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Geological Setting Of The New Discovering Gadir Low Sulfidation Epithermal Deposit, Gedabek Ore District, Lesser Caucasus, Azerbaijan

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Abstract Gadir deposit is located in the East of Yogundag, near Gedabek deposit, also, Shamkir uplift of the Lok-Karabakh structural-formation zone in the Lesser Caucasus Mega-anticlinorium. The deposit has complicated geological structure, and consists of different old and different composite intrusive bulks and fracture structure consisted of complicated with Middle and Upper Jurassic sediments. A structural position of Yogundag area (also, Gadir) predetermined a set of magmatic complexes and a character of magmatism occurrence for Gedabek-Bittibulag deeper fault direction as a whole including the investigated area where are widely developed a set of volcano-pluton formations and volcanism of central character. Gadir was first suggested as a low sulfidation epithermal deposit type by Gedabek Exploration Geologists (2014) following field work and geological interpretation. The Gadir deposit is belong to Pb-Zn-Cu-Ag-Au vein deposit which is characteristic to Low-Sulfidation epithermal deposit. The main ore minerals are sulfides. Sulfides consist of pyrite, sphalerite, galena, and trace amounts of chalcopyrite.

Keywords Epithermal Deposit, Low Sulfidation, Gadir, Gedabek, Azerbaijan

1. Introduction

The Gedabek high sulfidation epithermal deposit is one of the main producing mining of the Gedabek ore district Azerbaijan, and is the largest porphyry-epithermal ore field of the country. It belongs to the Lesser Caucasus, located in the central part of the Tethys metallogenic belt. It is emplaced within the Jurassic-Cretaceous Lok-Karabakh magmatic arc, resulting from the subduction of the Tethys Ocean along the Eurasian margin [1].

The Yogundag epithermal system in southern of Gedabek ore district has been explored for epithermal ore perspective areas due to its favorable geological setting for this type of deposit. In the result of exploration activities there were discovered several new local epithermal areas, one of which has underground mining, named Gadir low sulfidation deposit (by GEG, 2012) [2].

2. Gadir low sulfidation epithermal deposit

The NW Flank of Gedabek Mine is located in the Yogundag Mountain area. Yogundag it with respect to tectonics and metallogenic is confined to Gedabek volcano-plutonic structure of Shamkir uplift of Lok-Karabakh structure-formation, Lesser Caucasus metallogenic zone. The ore perspective areas, also Gadir low sulfidation epithermal deposit (Gadir lsed) is embedded in cone-shaped Mountain Yogundag at elevation 2085m [4].

2.1. Location and history

Gadir deposit is located in the East of Yogundag, near Gedabek deposit, also, Shamkir uplift of the Lok-Karabakh structural-formation zone in the Lesser Caucasus Mega-anticlinorium. The Gadir underground mine area is licensed as a 20.8 ha open-field site near the North-West flank Gedabek Mine, located approximately 400 m from mine, in a mountainous area known as Yogundag.

While carrying out geological exploration works in the NorthWest flank of Gedabek Mine, Gedabek Exploration Group (GEG) and geological consultant Allahverdi Agakishiyev discovered the Gadir low sulfidation deposit in 2012. Here are the probably outcrop of quartz porphyry subvolcanic formation was considered as the main factor, also observed intensive silicification alteration on surface. In the aim of discovering the ore formation in contact part of this rhyolite-dacite subvolcanic body was drilled AIMCDD86 drillhole in 2012. During geological-structural mapping, it has been defined Gadir Horst structure [7].

2.2. Reginal geological setting

The Gadir Area has a complex geological structure, and it has become complex with the intrusive masses and breaking structures of different ages and different composition. Lower Bajocian is essentially composed of an uneven succession of diabase and andesite covers, agglomerate tuffs, tuff-gravelites and siltstones. Tuffs of the Lower Bajocian were exposed to strongly metamorphism (hornfelsed) as a result of the impact of Upper Bajocian volcanism and intrusives of Upper Jurassic age. Rocks related to the Bathonian stage have developed mainly in the top of Yogundag.

The following folded structures were described by numerous researchers within the bounds of NW Flank of the Gedabek Mine: Arykhdam-Shekarbek anticline and Godekdere-Yenikend syncline [5].

