOSIT (UZBEKISTAN)

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ABSTRACT

The article presents the results of studies on the characteristics of formation and placement of gold mineralization at Pistali deposit. As a result of geological and structural studies, analysis of the distribution of gold in various positions in the established patterns of placement of gold mineralization.

Keywords: *Gold Mineralization, Ore Bodies, Features of Formation, Placement Regularity, PISTALI Deposit, Geological and Structural Analysis, Deformation Plan*

INTRODUCTION

Gold is one of the strategic minerals of Uzbekistan. Uzbekistan is one of the main producers of gold and is one of the top ten countries in the world (Mineral Commodity Summaries, minerals.usgs.gov) in explored reserves of metal. In the republic there are about a hundred gold deposits, from small to the world-class giant as a Muruntau.

The study of the patterns of placement of gold mineralization is important for prospecting, in particular, the geological and structural features of formation of gold mineralization give an idea of the prospects of gold deposits and are very urgent. The results obtained on the patterns of placement of gold mineralization can be used at other sites with similar geological positions.

MATERIALS AND METHODS

The method of studying the placement regularity and geological and structural features of the formation of gold mineralization includes a complex of field geological, special structural-tectonic (establishing existing deformation plans based on the kinematics of faults and striations of folded disturbances, followed by identification of positions favorable for ore formation) and laboratory studies.

Study area

Pistali deposit is located in the western part of the North Nuratau Ridge (Uzbekistan), which in geotectonic terms refers to the Kyzylkum middle massif, to its eastern flank (Ahmedov et al. 2001).

Metamorphosed sedimentary rocks of Taskazgan suite of Upper Proterozoic (PR₂ts) take part in geological setting of the deposit and represented by micaceous-quartz and muscovite-sericite slate, meta-gravolites, meta-sandstone and quartzite (Stratigraphic Dictionary of Uzbekistan, 2001). Metamorphosed-sedimentary rocks are broken by diorite porphyritic, granodiorite porphyritic dikes, pistali quartz syenite-diorite stock of Kattaich complex (Fig. 1).

In structural terms, Pistali deposit is confined to the western periclinal closure of Yambash-Ustuskiy brachyanticline with a length of 70 km and a width of up to 15 km. The azimuth of the strike of the anticline axis is 280-290°, the immersion angle of the hinge is 10°-30°. The core of the brachyanticline is composed of Taskazgan suite rocks, and the southern wing – rocks of Besapan suite. The rocks are metamorphosed at the level of the greenschist facies and partially epidote-amphibolite facies in the form of separate horizons of green quartz-albite-chlorite, albite-clinozoisite-chlorite-amphibole (metabasalts) and crystalline schists.

The fault tectonics in the area are mainly represented by longitudinal faults with a strike of 290-300°, largely healed by lamprophyre dykes and quartz veins. Part of the gaps is accompanied by metasomatic changes in the rocks with interspersed sulfide mineralization. Diagonal shear breaks are also noted.

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RESULTS AND DISCUSSION

A series of contiguous subparallel ore deposits with industrial mineralization of gold of vein-impregnated type was identified at Pistali deposit in the mineralized zones of metasomatically altered metaterrigenous rocks. According to the conditions of formation, it refers to the hydrothermal gold deposits, gold-sulfide-quartz geological-industrial type, poor-low-sulfide pyrite-arsenopyrite with native gold mineral type.

