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Research Article

MINERALOGY OF BISMUTH IN GOLD-RARE-METAL MINERALIZATION OF BUKANTAU MOUNTAINS AND ITS PROSPECTING VALUE

***Mamatkhon. S. Karabaev**
Institute of Geology & Geophysics, Academy of Science of Republic Uzbekistan, Tashkent, Uzbekistan
**Authors tor for Correspondence*

ABSTRACT
Occurrence form of bismuth in various mineral parageneses of gold - rare metal deposits of Bukantau mountains is studied and revealed its complex trace minerals. The close association of gold mineralization with bismuth minerals was established. In the earlier stages of mineralization bismuth is presented in native, sulphide and telluride formed in later stages - as sulphosalt. A comparative analysis of the mineral composition of gold - rare metal and gold-silver deposits in the mountains Bukantau and Auminzatau is carried out and stated that the presence and occurrence of bismuth minerals indicates the presence of industrial gold mineralization.

***Keywords**: Gold-Rare-Metal Deposits, Mineral Paragenesis, Bismuth Occurrence Form, Micromineralogy, Predictive Value*

INTRODUCTION
Features of concentration of elements in mineral and impurity form, caused by the conditions of their formation, carry important information about the nature of the ore-forming system, and therefore, have an important prospective value.
The most informative in this regard is the chemical composition of the ore minerals, generating regular macro and microparagenesis forms with gold (Koneev, 2006). The area is one of great economic importance with a number of important mineral deposits, their origin linked to accretionary processes (Yakubchuk *et al.*, 2005; Seltmann *et al.*, 2011).
In the paper new data on occurrence forms of bismuth in gold and rare metal deposits of Bukantau mountains and their comparison with the composition of the gold and silver objects of the region are presented. These deposits have different mineralization styles that likely represent variable formation depths.

MATERIALS AND METHODS
Methods
Our investigations of chemical composition of the minerals content and trace elements, peculiarities of their distribution were performed on the X-ray electron microscope Superprobe JXA-8800R (Jeol, Japan) in the Institute of Geology and Geophysics of the Academy of Sciences of Uzbekistan.
Geological Structure of the Area and Ore Fields
The studied objects are located within the Kyzylkum gold province of Beltau-Kurama volcano-plutonic belt (Dalimov *et al.*, 2002), associated with the processes of subduction of the oceanic crust of the Turkestan paleoocean under the Kazakhstan-Kyrgyz continent and its subsequent collision with the Karakum - Tarym continent (Goldfarb *et al.*, 2013; Seltmann *et al.*, 2011).
Gold and rare metal deposits (Sarytau and Sautbay) are genetically and spatially connected with processes of granitoid intrusions formation (Figure 1), intruding sedimentary-volcanic rocks of Kokpatas Formation (Karabaev, 1990).
The gold mineralization is combined by consistently manifested gold-rare-metal, gold-bismuth-telluride, gold-arsenic and silver-gold-sulphosalt mineral - geochemical assemblages.
Industrial significance of the gold ore is predetermined by gold-bismuth-telluride and gold-arsenopyrite associations.

