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Research Article

MINERALOGICAL AND GEOCHEMICAL FEATURES OF ORES OF 1ST SEPTEMBER GOLD DEPOSIT (UZBEKISTAN)

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ABSTRACT
Results of studying of material composition, mineralogical and geochemical features of 1st September gold deposit are given at the article. While mineralogical and geochemical researching of ores, main ore-forming minerals are described; major and associated components and their finding forms are defined and detrimental impurities, which affects negative on process of ore enrichment is studied.

Keywords: *Mineral, Chemical Composition, Ore, Gold, Major Component, Detrimental Impurities*

INTRODUCTION
Studying of material composition, mineralogical and geochemical features of ores is considered as an integral part of exploration project, due to results of mineralogical researches are used at following working out of the rational scheme of enrichment of ores and to solve technological problems associated with metal extraction. For objective presentation of ore's quality at 1st September gold deposit, detailed mineralogical and geochemical studies were conducted.

Study Area
1st September gold deposit is situated in the Auminzatau Mountains, within Zerafshan-Turkestan structural-formation zone of Southern Tien Shan (Central Kyzyl-Kum, Uzbekistan).
In a geological structure of the deposit, sedimentary-volcanogenic formations following three suites occur at the deposit: besapanskaya, taskazganskaya and auminzinskaya. Auminzinskaya suite consists of schist, quartzite, limestone, amphibolites, micaceous and quartz-micaceous slates. Geological age of suite is Archean-late Riphean. Taskazganskaya suite (Late Riphean) presents itself with volcanic-carbonaceous-siliceous-carbonate rocks. Besapanskaya suite contains sandy-silty-slate formation and considered as a main ore-contained suite. The geological age of the suite is about from Vend-Cambrian to Ordovician (Stratigraphic dictionary of Uzbekistan). In addition, around the deposit, a large Zakhkuduk and Mingchukur granitoid intrusion small stocked shaped bodies and dykes with various composition are located. Absolute age of the intrusions is estimated as late Carboniferous and early Permian.
Siltstone, sandstone and schist are considered as main ore-bearing rocks. Ore-bearing rocks are partially brecciated, schistose and contain layerwise, cross veinlets of quartz. Detrital parts of rocks were recrystallizated almost in full. Cement was transformated to lepidogranoblastic sericite-chlorite-quartz aggregate. Quartz veins are widespread at the research area and productive on gold. Quartz - greyish-white, fine-grained, contains inclusions of country rocks.

MATERIALS AND METHODS
Studying mineralogical and geochemical features of ores was done by using complex geological, mineralogical, geochemical and analytic methods. Researches consist of two main stages: field and laboratory works.
Field works contained studying geological structure of the deposit, sampling, geological-mineralogical profiling etc. More than 250 samples from various types of rocks, metasomatites and ores were sampled by linear and trench methods from trenches and core samples of boreholes. Features of metasomatic alteration of rocks are fixed while geological-mineralogical profiling.
Mineral composition of ores and ore-bearing rocks are studied by polished and thin sections (Betekhtin, 1950; Lodochnikov, 1974, Ramdor, 1962; Winchell, 1949, Tsoy and Sayitov, 2016). In addition, results

of silicate analyses are recalculated to mineral components with correcting by microscopic data (Wisniewski, 1965).

Chemical and elemental composition of ores is analyzed by following methods of analyses: semi quantitative spectral, atomic absorption analysis, full silicate analysis, chemical analyses on certain components (Cu, Zn, Pb, As, S), ICP-mass spectrometric. Impurity elements on certain minerals and composition of native gold were analyzed on electron probe X-ray spectrum microanalysis (JXA -8800R "Superprobe"). Analyses were done at the laboratories of SE Scientific Research Institute of Mineral Resources, SE Central Laboratory, Institute of Geology and Geophysics Uzbek Academy of Sciences.

For studying the distribution of major and associated components on products of gravitational enrichment, 40 samples of 6 kg were washed out on table concentrator and extracted concentrate, an intermediate product, light fraction, and slime. Quantitative parities of minerals on products defined under binocular. Content of gold, associated components and detrimental impurities were defined in each products of gravitational enrichment.