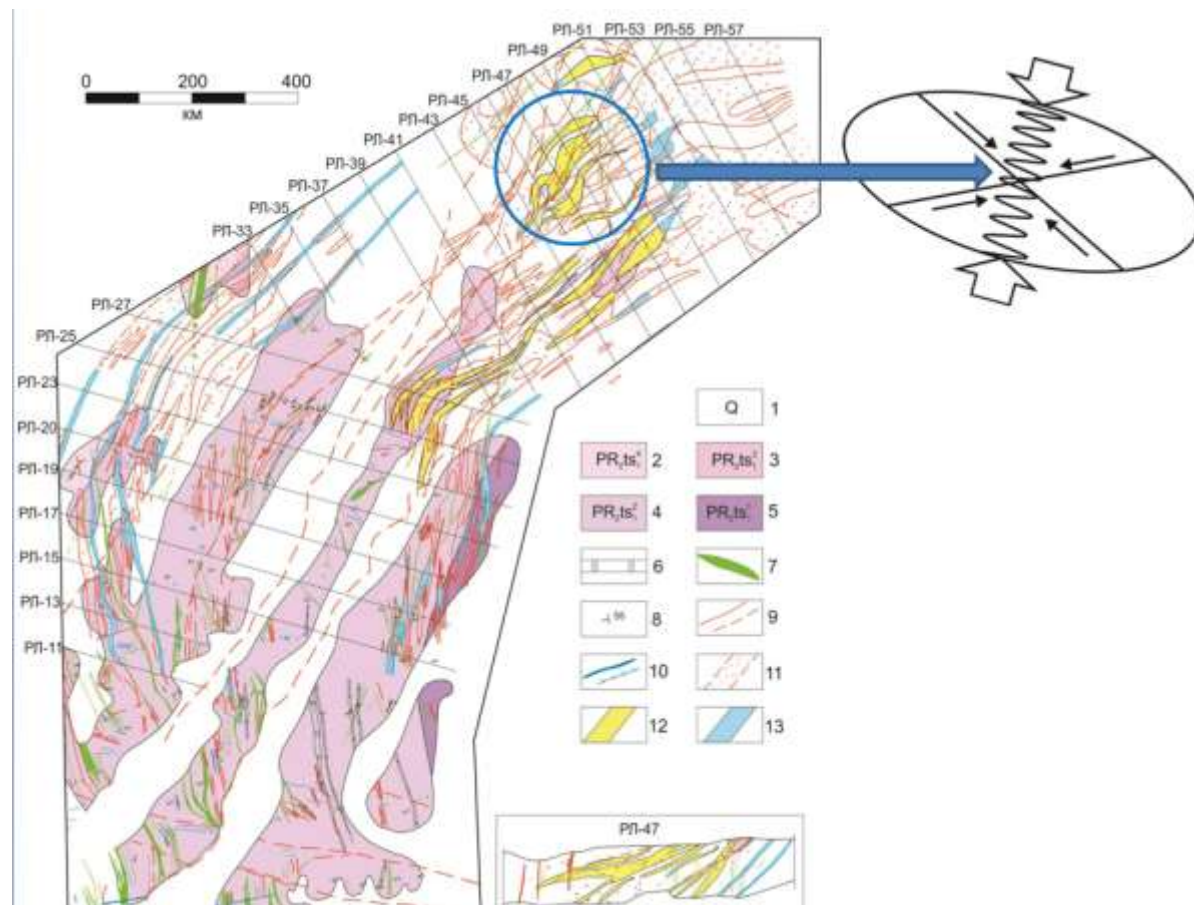


Figure 1: Schematic geological map, section and deformation plan (North-Northeast) of Pistali deposit. 1 - Quaternary deposits; 2 - pack No 4. Carbonaceous-quartzitic-siliceous. Quartz-micaceous carbonaceous batters, metaalevolrites, metacrystalline quartzites; 3 - pack No 3. Meta-siltstone, meta sandstones, quartz-mica schists; 4 - pack No 2. Carbon-bearing slates, quartz-mica meta-siltstone, quartzite-type meta sandstone; 5 - pack No 1. Meta siltstone, meta sandstones, quartz-mica schists, bodies of metacrystalline quartzites; 6 - traced horizons; 7 - lamprophyroid diorite porphyrites; 8 - elements of occurrence of rocks and faults; 9 - faults: a) established; b) the alleged; 10 - a) quartz veins; b) veinlet silification; 11 - layered metasomatites of biotite-quartz-muscovite composition with arsenopyrite; 12 - ore deposits in the zones of metasomatites, opened by coring wells, pits, clearing with the boundaries of reserves; 13 - gold-bearing zones, opened with coreless and single coring wells, partially cleared.

Two conjugate mineral-morphological types of mineralization are distinguished - ore deposits with streaky-interspersed gold-sulphide mineralization in metasomatites and gentle gold-bearing metamorphogenic quartz veins and veinlets. Quartz veins have an insignificant thickness of up to 0.5 m and a length of up to 5-10 m. They are found both in ore deposits and in host rocks, forming local

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manifestations in the form of lenses and nests with visible native gold with a content of up to 100 s/u and more. They do not detect patterns in their placement and have no independent practical significance.

