Micro- and nanogold in the auriferous of weathering crusts of Martovskoye and Ravninnoye deposits (west Kazakhstan)

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Abstract. Mineral composition of the ores of Martovskoye and Ravninnoye deposits in weathering crusts are studied to prepare them for mining by heap leaching. Microscopic study of ores involving highly precise methods revealed micro-and nano-gold associated with limonite zones. Nanogold is presented in the form of unusual branchy formations. When the deposit will be practiced are possible losses of gold because of the presence micro-sized gold particles on the border with nanoscale. In this connection it is necessary to pay close attention to their presence in the weathering crust.

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Introduction

Small reserves of gold deposits in the weathering crusts with small gold content represent practical interest for mining by heap leaching [1-6]. They are easily available, but not every deposit can be processed in such a way. There is a considerable presence in their composition of montmorillonite, minerals of copper, carbonates, which can be the major obstacle. The mineral composition of ores of the Martovskoye and Ravninnoye deposits were studied for this purpose.

Research

The Martovskoye deposit is located 14 km northwest of the Zholymbet deposit, in the southern part of the Aksu-Zholymbetsky metallogenic zone. The deposit area is covered by Cainozoic layers of clays and loams, with thickness from 5 to 20 km. The host rocks were shown to be volcanic rocks of sagskaya suite of the middle Ordovician by results of drilling and mining operations. They presented as rocks of basic and average composition, with thin of horizons of sandstones and silstones. Intrusive formations present small dikes of microdiorites of a krykkuduksky complex. Deposit includes Northwest 1 and Northwest 2 ore-bearing zones. Figure 1 shows the Northwest zone 1. They are represented by tuffs of the basic and average composition which have non-uniformly ochre and metasomatic alteration. The borders of these ore zones are indistinct and in most cases are determined according to the analysis. Within ore zone one 4 small ore bodies (the thickness of them is 1,0 - 15,0 m and length to 117 m) are revealed.

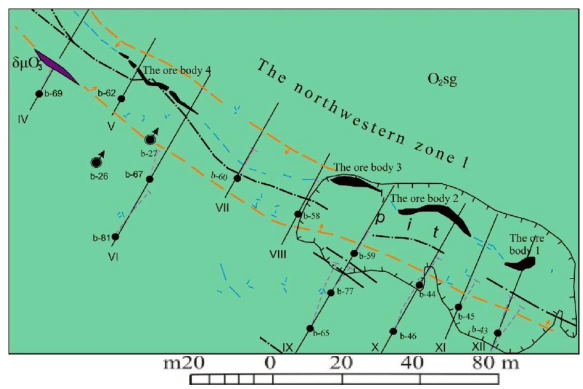
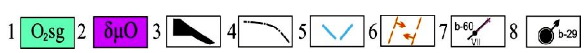


Figure 1 – the schematic geological map of the Martovskoye deposit



1- sagskaya suite - basalts, andesites, dacites and their tuffs, tuff sandstones and tuff siltstones, sandstones and siltstones; 2-dikes of diorite porphyrites; 3-ore body; 4-faults; 5-silification; 6-Zones of intensive development ofquartz veining and veinlet zone; 7- prospecting drillings; 8- boreholes of care drilling.

Microscopic studying of the oxidized ores showed that they are presented by intensively weathered tuffs and metasomatic rocks, which have different degrees of alteration (kaolinization, montmorillonization, seritsitization and hloritization). The dense, claylike and friable mass is light gray, light-yellow to brownish-yellow in color. In general, they have a weak limonitization. In the altered silicified rock of bluish-gray and gray color there are places with an intensive limonitization. Some quartz in them lies in vein, with light gray and gray color and pores of leaching. Some quartz is in the form of thin veinlets and small pieces in the alterated rock. The quartz is a cavernous and it contains rare disseminations of oxidized pyrites (limonite pseudomorphoses on pyrites) and iron hydroxides which develop round emptiness of leaching.

Ore minerals of the weathering crusts are represented: limonite, iron hydroxides, hematite, hydrohematite, rutile, pyrites, native gold, silver. Native gold presents an industrial interest.

