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Research Article

FORM OF FINDING OF QUICKSILVER IN ROCKS AND ORES OF THE CHATKAL-KURAMA MOUNTAIN

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ABSTRACT

In the Chatkal-Kurama direction, two sources of mercury are identified for endogenous deposits: mantle, subcrustal for antimony-mercury and gold-antimony ore and from host rocks - for mercury found as an impurity in endogenous ores and halos of lead-zinc, bismuth, etc. deposits.

Keywords: *Mercury, mantle, antimony, epithermal, endogenous, skarn, gold, form, magma, sulfide, mineral, syngenetics*

INTRODUCTION

The territory of the Chatkal-Kurama Mountains has a heterogeneous structure. In metallogenic terms, the North Chatkal sub-zone of the Karatau-Naryn metallogenic zone, the Kurama and Kassan subzone of the Kurama-Fergana zone are distinguished here. In tectonic terms, the North Chatkal part belongs to the Kyrgyz-Kazakh ancient microcontinent, the Kurama and Kassan parts belong to its activated margin. The North Chatkal subzone is characterized as an area of widespread development of sedimentary and intrusive rocks of acidic composition of abyssal and mezoabyssal facies. The Kurama's subzone is a volcano-plutonic frame of the continent with the widespread development of magmatism of intermediate composition, and the Kassan's subzone is an area of manifestation of volcanism from felsic to mafic composition. According to K.T. Mustaphin, the mercury-metallogenic appearance of the region (especially Kassan) was determined by its position at the junction of sharply different structural and formational subzones of the Middle Tyan-Shan, and V.P. Fedorchuk by its proximity to the Thalas-Fergana deep to the fault. The general estimate of the average mercury content in the Earth's crust is $8.3.10^{-6}$. A similar figure is given by Taylor S.R. (1964).

MATERIALS AND METHODS

In the Kassan subzone, an increased Hg content of up to 0.03% in the siliceous-carbonaceous rocks of the effusive shale formation Cm - O_2 was noted by M.M. Adyshev, K. Sagyndykov, K.T. Mustafin. In sandstones D it is 3.10^{-5}%, siltstones 2.10^{-5}%, limestones - 3.10^{-5}, dolomites - $5.10^{-5,}$ dolomites C_1 - 47.10^{-5}, and to the north-west, in similar carbonate rocks of Narin - 12.10^{-5}, occasionally - 2.10^{-2}%. Among D_3fr carbonates, the interlayers of clayey shales are enriched in it up to 1.10^{-3}%, and a correlation is noted between the Hg and P contents.

In the Chatkal-Narin zone, mercury is contained in syngenetic-diagenetic and syngenetic-epigenetic lead-zinc deposits (from 1.10-5 to 1.10-4); and in hydrothermal ones it is more – 1.10-4 – 1.10-3%.

K.T. Mustafin points out that in the low terrigenous-carbonate strata D_2gv - D_3, up to 0.02-0.1% Hg is found in areas. In the Kurama subzone, mercury was determined in 21 samples of sedimentary rocks of the Almalik region (in no. 10^{-6}): anhydrites 1.6; marls 1; limestones 0.6; dolomites 0.3. Single grains of cinnabar are common in concentrates washed from modern sediments throughout the Chatkal-Kurama Mountains.

In sedimentary rocks, syngenetic accumulation of mercury occurred in siliceous-carbonaceous rocks of the volcanic-shale formation Cm –O_2 (Kassan subzone), in dolomite layers among terrigenous-carbonate deposits D_2-D_3 (the entire territory) and in carbonate rocks C (Kassan and North Chatkal subzones).