The mineralized zones are represented as wide (up to 100-150 m) bands of metaterrigenous rocks with no clearly defined boundaries, in which metasomatites with ore mineralization and without it, poorly mineralized and barrenless metaterrigenous rocks are placed without a specific sequence. The outer boundaries of the modified terrigenous rocks are not established, since the field is undeserted and its boundaries are not defined.

Ore bed identified in the mineralized zones are metasomatically modified metaterrigenous rocks and do not have geological contours. They are contoured only by the results of analyzing on-board gold content. All of them are identical in terms of location, material composition and distribution of ore mineralization. They are located in the area of the periclinal closure of a submersible on the NW (300°) at an angle of 15-30° Yambash-Ustuksky brachyanticline, in connection with which they have a wavy arched bedding in the plan, complicated by post-rupture tectonics.

The geological structures enclosing the mineralization are consonant zones of tectonization and intensive schistosity, mostly hollow in the core of brachyanticline in the Taskazgan Formation. Their formation took place under conditions of regional compression on the initially crumpled rocks, as evidenced by fragments of schistated microglades installed in the mine workings and core of boreholes. The schistrous terrigenous rocks permeable to deep hydrotherms were compacted due to the introduction of petrogenic and ore-generating elements and recrystallization of the matrix, and therefore their boundaries with the lateral rocks are visually unclear.

In some cases, the boundaries of the deposits coincide with the contacts of metasomatites and lateral low-mineralized or barren rocks, in others, the lateral rocks are partially captured, in the third they are carried out directly in the metasomatite zone, which indicates a later gold formation in sulfas mineralization.

The deposits consist of aposlate, aposiltstone, and aposiltysandstone metasomatites of albite-quartz-muscovite-sericite composition and less modified lithological varieties of rocks, as well as post-ore dykes of diorite porphyrites. In addition to ore metasomatites, metasomatite bands parallel to them with a thickness of 1–2 m to 10 m are noted, in which gold is recorded in single detached samples.

In all ore beds, secant steeply dipping submeridional dykes of diorite porphyrites with a thickness of 0.5 to 10 m were recorded. They were discovered in ore sections with gold content from 0.2 s/u to 1.4 s/u. Gold is not typical of these post-fracture intrusions, and its presence is associated with rare quartz veins and veins of the later hydrothermal stage with diffused mineralization.

The morphology of ore deposits is lenticular-tabular, with bulges and pinchings. The deposits often break up along the strike and fall into the constituent ore parts separated by layers of barren rocks that characterize the non-uniform permeability of the mineralized zones.

In the oxidation zone, gold-bearing formations are visually distinguished by a variegated appearance and increased fracturing due to the oxidation of sulfides and carbonaceous matter. Primary ores are more massive and are somewhat lightened by metasomatic sericite and muscovite against the background of dark gray carbonaceous side rocks.

The main criterion of potential gold-bearing is metasomatites with impregnation of pyrite and arsenopyrite. Pyrite refers to passing typomorphic minerals and is present in all zones of altered rocks, including barren ones. Arsenopyrite, as a rule, is found in ore beds and has a positive geochemical correlation with gold.

Genesis and age of gold mineralization

The features of geological structure of Pistali deposit let to determine relative sequence of the main stages of its formation.

The geological features include:

- the deposit is located in the metaterrigenous Upper Proterozoic rocks of the lower sub-suite of the Taskazgan Formation, metamorphosed at the level of the greenschist facies. The rocks of the lower sub-suites are represented by albite-porphyroblastic micaceous-quartz, crystalline muscovite-feldspar-quartz

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schists and quartzite-like and greisenized rocks of the epidote-amphibolite facies of metamorphism of the upper sub-suite, which indicates the polyfacial zonality of regional metamorphism. The rocks of the epidote-amphibolite facies in relation to gold mineralization are barren;

