Mineral-petrochemical wallrock alteration of rocks in Bericul gold-ore deposit (Kuznetsk Alatau)

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Abstract. The distribution of mineral associations in near-veined zonal propylite-beresite metasomatic columns of mesothermal Bericul gold-ore deposit was analyzed. However, the polymineral composition in the inner (axial and adjacent with it rear) zones is inconsistent to the existing metasomatic column theoretical model. According to Korzhinskii metasomatic zoning theory, implied monomineral (quartz) and binary-mineral (quartz, sericite) compositions are characteristic of axial and rear zones, respectively. In common with above-mentioned facts, the zoning formation of differential component mobility is influenced by two additional factors: counter diffusion of components from fractured fluids into pores and diffusion mechanism of mass transfer it's from pores fluids into fractured of rock-fluid systems.

1. Introduction

Near-veined zonal metasomatic aureolas involve both beresite and propylite metasomatite formations in mesothermal gold-ore deposits. The inner zones of aureolas are composed of beresites and associated rocks, while outer zones of aureolas are propylites.

There is misunderstanding in defining the mineral composition of the inner zones - axial (ore-bearing quartz veins) and adjacent more outer zone. According to Korzhinskii metasomatic zoning theory [3] and corresponding theoretical model of metasomatic column, the rear zone is composed of quartz-sericite and is termed as beresite. Taking into consideration the previous 50-year observation data [2], the rear zone of naturally-occurring near-veined metasomatic columns are composed of mineral enriched rocks – quartz, sericite, carbonates, pyrite (sulphides). This rock is termed as beresite too. It should be mentioned that this misunderstanding still exists [4, 7, 8].

The investigation of naturally-occurring metasomatic columns could prove how the theory of near-fractured (near-veined) metasomatic zoning responds to the natural process itself, as well as the reasons of above-mentioned misunderstanding.

The research involved the investigation of the wallrock alterations in the mesothermal quartz-veined Bericul gold-ore deposit. Information on the geological structure of this deposit has been imported from [5].

Bericul gold-ore deposit is located in the northern area of Kuznetsk Alatau, 70km. southward from Trans-Siberian railway station Tjazhin (figure 1).

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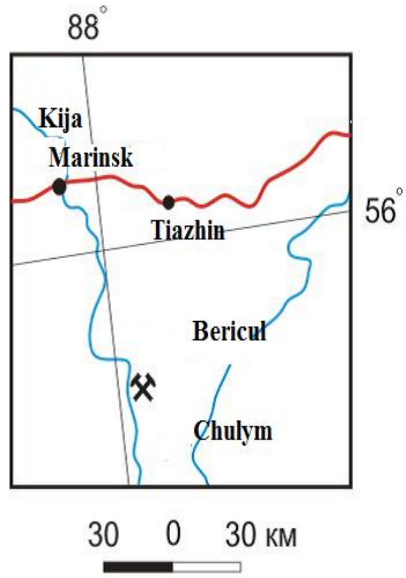

Figure 1. Geographical location of Bericul gold-ore deposit.

According to geology, there are several development stages [1]: oceanic (R_3–$Є_1$), peri-continental (R_3–$Є_1$), island-arc (V–$Є_2^1$), colliding ($Є_2^2$–S), rifting intraplate continental ($D_{1–2}$–K). This deposit developed during the colliding stage ($Є_2^2$–S) and it is 474 Ma.

Bericul deposit parallel with other deposits (Komsomolsk, Kommunar, Central, Fedorovsk and others) is controlled by Kuznetsk Alatau deep-seated faults.

2. Geological structure of Bericul deposit

Bericul deposit is located in the south-western flank of the Bericul syncline. The syncline fold is composed of Belokamen suite mramorized limestones ($Є_1$) and Bericul suite andesite-basalt volcanites ($Є_2$). In the eastern deposit area there is intermediate-mafic intrusive stock which formed the western margin of Dudetsk granitoid pluton in Early Palaeozoic Martayginsk complex. The stock rocks (intrusives) graded slowly to andesite-basalts and basalts in volcanogenic thickness. This factor indicates that gabbroids and dioritoids were formed as a result of magmatic replacement. The contacts between limestone thicknesses including volcanites and the eastern stock boundaries dip towards one another, resulting in preserved volcanites gradually converging N-W, while in depth, as a wedge increasing in width towards S-E. The volcanites in the southern area of the deposit host stock rocks identical to the eastern stock rocks.

Alternating basalt and andesite porphyrites and aphanitic volcanites of similar composition can be found in ore-hosting volcanic thickness. These rocks cut through numerous dykes of acid and mafic rocks.

Basalt porphyrite is composed of the following minerals: augite, labradorite with protobase and hornblende impurities, biotite having porphyritic structure, while there is basic plagioclase in porphyrite segregations. Andesite porphyrites are composed mainly of andesite and hornblende. Dykes of aplite include quartz, potassic feldspar, albite-oligoclase with impurities of apatite, zircon, magnetite and sphene. The pre-ore generation in dolerite dykes involves labradorite, biotite and titanaugite.

The ore bodies are confined to the volcanite thicknesses within quartz-veined ore deposits. There are two types of veins: massive (up to 20 m.) discontinuous shallow-dipping (up to 20°) vein № 4 trending EW was formed in the superimposed bed of the central displacement and submerging southward; steeply-dipping veins (more than 100) underlying vein № 4 with thicknesses ranging from 0.3 to 3 m., submerging NW at an angle of 30...60° and pinching into the contacts of SW limestones with the eastern stock rocks in the NE.