RESULTS AND DISCUSSION

Mineral Composition

As a result of mineralogical research, mineral composition of ores included more than 40 minerals (Table 1). In Hypogenic ore minerals, organizing notable clusters are pyrite, marcasite, arsenopyrite, melnicovite- pyrite, native gold, chalcopyrite, pyrrhotite. They are marked as separate micro exposures, and as micro inclusions in other minerals.

Among oxidized minerals, goethite, limonite, scorodite are most commonly found. Secondary sulfides of copper, hematite, jarosite are sporadically marked. The main rock-forming minerals (including veined, metasomatic minerals) are quartz, albite, sericite, rarely-biotite, chlorite, carbonate and epidote.

Table 1: Mineral Composition of Ores and Ore-Bearing Rocks of 1st September Gold Deposit

Prevalence	Rock-Forming Minerals	Primary Ore Minerals	Hypergene Minerals
Major	Quartz, albite, carbonaceous matter, sericite	Native gold, pyrite, marcasite melnicovite-pyrite, arsenopyrite	Limonite, goethite, scorodite
Secondary	Chlorite, calcite, siderite, biotite	Pyrrhotite, chalcopyrite, sphalerite, galena, magnetite	Chalcolite, covellite, malachite, jarosites, hematite, kaolin, oxides of Pb, Zn, gypsum
Accessory	Epidote, rutile, zircon, moissanite	Tetrahedrite, monacite, xenotime, Sn-Cu mineral	Leucoxene, ruby copper, native copper, Pb-As-Fe-S(?)

Quantitative mineral compositions of main ore-bearing rocks, taken by recalculation of results of silicate analyses to mineral components are given in table 2.

Description of Major Ore Minerals

Native gold was found on polished sections and concentrates of gravity separation. It is free in quartz veins, situated between crystals of sulphides ore aggregate with pyrite, arsenopyrite. Native gold is classified as fine grained (0.001 mm -0.007), powdered (0.01 -0.05 mm); small (0.1 -0.9). Rare gold grains belong to the category of average size (1-2 mm).

Shape of native gold exposure in polished sections is xenomorphic, extra long, determined by the form of cavities, cracks. Form of golden grains varies, such as: amoeboid, lumpy, wire-like, rounded (Figure 1). Color: light yellow with reddish tinge, pale-yellow, rare- dark yellow. The number of characters varies from 1 to over 40.

According to electron probe X-ray spectrum microanalysis, composition of native gold varies. So, larger grains (1-2 mm) of native gold contain Au from 65, 7 to 95, 2% and Ag – from 5, 13 to 34, 3%. Fine grain of native gold contains lower-grade of Au: 51.8-61.9%, Ag from 36.3 to 46.9 and Cu – 1.26-1.77%.

Table 2: Quantitative Mineral Composition of main Ore-Bearing Rocks of 1st September Deposit

	Contents of Minerals by Samples (%)									
Minerals	**Snt-10**	**Snt-16**	**Snt-17**	**Snt-11**	**5037**	**5048**	**5301**	**5520**	**5647**	**5945**
Quartz	38	45,2	40,7	63	47,8	55,8	56,7	43	65,2	42,2
Albite	30,5	13	14,4	16,4	23,8	25,5	14,5	49	23,8	28
Sericite	22	25,5	21,1	10,5	19,8	13,5	29,5	1,5	1	13,9
Biotite & Chlorite	3,5	4,5	0,2	2,2	2,5	0,8	4,5	0,9	5,5	4
Calcite	0,6	3,4	8,1	2,6	0,7	7,9	1	0,5	0,9	4,8
Gypsum	-	3,7	6	0,9	-	-	-	0,2	0,1	2,1
Iron hydroxide	4,5	1,9	8,6	4	2,6	0,9	5,7	2,1	3	3,8
Rutile	0,9	0,8	0,9	0,4	0,8	0,8	1	1,3	0,5	0,9
Epidote	-	-	-	-	2	-	-	-	-	-
Pyrite	rare	2	rare	rare	rare	0,8	0,5	1,5	rare	0,3
(Chalcopyrite, arsenopyrite, sphalerite)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Snt-16, Snt-17, 5945, 5647, 5520 – metamorphic altered psammitic siltstone
Snt-10, 5301, 5048, 5037 – meta siltstones
Snt-11 - carbonaceous silty schist