Arykhdam-Shekarbek anticline fold axis is observed from a confluence of rivers Gedabekchay and Shamkhirchay, passes across village Arykhdam and stretches in a northwest direction to village Shekarbek. In a structure core are cropped out effusive and effusive-pyroclastic sediments of Lower Bajocian substage being overlapped by vulcanites of Upper Bajocian Substage on extrusive. In the southeast of a central part of fold was irrupted Gedabek granitoid massif. In its northwest plunge among Lower and Upper Bajocian vulcanites are observed numerous subvolcanic bodies morphologically represented by compound stock-like and dyke forms.

Godekdere-Yenikend syncline is traced from northwest of village Godekdere across villages Gozgaraly, Saryhesenli to an east edge of village Yenikend. At the NW Flank of the Gedabek Mine, along on Yogundag Mountain it is shaded by a like volcanic structure. The syncline is composed of volcanogenic, volcanogenic-sedimentary of Bathonian Stage. The fold structure is gentle-symmetric with a rock dip on limbs at an angle 10-15° [6].

There are 3 groups of fault zones on the basis of strike direction and morphological characteristics: 1) faults-dislocations in north-west direction (Gedabek-Bittibulag deeper fault, Misdag ore-controlling fault). 2) faults in north-east, submeridional direction and reverse faults (Gedabek-Ertepe, Gerger-Arykhdam, Gadir ore-controlling faults); 3) transverse faults (local fault).

2.3. Local geological setting

Gadir low sulfidation epithermal deposit is located in the area East side of Yogundag Area. Gadir deposit has complicated geological structure, and consists of different old and different composite intrusive bulks and fracture structure consisted of complicated with Middle and Upper Jurassic sediments (see Fig.1).

Geological structure and conditions of the NW Flank of Gedabek Mine formation are briefly given below. The NW Flank of Gedabek Mine is composed of:

Volcanogenic rocks of Lower Bajocian. On the studied mapping area Lower Bajocian volcanogenic rocks (or sediments) are widely developed and stretch from South-East of Yogundag area (Gedabek deposit) to the center and North-East directions to Zefer area.

The lower horizons of the sediments for this substage aren’t outcropped on the investigated area. The sediments of Lower Bajocian Substage in Gedabek deposit and NW Flank are represented (from bottom to top) by:

1. Andesite-basalts and andesite porphyrites with low-thick interlayers of thin fragmental crystalline-lithoclastic tuffs of andesites. The exposure thickness is 119m. Mantle alternation of andesites, andesite and andesite-basalt porphyrites with packets of medium- and thick-layered fine- and medium-fragmental tuffs with diabase mantle in a basis.
2. Mantles of diabases and diabase porphyrites. The thickness is 8.0m. The total thickness of Lower Bajocian formations is more than 147m.

Upper Bajocian volcanogenic rocks. These rocks represented by rhyolite-dacite lava facie and rhyolite subvolcanic rocks. The rocks of this substage on an investigated area are widely developed and traced from the southeast (Gadir Gallery area) to the centre (east contact of Gedabek Hydrothermal Eruption Breccia Pipe) and northeast directions to Mubariz Area. In the northwest of Mubariz area observed outcrop of AC rhyolite-dacite subvolcanic facie.

In tectonic condition they are confined to a block of Arykhdam anticline bounded from northeast and southwest by Gedabek-Bittibulag and Gedabek-Shekarbek faults respectively that are composed of magma-incurrent and ore-incurrent canals of Upper Bajocian volcanism.

Bathonian volcanogenic rocks. On sediments of Upper Bajocian Substage are transgressively occurred formations of Bathonian stage represented by an alternation of fine- and thin-layered, ashy and agglomerated tuffs with rare interlayers of andesitic-porphyritic breccia and andesitic-dacitic lavas.

Their thickness is various and by the data of the GEG comes to 160-180 m within the bounds of the prospecting area.