The ores embrace five mineral complexes. The first complex is formed as a result of the two generations of quartz, pyrite and arsenopyrite with impregnated gold, calcite, pyrrhotite, bismuth, bismuthinite emulsion. The second mineral complex is predominately composed of sulphides, zinc, copper, lead, as well as quartz with gold impurities. The third mineral complex includes carbonates intertwined with growths of quartz, arsenide and sulphite-arsenide cobalt and nickel with impurities of gold and other minerals and is located not only in gold-ore veins but also in lateral pre-ore and inter-mineral displacements. The fourth complex embraces predominately calcite and zinc, copper and lead sulphides. The final complex is composed of pure calc spar.

3. Results and discussion

Near-veined alterations in overlying basaltic and andesitic volcanic porphyrites within ore-hosting volcanic thicknesses and in aplite and dolerite dykes were investigated.

Near-veined metasomatic columns [6] with typical mineral zoning formed in all rocks (the following italicized minerals disappear in direction to rear zone).

Frontal zone:	Quartz+ sericite + leucoxene + rutile + magnetite ± pyrite ± calcite + albite ± chlorite± zoisite ± *actinolite* ± *tremolite*
Chlorite zone:	Quartz+ sericite + leucoxene + rutile + magnetite+ pyrite ± calcite ± dolomite + albite ± *chlorite* ± *zoisite* ± *clinozoisite* ± *epidote*
Albite zone:	Quartz+ sericite + leucoxene + rutile + magnetite+ pyrite ± calcite ± dolomite-ankerite ± siderite+ *albite*
Rear zone:	Quartz+ sericite + leucoxene + rutile + magnetite+ pyrite ± calcite ± ankerite ± siderite ± breunnerite

The thickness of the frontal zone extents to hundreds of meters, chlorite zone – tens of meters, albite zone – several meters, while the rear zone (beresite) ranges from 1...1.5 m. The rocks are slightly alternated in the frontal zone. Masses of newly-formed minerals increase towards the rear zone.

The decrease of the number of newly-formed minerals from the frontal to the rear zones, resulting from the dissolution of actinolite-tremolite, epidote (either zoisite or chlorite) and albite within the inner boundaries zones, respectively, is compensated by the formation of new minerals – ankerite, siderite and breunnerite, predominately within the inner zones.

According to the balance calculations, sodium is almost completely disposed (up to 97 wt. %) from the rocks, while silica- only 25wt. % during metasomatism. Beresitization is characterized by the increase of content of potassium-up to 540wt%, carbon dioxide (up to 2000 wt. %) and sulphide sulphur (up to 11705 wt. %). Potassium is captured in sericite, carbon dioxide-in carbonates, sulphur – in sulphides (pyrite).

The described rock hydrothermal alterations during the deposit formation involve factors determining the specific composition of neocrystallisation and the structure (mineral petrochemical zoning order) of near-veined metasomatic columns. The specific mineral composition correlates with the average-low fluid temperature regime during metasomatism. At the same time the specific mineral composition is insignificantly influenced by the wallrock chemical composition as impurities in nonstoichiometric minerals. In this case, the combinations of newly-formed minerals are regularly recurrent in apobasalt, apoandesite, apoaplite and apodolerite metasomatic columns. This dependency is possibly less extensive within the inner zones of the metasomatic columns. The decrease of the number of newly-formed mineral phases from the frontal to rear zones results from the dissolution of actinolite-tremolite, epodite-zoisite, chlorite, albite within the inner zones boundaries, respectively. Differential component mobility could describe this fact. This major factor forms the basis of the metasomatic zoning theory itself [3]. It also provides evidence of the correlation between the described naturally-occurring columns and the Korzhinskii theoretical model. Polymineral composition of the rear zone columns responds to the counter diffusion of components from fractured fluids into pores, which, in its turn, proves the diffusion mechanism of mass transfer into fractured porous, rock-fluid systems [9] and is based on the results of calculation balance of component migration [6]. However, this is inconsistent with the existing theory of quartz-muscovite and mono-quartz composition. The spatial superposition of mineral assemblages deposited as a result of gradual alternating metalliferous fluids in the existing pulsing regime [5] of hydrothermal ore-bearing rock-fluid systems impedes the mineral-petrochemical zoning of the columns.

4. Conclusion

Based on the Bericul deposit investigation results, gold mesothermal deposits are characteristic of potassium-sulfur-carbon dioxide petrochemical profile of near-veined metasomatism, while in all rocks - polymineral composition within the rear (beresite) zone of near-veined metasomatic columns. The latter mineral-petro-chemical zoning sequence could be correlated to the Kucherenko model. This model reflects the structure of naturally-occurring near-ore metasomatic columns, the mineral petrochemical zoning of which is recurrent in rocks of different age and origin, and in hosting metasomatic gold deposits located in mountain-fold structures in southern Siberia [6]. Relationship of newly-formed minerals in all mineral -petrochemical zones of near-veined metasomatic deposit columns is evident. The mineral composition in inner, albite and rear zones is regularly recurrent; whereas, the composition in the rear zone is determined predominately thermodynamic and physico-chemical regimes of metalliferous fluids.

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