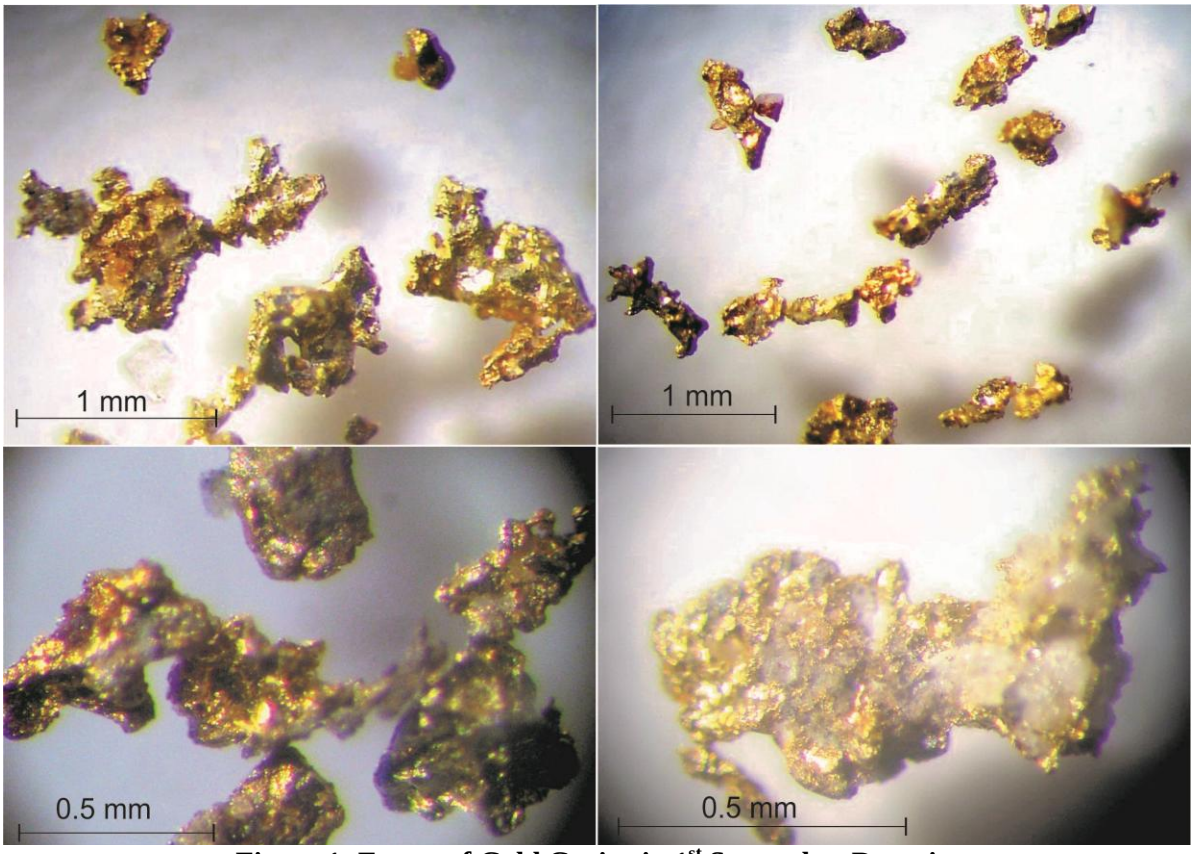

Figure 1: Forms of Gold Grains in 1st September Deposit

Pyrite is the most common mineral of ore zones. Quantity of pyrite in ores varies from single grains to 1.5%. Pyrite content in heavy fractions ranges from single grains to >90%. Forms of grains are various: cubic, pentagon-dodecahedric; xenophormic, aggregate fusions are often marked; veins, lenticular

congestions. Size of grains is from < 0,003 to 1-12 mm. Grains are broken down; cracks are marked with quartz, carbonate, chalcopyrite. Pyrite often grows together with arsenopyrite, is replaced by marcasite, melnicovite-pyrite; contains inclusions of pyrrotine. Pyrite is replaced by iron hydroxides up to pseudomorphose. Gold content in pyritic concentrate (80 %> pyrite) 5,6 – 21,48 g/t, Ag - 4,33-102,5 g/t. associated components (%): Cu-0,1; Pb-0,12; As->1; Ni-0,013; Co-0,03; Mo->0,03; Cr-0,027; Zn-5,2.