Native gold can be found in the limonite pseudomorphoses on pyrites. The size of the pseudomorphoses of limonite is 0,1x0,15 mm. The gold particles (about 30 inclusions) have isometric form, the size is 1 micron and less (to 300 nanometers). They are in the form of thin disseminations developing at the edges of the pseudomorphoses. Gold is hyper gene and has alloy standard of gold – 976 (figure 2, table 1). Native gold is found also in the form of unusual aggregates in which they have alongated and irregular forms in the limonitizion part of the rock of brownish color cementing quartz. There are about 20-25 inclusions of gold. The thickness of the alongated inclusions is 1 micron and less and the length is up to 5 microns. The alloy standard of gold is 907 – rather high-level (figure 3, table 1). Such unusual aggregations can represent on the remains of microorganisms replaced with gold. Similar formations were found on the Suzdal gold deposit (East Kazakhstan).

Small inclusions of native gold in the limonite have ballstone form too (their size – 2 grains is 1 micron; 1 grain - 3 microns and 1 grain - 5 microns). The alloy standard of gold is very high - 1000. Gold is hyper gene, pure (table 1).

Table 1 - Composition of gold according to the micro x-ray spectral analysis, in weight. %

Polished sample number	Elements		Total
	Au	Ag	
1м	97, 61	2,39	100
28 м - 2	90, 72	9,28	100
28 м - 1	100	-	100

Table 2 – Results of semi-quantitative X-ray analysis

Sample number	Mineral composition, wt. %						
	Quartz	Serpentine	Mica	Galit	Kaolinite	Feldspar	Smectite
4 m	8	4	6	-	-	1	81
6 m	44	-	18	-	37	1	-
12 m	23	-	-	2	41	-	34

Analytics V. Levin and P. Kotelnikov. JCXA microprobe – 733.

Dimension of gold is accepted on V. Moiseenko's [7] classifications, the alloy standard of gold on the Petrovskaya [8].

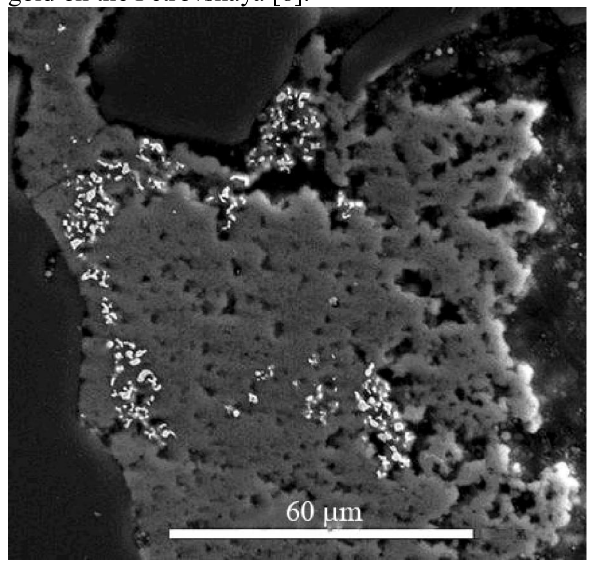


Figure 2 - Thin dissemination of gold in the limonite pseudomorphosis on pyrites. Polished sample 1m. The picture is executed on JCXA microprobe - 733

Clay minerals in the weathering crust, according to X-ray analysis, is presented as kaolinite and smectite (table 2). The latter refers to the number of undesirable minerals for mining by heap leaching because of ability to absorb water and swell in volume in several times [9, 10].

The recording conditions: DRON-4, accelerating voltage – 35 kv, anode current – 20 mA. Note: smectites in the samples 4 m and 12 m contains in the interlayer of interspace divalent exchange cations (Mg and Ca).

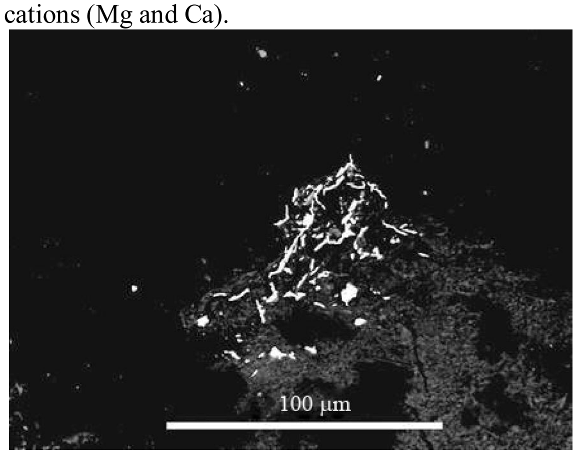


Figure 3 – The aggregation of particles of hyper gene gold which have elongated and irregular forms in the iron hydroxide. Polished sample 28m – 2