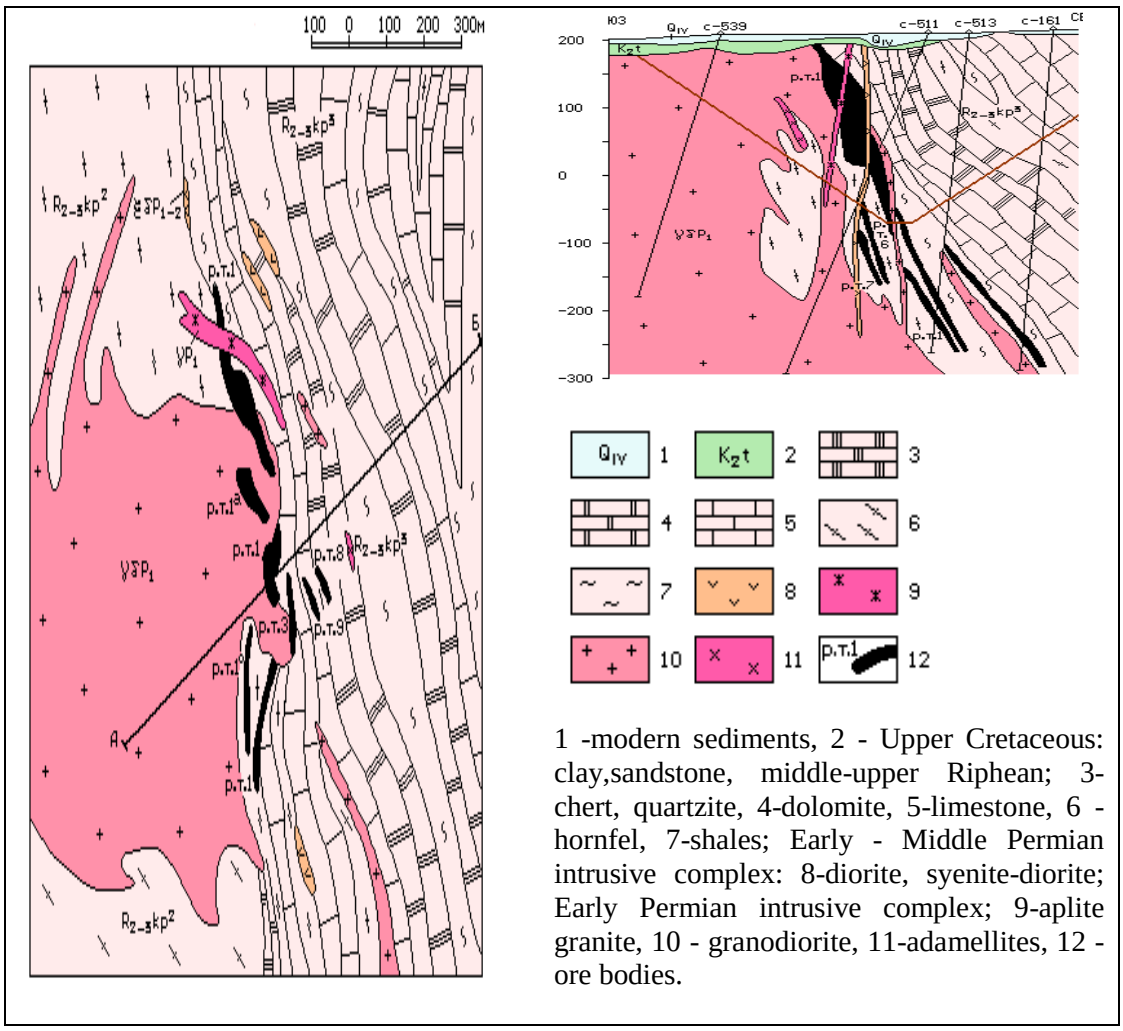

Figure 1: Schematic Geological Map of the Deposit Sautbay

Gold and silver objects (Peschanoe, Shohetau, Karabugut *et al.*) are located in areas of disjunctive faults in the rocks of Besapan Formation in the mountains Auminzatau. Ore-bearing association: mainly gold-arsenopyrite and minor gold-sulphosalt. Gold is found as disperse impurities in sulfide minerals and in the native state.

It was established that gold mineralization of gold and rare metal deposits Sarytau and Sautbay, forming in a wide range of ore-forming process, is closely associated with bismuth minerals, but geochemical paragenesis of bismuth in gold-rare-metal deposits is different in these associations (Table 1).

In the earlier stages of mineralization bismuth is presented in native, sulphide and telluride form - in the form of bismuthine, native bismuth, telluride bismuth, hedleyite and joseite, with native gold of higher fineness (866-882), chalcopyrite, pyrrhotite, pyrite (Figure 2). This association, in the lower level of deposits, often spatially superimposed with the areas of rare metal mineralization. In the later stages of mineralization bismuth is part of numerous sulfosalts, confined to the upper part of the deposit. So, for the silver-gold-sulphosalt association of gold-rare-metal deposits is characteristic bismuth sulfosalts of tellurium, lead, copper, antimony and silver - ingodite, sulphotsumoite, bursait, tetradymite, bismutoplagionite, acicular bismuth (Table 2).

It was noted (Koneev, 2003) that the specifics of ore paragenesis of gold-rare-metal mineralization of Muruntau, Myutenbay and Charmitan deposits is the formation of bismuth telluride, in contrast to deposits of Chatkal-Kurama region, often containing tellurides of gold, silver, lead, copper and other.