- directly at the western and northern borders of the deposit, according to a gravity magnetic survey of 1:50000 scale, passes the contour of the hidden Kulkudusky granitoid massif with 110 km² are;
- the field and its flanks are confined to the end-tectonized part of the periclinal closure of the large Yambash-Ustusky brachyanticline, which is gently sinking towards the Kulkudusky massif;
- the metasomatic transformation of the source rocks and the placement of impregnated gold mineralization is controlled by gently sloping (10-30°) zones of intensive schistose as zones of increased permeability;
- fragments of primary isoclinal folding and tangling rocks of Taskagan suite are marked;
- morphologically, the deposit refers to the type of mineralized zones, within which ore deposits have been identified by testing, repeating the occurrence of enclosing rocks in horizontal plans and sections;
- in the ore deposits, anisotropy is characteristic in the metasomatic transformation of rocks and the placement of gold and sulphides in terms of schistosity;
- relatively great tolerance of mineralization, simple mineral composition and the presence of a weakly expressed stages of mineral formation;
- large thickness of ore beds and low gold content;
- in the ore deposits, a very small amount is characteristic according to the underlying quartz vein (up to 5-10%);
- not all igneous formations (lamprophyres, diorite porphyrites, syenite-diorites) intersect ore deposits;
- Often there are manifestations of latitudinal steeply dipping scattered veins and veinlets with gold, dissecting ore deposits, sediment-metamorphosed rocks and igneous formations.

Taking into account the above factors, the formation of the Pistali deposit is as follows.

In the Proterozoic and Early Paleozoic, under the restorative conditions of the ocean basin in a stable tectonic setting, almost devoid of volcanic activity, there was an accumulation of powerful well sorted sedimentary strata of the Taskazgan and Besapan suites.

In the initial stage of the Caledonian tectogenesis, with a progressive increase in temperature and pressure, a metamorphic reorganization of terrigenous rocks begins, followed by the formation of complex depth folding. In the late-folded stage of deformation, the formation of nodules, scaly thrusts and shear zones occurs, which subsequently play the role of ore-bearing structures.

Magmatic activity of a huge scale led to the formation of large granitoid massifs in different depths in the Precambrian terrigenous strata.

In parallel with the formation of granitoids against the background of complex isoclinal folding, the formation of a large open Yambash-Ustusky brachyanticline, the formation of which is not due to tectonic processes, but the formation of autochthonous granitoids in its core.

In the ore stage in the western part of the North Nuratau Ridge, in the Proterozoic carbon-terrigenous sequence of the Taskazgan Suite at great depths (3-5 km), multi-tiered zones of mineralization, structurally controlled by gentle areas of intensive schistosity, took place for a long time (10-20 mln. years). The vertical range of ore formation reached 1.5-2 km.

The main amount of gold was introduced by hydrothermal solutions from the deep high-temperature zones of metamorphism and granitization. In addition besides gold water, carbon dioxide, sulfur, and calcium were supplied in sufficient quantities, and calcium-containing carbon-sulphurous hydrotherms were formed as a result, leading to intense metasomatism of carbon-terrigenous rocks at the sites of their discharge, accompanied by the deposition of sulphides and gold. In this sense, the ore-localizing zones of increased fracturing can be considered as drainage structures for hydrotherms that captured significant volumes of terrigenous rocks, especially in metamorphic domes above granitization sites.

Ore-generating processes of high-temperature regional metamorphism and granitization were probably controlled by longitudinal deep faults from the north and south of the present-day ridge.

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Interspersed poor-sulphide mineralization of the Pistali deposit, by the combination of these factors, belongs to the hydrothermal genesis.

The analogs of the Pistali deposit are the gold deposits of the Central KyzylKum, regardless of the scale of their mineralization.

Patterns of gold mineralization

Structurally, the deposit is confined to the nuclear part of the Yambash-Ustusky brachyanticline. Immersion of the anticline hinge along $\text{az. } 290\text{--}300^\circ$ with an angle of inclination from 10° to 30° . The occurrence of rocks in the core of the fold has angles of incidence from 20 to 70° , often with tilting elements. The folds of the wings are complicated by numerous small folds with gentle hinges. The axial planes of the small folds are inclined in the direction opposite to the inclination of the lamination - schistosity. The stretch of the axial planes of small folds is sustained over the entire area, is $330\text{--}340^\circ$, and is fixed by hatching on the planes of shale. The position of these folds probably determines the configuration of the ore deposits.