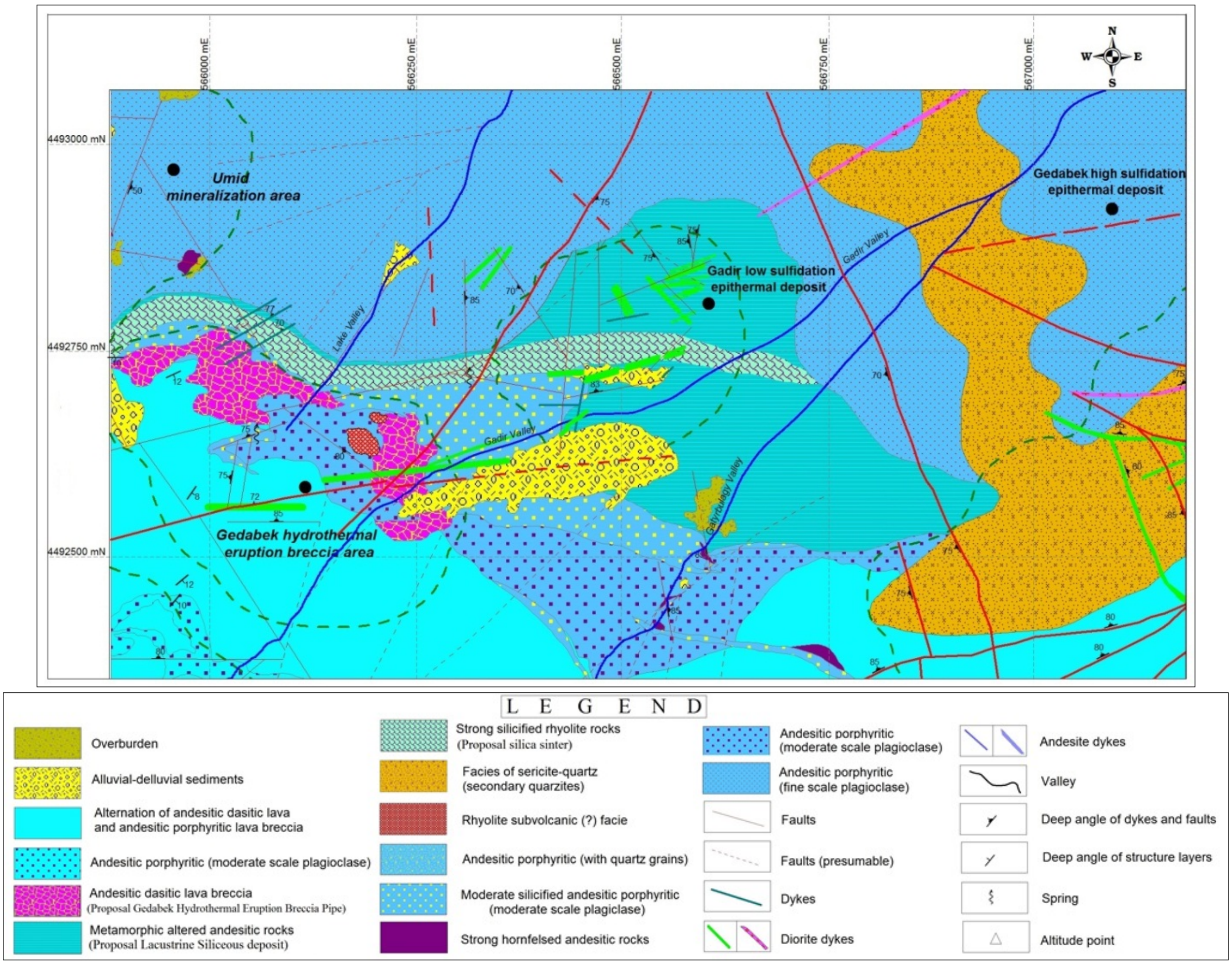

Figure 1. Lithological-structural map of the Gadir low sulfidation epithermal deposit

Metamorphic rocks. Within the bounds of the prospecting area are widely developed different facies of contact-metamorphic and hydrothermal-metasomatic rocks. Contact-metamorphic rocks are represented by hornfelses and silicified andesite rocks.

Hornfels have been formed due to enclosing intrusions of medium and medium-basal rocks in a zone of contact aureole and they are represented by the following types of facies: albite-epidote-hornblende, hornblende-hornfels and pyroxene-hornfels.

Rocks of high-thermal facies (pyroxene-hornfels) occur in an internal zone of contact aureoles and medium and lower-thermal facies comprise middle and external zones. In the external zone is also observed slightly metamorphosed (corneous) rocks.

Hornfelses and corneous rocks are macroscopically represented by dark, almost black thick fine-grained rocks with typical shelly fracture (see Fig.2).