Arsenopyrite is marked constantly in concentrates and polished sections. Forms of grains are– interspersed, short-columnar crystals, often with rhombus in section. Junctions with pyrite, chalcopyrite are observed. In arsenopyrite, inclusions of pyrrotine, tetrahedrite are found; scorodite develops on cracks, the periphery of the grains. Sometimes the whole crystal is replaced with scorodite, and in the process of leaching boxy textures remain. The size of the crystals is from <0.003 to 0.5-1.5 mm. Gold content in concentrates, where quantity of arsenopyrite is 82%-8.06 g/t, silver-30 g/t. The following impurities are found (%): Cu – 0.0054; Pb – 0.0036; Sb – 0.14; Ni – 0.024; Co – 0.024; Mo - >0.03; Cr – 0.027.

Pyrrhotite is marked in the form of sporadic impregnation in foliation cracks of metaterrigene rocks, lenticular clusters, rare emulsion impregnation in pyrite and arsenopyrite. In addition, bunches with marcasite, melnicoviye-pyrite, magnetite are met. Size of grains is from < 0.001 to 1-11.3 mm.

Melnicovite-pyrite is found in hypogene ores in the form of xenomorphic clusters, veins, wire-like veinlets in shale rock. It intergrows with marcasite, pyrite.

Marcasite is noted among clusters of melnicovite-pyrite, pyrrhotite. Form of junctions is winding, rough. Grain size is from < 0.003 to 0.2-0.5 mm. In the zone of oxidation, it is replaced by limonite.

Minerals of oxidized ores.

Oxidation zone is represented mainly with products of decomposition of primary sulphides-pyrites, arsenopirite, pyrrhotine, chalcopyrite, marcasite, etc.

Goethite is a widespread mineral in the zone of oxidized ores. It occurs in the form of pseudomorphoses by pyrite, marcasite, melnicovite-pyrite, pirrhotite. Macroscopically, it is presented in different forms: cube, pentagon-dodecahedral, etc. There are relics of pyrite, pyrrhotine, marcasite in goethite. A large part of goethite is replaced by earthy ore of limonite. It contains inclusions of non-metallic minerals-quartz, sericite, clay particles. Gold content is from 1.1 up to 158 g/t.

Scorodite develops by arsenopyrite, sometimes completely replaces the last. Often rhombic, prismatic crystals of arsenopyrite are replaced by dark grey scorodite clusters. A large part of scorodite is replaced subsequently by limonite and, together with the pelitic carbonate, gypsym. Relics of arsenopyrite are marked in the clusters.

Scorodite content does not exceed 2.2%. Together with it, native gold, oxides of Fe, Cu are marked. It should be noted that, in oxidized and semi-oxidized ores, content of As 0.4 - >1%, Gold content in gravity concentrates with scorodite is 100-1785 g/t and native gold is marked.

Composition of Gravity Separation Products

Composition of concentrates of gravity separation variety over wide range. Sulphide concentrate with 82% arsenopyrite and 18% pyrite contains 8.06 g/t Au and 30.0 g/t Ag. Gold composition fluctuates from 0.4 to 9.32 g/t in concentrates with repossession of pyrite over arsenopyrite. Concentrates of samples, sampled from oxidized zone represents their selves with goethite, limonite and scorodite substantially. In addition they contain granules of native gold. The number of gold granules in concentrates varies from 1 to over 40. Gold and silver contents in the concentrates with native gold ranges from 100 to 1785 g/t and 67.5 to 322 g/t respectively.

Intermediate products consist of rock-forming minerals and fine-grained ore minerals in aggregate with rock-forming minerals. Gold content in the product from <0.05 to 5.28 g/t. In light fractions and slime gold content <0.05 – 0.69г/т and 0 – 1.1 g/t correspondingly. Foam product of gravitational enrichment represents itself carbonaceous matter and contains fine gold with gold content to 8.1 g/t.

Balance calculation of distribution of gold is given in Table 3. From the native gold found in samples, 54 to 92 % of gold is extracted into concentrate. In concentrates with oxide ore minerals significantly more gold grains was found than sulphide concentrate.