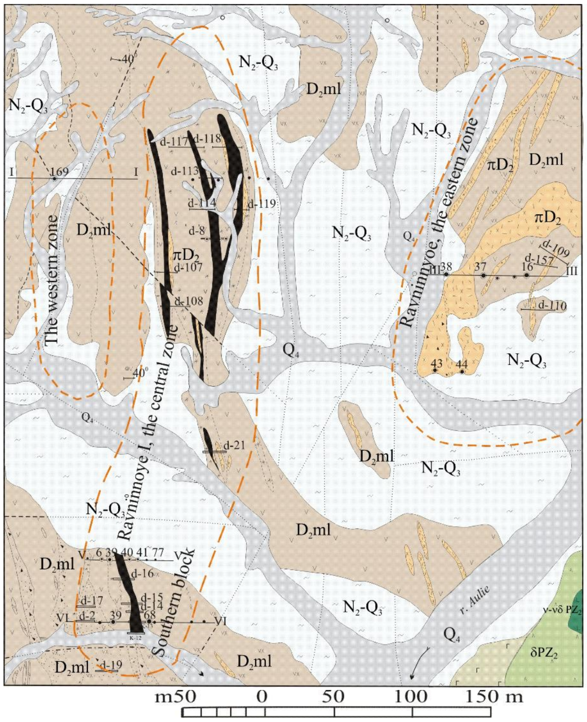
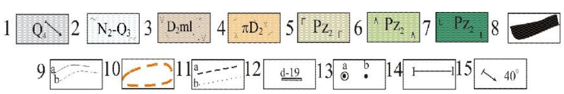


Figure 4 – the schematic geological map of the Ravninnoye deposit



1 – alluvial sediments: gravels, sands, loams and clays; 2 – loams; 3 – andesit-basaltic porphyrites, rhyolites, dacites and andesit-dacites and their tuffs, milyashinskaya suite; 4 – metasomatically altered basalt, dacite and rhyolite porphyrites; intrusive formations: 5 – gabbro, 6 – dacites, 7 – gabbroids and gabbrodiorites; 8 – ore bodies with stringerporphyry mineralization; 9 – boundaries between different ages of the rocks (a) and of different composition (b); 10 – boundaries of Western, Central and Eastern zones of the Ravninnoye deposit; 11 – inferred faults (a) and nonidentified (b); 12 – ditches and their numbers; 13 – boreholes of core drilling (a) and prospecting drillings (b); 14 – the line of profiles boreholes; 15 – attitude of rocks.

Ravninnoye deposit

The Ravninnoye deposit is presented by two parallel zones of the sulphide mineralization in the metasomatic altered dacitic porphyrites, lying among andezito-basalt porphyrites of milyashinsky suite (figure 4). The direction of these zones is the submeridional. The horizontal thickness of the Central zone is 25-30 m, extent is up to 2 km, falling to the West - Northwest 80-85 °. Allocated in the zone is a steeply dipping ore body which has a length of – 125 m, a thickness of – 2-17 m. The East zone presents a number of the consecutive mineralized dikes of the liparite porphyries which lie in the northeast direction. On the surface ore-bearing zones are determined by altered rocks.

The results of the study of the mineral composition of the weathering crust of the Ravninnoye deposit showed that it consists mainly of intensive weathered metasomatites mottled in brown, light gray-brown, purple, clay-like rocks up to brown (figure 5).

In general, they have varying degrees of change (kaolinization, silicification), limonitization on thin cracks and pores of the leaching. Around the cracks and pores collomorphic allocation of iron hydroxides are developing. Pseudomorphs of limonite are also marked. Hydroxides greatly expanded and in crossed nicols give brown internal reflections. In some places there are marked gouges of copper green.

Little weathered quartz-sericite-chlorite metasomatites with small pores of leaching are less common and they can contain sulfides (pyrite, chalcopyrite, chalcosine and covellite). Pyrite ore in metasomatite is extremely rare and it is unequally oxidized. Sometimes clasts of metasomatites a light gray color are cemented by pyrite aggregate.

Ore minerals of the weathering crust are represented: limonite, iron hydroxides, hematite, pyrite, chalcosine, covellite, sphalerite, malachite, chalcopyrite, rutile, native gold, silver.