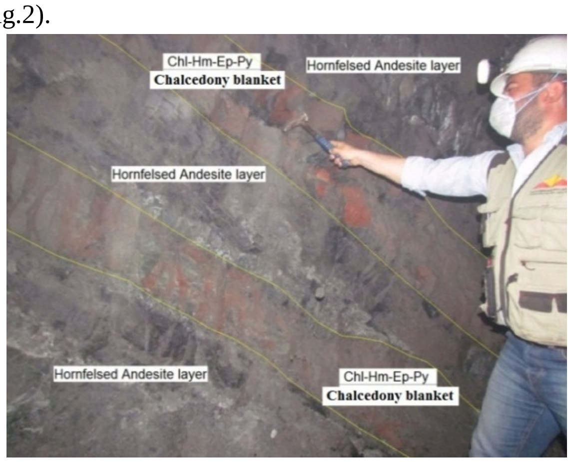

Figure 2. Contact zone: Altered Moderate Hornfelsed Andesite layers with Chalcedony blanket (Chloritic-Hematitezed-Epidote-Pyrite (abbreviation: Chl-Hm-Ep-Py), Gadir Gallery (by Anar Valiyev and etc., 2015)

The rock by mineralogy generally consists of chalcedony blanket, plagioclase, pyroxene, biotite, epidote and magnetite. There are less common amphibole, chlorite, pyrite and etc. The rock is characterized by an outline crenulation of separate crystalline grains and quite often manual location of different minerals that is biotite in most cases.

Silicified andesite rocks are developed in an exocontact band of rhyolite subvolcanic facie.

Diorite and Andesitic Porphyritic dyke: Out of magmatic formations in an ore field are also observed the rocks of Gedabek intrusion which described in chapter "Geological structure of region". The deposit is genetically connected with Gedabek intrusion (its quartz-diorite phase).

Dyke formations within the ore perspective areas bounds are widely developed and represented by early quartz-diorite, microdiorite and late diabase formations. Diabase dykes are mainly developed and generally confined to latitudinal discontinuities. Andesite and microdiorite dykes are less developed and confined to discontinuities of various directions from the North to the North-West.

Quaternary sediments in the prospecting work area are widely spread and represented by Quaternary and Holocene. Quaternary formations are developed outside the prospecting area along the valley beds Umid, Gadir, Mubariz, Gatyrbulagy and etc. where they form series of river terraces. Their thickness comes to 5-25 m. Holocene elluvial-delluvial sediments are developed on the divided parts: the mountain slopes and the river valleys.

They are represented by fine and large acute-angled, sometimes poorly rounded fragments of different rocks, loams and sandy loams that are in most cases overlapped by soil layer. Along the riverbeds and the dry ravines are developed alluvial formations represented by rock debris, fine-fragmental gravel, sandy loam and sand rarely. Their thickness oscillates from 0.5 up to 10m.

The Gedabek hydrothermal eruption breccia pipe (GHEB pipe) is located in the central-eastern part of the Yogundag Mountain around the Gadir low sulfidation deposit. The present shape of the pipe with about 50m diameter resulted from both volcanic and erosional processes. Erosion has reached the deep levels of the pre-pipe stratovolcano at the bottom of the depression and the hills forming the margins of the pipe. Breccia pipe are mostly consist of after Bathonian andesitic lava and tuffaceous rocks. A rhyodacite dome is well preserved in the center of the volcanic structure.

The total thickness of the volcanic pipe is not known exactly. The lower part of the Pipe is drilled (GEGDD 01 & 02) and South part of the pipe consists of submarine dacitic and andesitic lava and tuff of after Bathonian age (see Fig.3).