Table 3: Balance Calculation of Distribution of Gold

Sample No.	Composition of Concentrates	Products	Fission Yield (%)	Au Content g/t	gB	% (e)
5301	Goethite, limonite, scorodite	Concentrate	3.5	43.7	153	96
		Intermediate product	34	0.09	3	2
		Light fraction	28	0.05	1.4	1
		Slime	34.2	0.05	1.7	1
		Foam	0.3	0	0	0
		parental sample	100	1.6	159	100
5648	Arsenopyrite 52%, pyrite 48%	Concentrate	3.9	5.78	22.5	46.3
		Intermediate product	18	0.77	14	28.3
		Light fraction	72	0.15	10.8	22.3
		Slime	6	0.18	1.1	2.3
		Foam	0.1	0.89	0.1	0,4
		parental sample	100	0.48	48.5	100
5945	Native gold, semi-oxidized sulphides, goethite, scorodite	Concentrate	2.6	37.3	97	54
		Intermediate product	14.3	1.91	27	14.7
		Light fraction	81	0.69	56	30.4
		Slime	2	0.68	1	0.7
		Foam	0.1	4	0.4	0.2
		parental sample	100	1.8	184	100
5520	Pyrite 97%, arsenopyrite 2-3%, chalcopyrite, sphalerite	Concentrate	0.4	21.4	8.6	21
		Intermediate product	16.7	0.51	8.5	21
		Light fraction	72.8	0.29	21.1	51.9
		Slime	10	0.2	2	4.9
		Foam	0.1	5	0.5	1.2
		parental sample	100	0.41	40.7	100
8023	Native gold, goethite, limonite, scorodite, native copper,	Concentrate	1.7	1610	2737	92.42
		Intermediate product	24.7	5.59	138.1	4.6
		Light fraction	70	1.2	84	2.84
		Slime	3.5	1.1	4	0.14
		Foam	0	0	0	0
		parental sample	100	29.7	2963	100
5001	Goethite, hematite	Concentrate	0.7	1.11	0.8	15.4
		Intermediate product	23.4	0.05	1.2	23.1
		Light fraction	65.9	0.05	3.2	61.5
		Slime	10	0	0	0
		Foam	0	0	0	0
		parental sample	100	0.052	5.2	100
5047	Native gold, goethite, limonite, scorodite, Semi-oxizided sulphides, native copper	Concentrate	2.5	1153.3	2883	85.9
		Intermediate product	32	5.28	169	5
		Light fraction	71	4.24	301	9
		Slime	3	0.6	2	0.06
		Foam	0.5	1.73	1	0.03
		parental sample	100	33.8	3353	100

Part of gold is extracted into intermediate product, light fraction and slime. Although the metal content in these products is insignificant, but their outputs are high. With this in mind, material losses during gravity separation may be considerable.

Cu, Mo, Zn, Pb are considered as main associated components of ore, where As, Sb, S as detrimental impurities. Contents of associated components and detrimental impurities in concentrates are following ($n*10^{-3}$%): V – 0.7->100; Mo – 0.07->50; Cu – 2-500; Pb – 2->1000; Zn – 0-5520; As – 20-37810; Sb – 0-140; S – 1210-35470. In intermediate products, contents of associated components and detrimental impurities are following ($n*10^{-3}$%): V – 8.7-50; Mo – 0.1->30; Cu – 0.5-70; Pb – 0.87-180; Zn – 0->1000; As – 1->1000; Sb – 0-10. Light fractions and slime contain low content of associated components.

Conclusion

1. Native gold, pyrite, arsenopyrite are main ore-forming minerals. In oxidation zone, pyrite and arsenopyrite are substituted by goethite, limonite, scorodite. Quartz, albite, sericite are considered as main rock-forming minerals in the deposit.

2. Gold is major industrially valuable element. Gold content in parental samples varies from 0.05 to 33.8 g/t. In concentrates of gravity separation, content of gold reaches to 1610 g/t. Finding forms of gold is native gold generally and fine-dispersed in sulphides, carbonaceous matter (0.001-0.007 mm) in part. Composition of native gold varies according to their size of grains: larger grains contains higher-grade of Au (65.7 – 95.2%), fine grains contain lower-grade (51.8-61.9%).

3. Majority of gold grains are free and situated by cavities, cracks of other minerals and with aggregate with sulphide minerals. Therefore, while gravity separation majority of gold grains extracted into concentrate.

4. According to results of balance calculation of gold distribution, 54 to 92 % of gold is extracted into concentrate at presence of native gold in samples. Concentrates with oxide ore minerals contain significantly more gold grains than sulphide concentrate.

5. Cu, Mo, Zn, Pb are considered as main associated components of ore, where As, Sb, S as detrimental impurities for process of metal extraction and ecology.

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