Native gold is found in the clay-like rock which has a brown color and contains small clasts of quartz and the pores of leaching. There are iron hydroxides developing in the cracks of the rock mass. Iron hydroxides develop between the grains and aggregates of quartz, corroding at quartz and contain quartz in its mass. They are also observed in the form of veinlets and irregular formations along cracks and pores of leaching. Sometimes we can see pseudomorphoses iron hydroxides on pyrite, relicts of pyrite not been found.

Native gold is found in limonite, in the form of unusual, thin threadlike branched secretions. These branched threadlike secretions are up to 1x15 microns in size. This photo taken on a microprobe shows the thinest secretions of gold thread-like form, that have a high alloy standard of gold – 981 (figure 5). On another photo taken on a microprobe, the threadlike gold has alloy standard of gold – 977. Nanoscale secretions of gold were found in thread-like formations gold using a scanning electron microscope (figure 6).

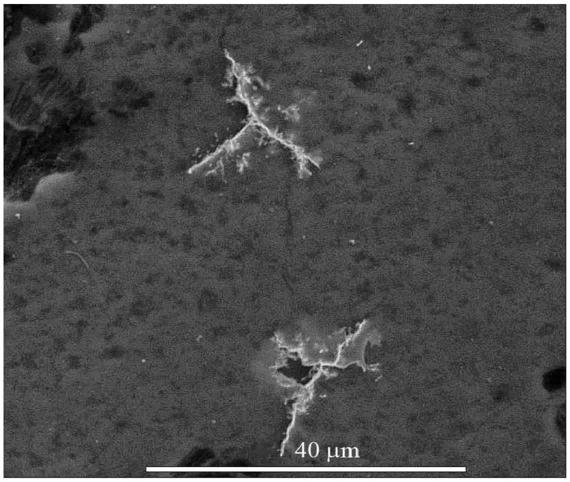


Figure 5 – The threadlike branchy secretions of gold in the limonite. Polished section 3. The picture is executed on JCXA microprobe – 733

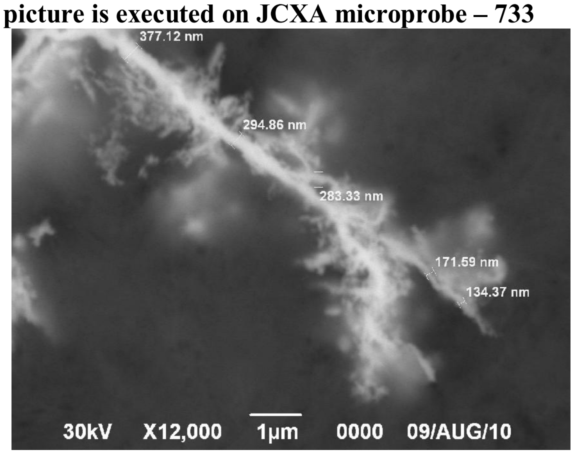


Figure 6 – The threadlike branchy of gold in the limonite. Polished section 3. Scanning electron microscope

Findings

The weathering crust was sufficiently elaborated and presented strongly weathered metasomatites up to clay-like. Incision of weathering formed on the rocks of medium-basic composition. Clay minerals are represented by smectite (montmorillonite) and kaolinite. The prevalence of oxidized minerals – iron hydroxide, limonite, no relics of primary minerals, and the presence of cavernous quartz, indicates a high level of transformation of the weathering crust. The presence of smectite and copper minerals is unfavorable for mining by heap leaching (Ravninnoye deposit). Gold in the studied deposits is contained in limonite, rarely in quartz. Residual gold in the form of micrometric on the border with nanoscale set to pseudomorphoses of limonite on the pyrite. Hypergene gold in the form of extremely thin branching secretions is found in the limonite that contains nanosized particles of gold. Particles of gold 1 micron or less dominate. Nanosized particles of gold were identified by means of a scanning microscope. The purity of gold ranges from 971 to 1000.

Conclusion

Gold is an important metal in the economy, and creates reserves. This becomes more relevant in connection with implementation of the government program "Gold of Kazakhstan." Identification of micro-and nano-sized gold particles is allowed to increase the general resources of gold deposits at the expense of selection and study of the so-called "of invisible gold", which eventually will result in a significant economic effect.

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