Bursting violations. The most recent longitudinal structures are more clearly fixed. Morphologically, these are steeply dipping faults. The zones of these faults are expressed by milonitization, silicification, sometimes healed by quartz veins.

The largest longitudinal faults in the area include the zone of the North-Nurata deep fault and its virgations, passing along the northern foot of the ridge and exciting cover of the young platform. The surfaces of fault mixers are inclined to the south and south-west at angles of $60\text{--}80^\circ$. Fault zones are clearly expressed by milonitization, brecciation, and significant ironing. These structures are developed in the northern part of the field.

Within the limits of the deposit, faults are fixed, the longitudinal axes of the brachyanticline with a strike of $275\text{--}290$. By character - this is the right shift with an amplitude offset from the first meters to $100\text{--}150\text{m}$. The power of fault zones from a fraction of a meter to $10\text{--}15\text{m}$. Likely elements of thrust component. The slope of the displacement plane is steep towards the southwest ($70\text{--}80^\circ$). The faults are represented by the zones of crushing, ironing, and schistosity, less silicification.

Clearances are used to establish faults and splintering zones of the submeridional-northeast strike (dip azimuth $280\text{--}300^\circ \angle 70\text{--}30^\circ$), as well as diagonal gaps - of the northeastern and northwestern direction, which also have a shear character. Moreover, the faults of the northwestern direction are right shifts, and the northeastern faults are left (signs of a submeridional deformation plan).

The longest faults are submeridional - northeast direction. They are expressed by cataclysm, crushing, milonitization, carbonation, areas are accompanied by quartz veins. As a rule, faults of this direction develop along dikes of diorite porphyrites, lamprophyres (most likely these are submeridional separation structures with the same plane of deformation). In general, the direction of faults is consistent with the orientation of the overall structure. They are traced through the entire area of the field, stretching them from the submeridional in the south to the northeast in the north. Fault zones mainly to the west and north-west. Occurrence from $\text{az. pad. } 270\text{--}280^\circ$ in the south to $300\text{--}315^\circ$ and $330\text{--}340^\circ$ in the north.

Branches of the north-east strike are marked with a fall of dip azimuth $320 \angle 60\text{--}70^\circ$ (strike $30\text{--}60^\circ$). The power of faults from the first tens of cm to $2\text{--}3$ and 5m .

Numerous shallow cracks and dynamo metamorphism zones have been established, consistent with the orientation of foliation of the host rocks, coinciding with the zones of mineralization and determining their boundaries. Sometimes accompanied by silicification zones. On the area of the deposit, systems of splitting cracks of various directions are recorded: 1) sublatitudinal (dip azimuth $160\text{--}210^\circ$), 2) northwest (dip azimuth $210\text{--}250^\circ$), 3) submeridional (dip azimuth $250\text{--}300^\circ$) and 4) northeast (dip azimuth $115\text{--}165^\circ$). Quartz veinlets bearing ore mineralization are connected with the cracks of the first and second groups. In general, cracks and ruptures of the submeridional direction prevail. Thus, based on the study, we can draw the following conclusions.

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CONCLUSION

The ore-bearing rocks of the Pistali deposit in the south have a submeridional strike that passes north to the northeast. The arc structure in the west of the deposit plays an important role on ore localization. This structure is associated with elevated gold contents and increased thickness of mineralized zones.

Fractures in the south of the Pistali deposit have a prevailing submeridional strike, as well as to a lesser extent, sublatitudinal, northwestern and northeastern. Quartz veins and veinlets have sublatitudinal, submeridional strikes that coincide with the directions of discontinuous violations.

In the central and northern parts, the faults are mainly of the northeast strike and less frequently the submeridional ore-cutting.

Ore beds in the central and northern parts of the deposit have a northeast strike, complicated in the places of inflection of ore-bearing rocks. In this position (the castle part of the fold), the ore deposits are split and have a horsetail type.

In the northern part, the ore deposits are associated with combinations of faults of the northeastern and submeridional directions (and figurative structure in the plan). The concentration of ore deposits is confined to sharp corners and shaped structure. An increase in the thickness of the ore deposits is observed at the interface points of the submeridional and northeast faults. The available facts of displacement along the faults in the eastern, central parts with the right shift indicate the existence of a north-northeast deformation plan in the conditions of which ore deposits were formed. The increase in thickness of the ore bodies is associated with cracked facetways.