Table 1: Comparative Characteristics of Paragenetic Mineral Associations and Polymorphic Minerals of Gold-Rare-Metal and Gold-Silver Mineralization of Bukantau and Auminzatau

Mineral Associations	Gold-Rare-Metal	Gold-Silver
	Polymorphic Ore Minerals	
Gold-Rare-Metal	Scheelite, molybdenite, native Au (905-922)	-
Gold - Bismuthite - Tellurid	Tellurid bismuthite, hedleyite, joseite, bismuthite, native bismuth, native Au (882-866)	-
Gold - Arsenical	As- pyrite, arsenopyrite, chalcopyrite, pyrrhotine, gersdorffite, Ni-Co- pyrrhotine, gold dispersive	As-Ni – pyrite, arsenopyrite, pentlandite, gold invisible
Polysulfide - Tellurid	Chalcopyrite, sphalerite, galenite, tetradymite, tennantite, ingodite, sulphotsumoite, bismutoplagionite, wittichenite, aikinite, native Au (732-767)	Chalcopyrite, sphalerite, galenite, greenockite, hessite, petzite, stutzite
Gold - Sulphosalt	Sphalerite, naumannite, acanthite, native Ag, native Au (687-701), cosalite, kobellite, matildite, miargyrite, stephanite, boulangerite, polybasite	Ulmanite, clausthalite, Ag- clausthalite, Ag-Se- galenite, native Ag, native Au (386-622), acanthite, gray copper, freibergite, boulangerite, jamesonite, bournonite, pyrargyrite, Se- Mckittrite

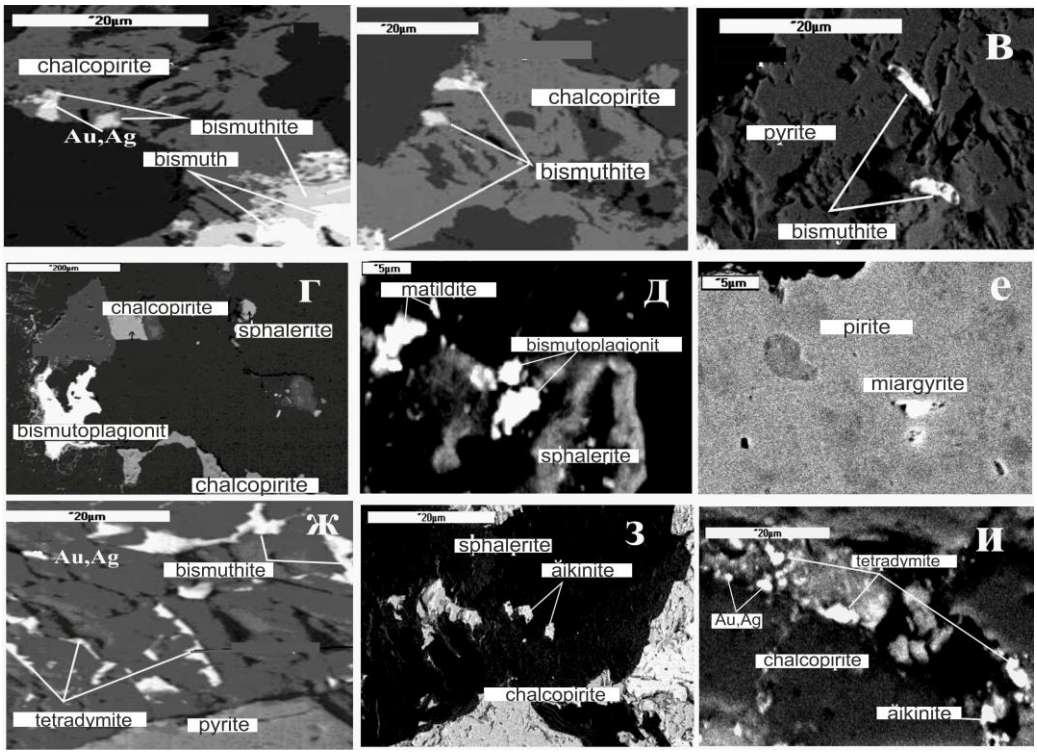

Figure 2: Micro Parageneses of Bismuth Minerals in Gold-Rare-Metal Ores of Deposits Sarytau and Sautbay. Image in Secondary Electrons