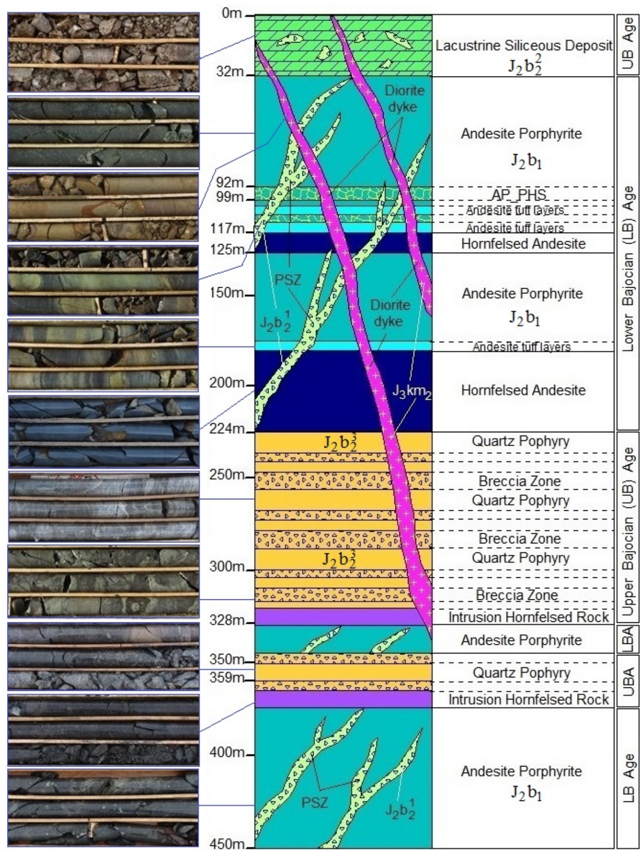

Figure 3. Stratigraphic column and typical core showing multiple hosts for NW Flank of the Gedabek Mine (also, Gadir LSED (by GEG, 2015)).
Abbreviations: PSZ-Propyllitic Silicification Zone; LB-Lower Bajocian; UB-Upper Bajocian

The few meter thick hydrothermal products cover an approximately 1000 m^2 area and bed on andesite lava flow. This hydrothermal environment can be divided into several zones: a white (strong silicified andesitic porphyritic rocks), poorly-sorted and clast-supported breccia occurs in the center. The white color fragments are well rounded and primary hematite (specular and bladed texture, characteristic to GHEB pipe) is located in cement material. The outermost layered siliceous deposit contains 10-20 m thick uneven beds on the surface toward the South-East part of the volcanic structure. The mixed tuff that surrounds the zone of breccia and siliceous layers contains pumice, quartz, glass and andesite fragments and is characterized by argillic alteration, weak silicification (opal) and subordinate presence of alunite. The surrounding and underlying pyroxene andesite is partly altered to smectite (after plagioclase) and hematite-limonite (after mafic minerals). In the western part of the hydrothermal center the zonation cannot be observed due to the recent cover and erosion. The textural, mineralogical and geochemical characteristics suggest that this outcrop represents a paleosurface of a hot spring center in which eruptions occurred during hydrothermal activity. The accumulated breccia was cemented by the precipitations from the outflowing fluids and the layered zones towards the margins represent a transitional zone to a Gedabek Silica Sinter apron.

The adularia-sericite alteration in the subvolcanic facies of the lower andesite represents the deepest level of hydrothermal effects in the Gadir and Umid area. This type of alteration follows N-S and NE-SW directions and envelops quartz veins that are 3-10 cm wide and can be followed up to 1 km length. These subvertical-vertical veins are banded and locally brecciated. Distal alteration zones comprise quartz, chlorite, epidote and pyrite. The veins and their stockwork zones contain minor disseminated pyrite, malachite, hematite, magnetite and secondary Mn-oxy-hydroxides.

Gedabek Silica Sinter. Silica sinter observed around GHEB pipes in the central part of Yogundag Mountain (see Fig.4).

Gadir Silica Sinter forms from discharging alkali chloride hot springs and provide evidence at the surface of a deeper geothermal reservoir. Long after hot spring discharge ceases, sinter textures are preserved and an exploitable geothermal system may remain at depth. Therefore, sinters may be the only evidence at the surface of a hidden geothermal resource. The recognition and mapping of preserved environmentally-significant textures in ancient sinters reveals hot spring paleo-flow conditions and temperature gradient profiles from high temperature vents to low-temperature distal-apron slopes. Sinter dating reveals the timing of discharging hot springs enables the tracking of discharging fluids on a regional scale and identifies sinters that are most likely to be related to a blind geothermal resource. Sinter textural mapping combined with sinter dating, provides a simple tool that assists existing exploration techniques used in the search for hidden geothermal resources [3].

Gadir quartz veins where the ore is settled are general in the most of the epithermal mineralizations. The kind of the hydrothermal activity is easily decided by studying the textures observed within a quartz vein met in the NW Flank. Therefore, the place of this quartz vein in the epithermal system on the paleo-topography can be estimated. It is decided whether the precious metals zone of the vein was cut by the erosion or an ore existence can be expected at depth while there is not any evidence on the surface. As a consequence, the textures of the quartz veins are used as guide in the exploration.

Two major textural groups are recognized on the hand specimens collecting during the field studies in the Yogundag epithermal system:

1) Primary growth textures representing the open-space fillings;

2) Superimposed.

Primary quartz vein textures are classified as buck, comb and banded textures. Superimposed textures are replacement and breccia textures. Quartz textures can be seen in all epithermal settings. These textures can be formed by different quartz species such as quartz, chalcedony, opaline and amethystine. Banded textures of microcrystalline quartz are more dominant at the boiling level or just above. Massive or slightly banded chalcedony exists in the shallow depth. Sinter consisting of amorphous chalcedony is seen at the surface.