Thus, the ore deposits and mineralized zones are associated with northeastern faults, and an increase in the contents and capacities is noted in the pull end of the brachyanticline and in the junctions of the meridional and northeast faults (Fig. 1).

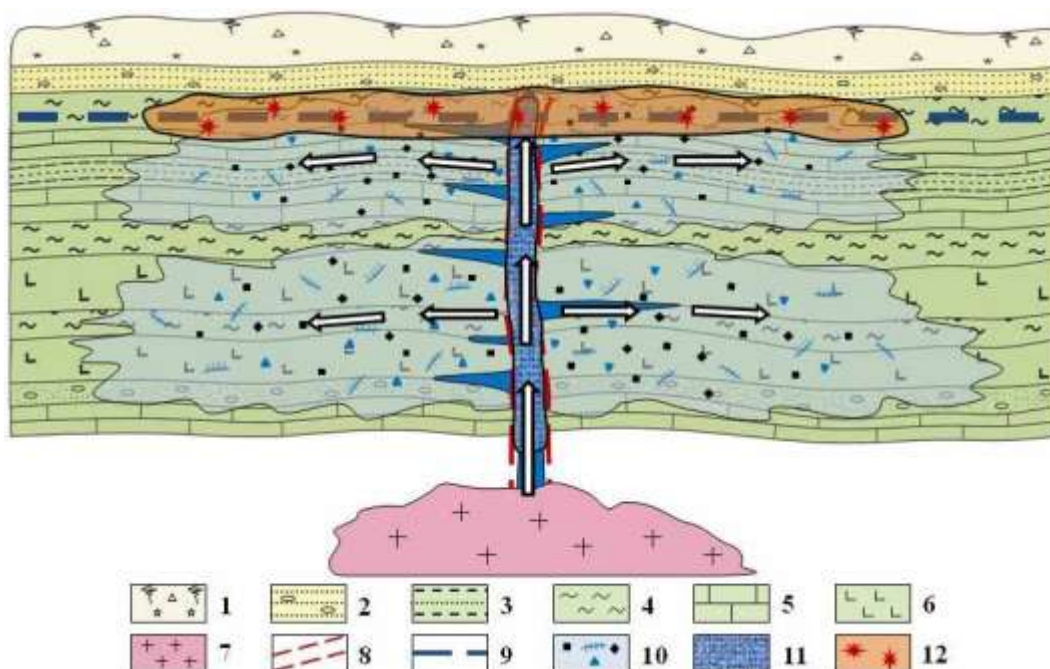


Figure 2: Scheme of gold mineralization formation at the Pistali deposit .1 - sediments; 2 - sandstone, gravel; 3 – silty-sandstones; 4 - slates; 5 - limestone; 6 - andesites; 7 - leucocratic granites; 8 - ore bearing fracture; 9 - groundwater level; 10 - gold-bearing metasomatite; 11 - quartz veins with precious gold; 12 - oxidized ores.

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Based on the analysis of the patterns of gold mineralization, taking into account genetic ideas, a scheme for the formation of gold mineralization at the Pistali deposit has been developed, which has a similar character to the gold deposits of the Central KyzylKum region (Fig. 2).

The initial potentially ore-bearing rocks are subject to tectonic disturbances, through which hydrothermal ore-bearing solutions, which have a predominantly aluminosilicate composition, have penetrated. As a result of the interaction of hydrothermal solutions with host rocks, metasomatites containing gold were formed. The deposition of gold in the host rocks was accompanied by metasomatic and small-leaved silicification associated with the introduction of hydrothermal solutions. Different subtypes differ in silica, quartz and gold content.

The formation of ore is associated with the following conditions and sequential processes: 1) the presence of a variegated in lithological composition section of the stratum (terrigenous, carbonate and volcanogenic rocks); 2) the presence of the ore-bearing fault, through which hydrothermal solutions penetrated; 3) hydrothermal development of host rocks with the formation of metasomatites with gold, 4) formation of a quartz-type fracture with gold in the zone of fracture; 5) formation of oxidized ores in the hypergenesis zone (Figure 2).

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