Important criteria for the assessment of formation conditions and mineralization forecast, are the results of comparison of the mineral composition of the later carbonate-polysulfide and silver-gold-sulphosalt associations. In the gold and rare metal deposits Sarytau, Sautbay in ore content are widespread sulphobismuthite which is not characteristic for gold and silver objects. Thus, in the gold-rare-metal ores copper sulfosalts are present in the form of arsenic (tennantin) and bismuth (vittihenit, aikinite), in gold and silver - antimony (tetrahedrite and Ag-tetrahedrite) and in lead-antimony (bournonite) differences. Sulfosalts of lead in the first are presented by bismuth (cosalite, kobellit and galenovismutit), and in second by antimony (boulangerite, jamesonite) differences (Table 2).

Table 2: Chemical Composition of Bismuth Minerals by the Data of Microprobe Analysis

Mineral	Au	Ag	Cu	Fe	Pb	Bi	Te	Se	Sb	S	∑
		1,79	0,42			97,24					99,45
Native		1,83		0,27		97,4					99,50
Bismuth	0,2		0,52	0,24		98,7					99,66
				0,67		84,71				14,6	99,98
Bismuthite				0,43		83,01				16,6	100,0
			0,64		0,31	81,05				18,0	100,0
Hedleyite	0,24	0,08				79,12	20,0				99,44
		0,08		1,1		79,73	17,8			1,07	100,0
Bismuth-Tellurate	0,22			1,34		53,34	44,2			1,03	99,98
Joseite A						78,91	12,1	2,8		6,19	100,0
Joseite B						76,03	20,4			3,25	99,68
				0,23		75,39	18,9	1,8		3,68	100,0
Ingodite						71,06	20,8	1,9		6,23	99,99
				0,51		71,53	21,5	1,6		4,81	99,95
Sulphotsu-Moite				0,44		67,56	27,7			4,26	99,96
Tetradymite		0,24	0,12			60,1	34,2	0,3		4,86	99,82
						59,9	35			5,1	100,0
Ag-Bursait		7,75	0,08		38,8	37,24	0,68	0,5	0,69	14,2	99,94
		6,37	0,57		33,92	38,56	0,87	0,7	4,08	14,9	99,74
Bismutoplagionite		1,23		0,34	23,8	57,5	0,4	0,5		16,2	99,97
Aikinite		0,25	11,3		34,3	37,32			0,26	16,5	99,93
			10,8		35,6	37,14			0,22	16,2	99,96

Compounds of silver sulfosalts in gold-rare-metal ores, along with miargyrite and stephanite, often presented by matildite ($AgBiS_2$), in gold - silver by pyrargyrite (Ag_3SbS_3). All these minerals, of silver-gold-sulphosalt paragenesis in gold-rare-metal deposits are associated with native gold of lesser fineness (687-701). In this case fineness of gold in their respective associations of gold - silver objects is lower (386-622).

Conclusions

Presented data suggests that the gold mineralization of gold - rare metal deposits, formed in a wide range of ore-forming processes, is closely associated with bismuth minerals, both in the early stages and in the final stages of mineralization, indicating their immensity. There by geochemical bismuth paragenesis in gold-rare-metal deposits is different in these associations. In the earlier stages of mineralization bismuth is presented in native, sulphide and telluride form. In the later stages bismuth is a member of various sulphosalts. In the oxidation zone of gold - rare metal deposits often found supergene bismuth minerals - bismoclite, bismite, bismuthite.

Analysis of the data on the mineral composition of ores of large and giant gold-rare-metal and rare metal deposits, also confirms the aforementioned, with the difference that in these objects bismuth minerals presents an even greater set (Koneev, 2006; Eshimov *et al.,* 1990).

The data obtained demonstrate that the presence and occurrence form of bismuth minerals are reliable criteria for evaluation of the mineralization. Association of native bismuth, its sulfides, tellurides and sulphobismuthites with other minerals in the test region indicates the presence of industrial gold mineralization. Native and telluride occurrence form of the bismuth indicated lower part, sulphosalt occurrence form - top part of the mineralization.

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