In general, the richer part of the epithermal vein in precious metals exists at the banded textures. Whereas, base metal content is in below part. In the deeper parts of the vein is representing by the comb texture.

Gadir lacustrine siliceous deposit. The sedimentary sequences of the lacustrine basin are in East of Gadir outcrop over an approximately 85000 m^2 area. The original size of the basin is not known because it is bordered by normal faults to the west and south. The basin history was reconstructed by GEG (2015) from observations of more than 12 drill holes. The limnic sequence of the basin is cover by a andesite flow related to the intermediate volcanic activity between the fourth and fifth rhyolite tuff unit of the area. The upper parts of the lava beds show shallow subaqueous accumulation with breccia [8].

In the lacustrine sequence, three major consolidated siliceous layers occur. However, there are unconsolidated beds which are composed of uncemented quartz plates 5-20 m size and very little argillic material. The siliceous layers show bedding in which the individual layers have very variable thickness from a few centimeters up to 1-2 meters. The thick siliceous layers also contain interbedded rhyolitic tuff without silicification. This field evidence suggests that the silica was precipitated as very fine mud from the hydrothermal solutions. The color of individual beds varies from white to grey, white, brown and black. The variation of the color from layer to layer is related to the presence of minor mineral particles. Red and brown layers contain fine Fe-oxides, while black layers contain framboids of pyrite and marcasite. These sulfides occasionally correlate with the distribution of organic material. The siliceous beds are generally characterized by high concentrations of Sb, and lesser As and Hg, as well as some Ag (based on assay results of drill holes) [3].

Close to the centers, the thickness of siliceous deposits is up to 10-12 meters, while on the margins they totally pinch out. In feeder zones within the basin, also outlined subaerial hydrothermal centers around the depression. These centers now form small hills with strongly silicified and brecciated rocks.

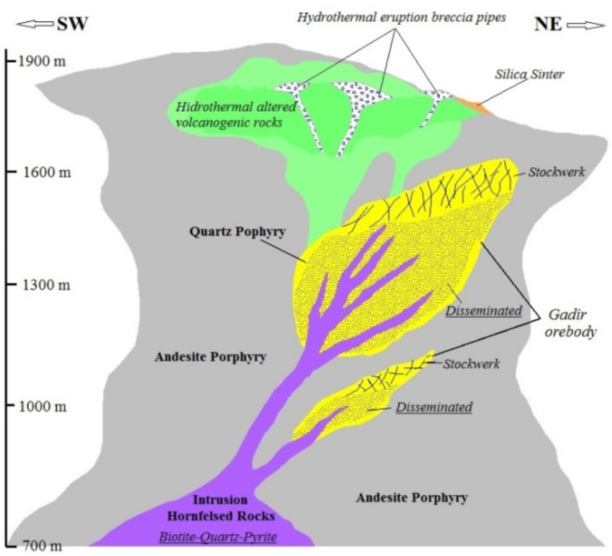

Figure 4. Gadir low sulfidation epithermal 2D model SW-NE direction (by GEG, 2014)

Local structure: In the Gadir LSED area is main three faults types:

1. Gadir pre-mineralization faults;
2. Gadir mineralization bearing faults;
3. Gadir post-mineralization faults.

Gadir mineralization bearing faults.

Gadir deeper (ore-controlling) bearing fault the later concerning the described systems of the faults within the deposit bounds are the sub-latitudinal faults having a northwest strike (270-310°) and a steep dip to the south (80-85°). The thickness of these faults doesn't exceed 50 m. The rocks along these faults are brecciated, slightly schistose and kaolinized.

Gadir parallel bearing fault system passes through north of the previous fault along a north flank of Gadir mineralization area. On a map both faults change a strike from the west (270°) to the northwest (310°), are turned by a concave side to the north towards a subvolcanic body of rhyolite-dacites and have a semi-annular character. Along these fault is observed a vertical displacement of rocks. The north blocks are down about 60-75 m concerning the south blocks. All described systems of the faults are pre-mining and divide the deposit into the separate blocks dislocated along a vertical line at different levels concerning one another and formed a small dome-like elevation. Also several parallel faults of NW Flank have the same situation (strike and deep angle) with Gadir parallel fault [9].

Conlusions

In this study Gedabek exploration geologist have identified many factors (eruption breccia, silica sinter, lacustrine siliceous deposit, quartz vein and veinlets and other) of low sulfidation epithermal type deposits. And other geological-structural information showing us Gadir undergraound deposit type belongs to epithermal low sulfidation.

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