Information on Hg in these rocks is scarce. From the North Chatkal subzone, 2 samples of dike diabase porphyrites-C_3 of the Ustarasay ore field showed $3.8.10^{-6}$% Hg. In the Kurama subzone, in the Hercynian intrusions of granitoids of the Angren Plateau, the Hg content is determined to be below 1.10^{-6}%. In the Kizilgut region, according to our data, granodiorite - porphyry-P has 3.10^{-6}% Hg, alaskite-D - $1.8.10^{-6}$%, which corresponds to the average figures for igneous rocks. The Hg contents are significantly increased in the Almalik ore region. In syenite, diorite, gabbro-diorite, etc. - 13.10^{-4}% Hg in 13 samples, in quartz porphyries $3.5.10^{-6}$%, in andesite-dacitic porphyrites $4.5.10^{-6}$ in 4 samples. From these data it is clear that the mercury content in the main mezzo-abyssal rocks of the lead-gold-molybdenum-copper ore region of the Almalik region is hundreds of times higher than the average estimate for similar rocks. At the same time, in the subvolcanic rocks of the region it is consistent. Apparently, the distribution of mercury was affected by the general geochemical specialization of igneous rocks of high basicity and the volatility of mercury in subvolcanic facies.

Form of occurrence of Hg in igneous rocks. According to B.G. Khairulin and R.G. Yusupov, mercury in the C_2-P granitoids of the Kurama Range is in the form of accessory cinnabar (0.001-0.17 g/t) and a syngenetic impurity in biotite 1.10-3 – 3.10-1% [, 2.10^{-6} – $1.5.10^{-2}$% and $8\text{-}1040.10^{-4}$. Mercury is found in hornblende - 6.10^{-7}% and accessory minerals: magnetite and apatite - 4.10^{-6}%, gold - 0.7%.

The form of occurrence of mercury in biotite from this region is debated. Syngenetic, atomically scattered and postmagmatic showed the heterogeneity of its distribution using a microprobe on the same samples. In a biotite crystal with a gross Hg content of 0.012%, sulfide inclusions (5-12% Hg; 1.8% Zn; 1.5% Fe and 2.4% S) were found in areas of fracturing. R.G. Yusupov considers the biotites of this region to be mercury-containing, suggesting that initially, at high temperatures, zinc and mercury were isomorphic in them, and when it decreased in the post-magmatic stage, they were released in the form of sulfide.

Single signs of accessory native mercury were found in 1960 by P.S. Kozlova in granite porphyry of the R. Babaytag massif (Southwestern spurs of the Chatkal ridge).

Materials show that among the intrusive rocks of the Hercynian cycle in the north-eastern part of the Kurama Mountains (Angren Plateau), the highest average contents of accessory cinnabar are found in hypabyssal intrusions of alkaline and basic composition (syenite, syenite - porphyry, granosyenite - porphyry - 0.54 g/t, gabbro – 0.41 g/t). Accessory cinnabar in intrusive bodies, judging by their erosion sections, is not evenly distributed: in alkaline and acidic bodies it increases with depth, and in basic ones it decreases. In the upper parts of hypabyssal alkaline intrusions, P cinnabar is 0.1-0.2 g/t, at a depth of 3 km – 3.16 g/t, and in the mezzo-abyssal bodies of granodiorites and granites C_2 only at a section deeper than 2 km appears 0.05- 0.005 g/t. In the hypabyssal main intrusions P, cinnabar is distributed to a depth of 1.5 km (Aktepa), reaching 1.8 g/t in individual samples. Cinnabar has not been identified in the mezzo-abyssal bodies of gabbro and C_2 diorites, eroded over 3-3.5 km. In the Kassan subzone, it is present in granosyenite porphyries $P_{1\text{-}2}$.

In the magmatic process, accessory mineralization of mercury formed in the form of sulfide in hypabyssal conditions in mafic and alkaline rocks of the final stage of the Hercynian cycle.

SYSTEM ANALYSIS

The Chatkal-Kurama Mountains are known from the work of a large team of geologists as a province with gold, bismuth, lead-zinc, fluorite, gold-mercury, antimony-mercury ore occurrences and deposits. The latter are found only in the Kassan subzone. In the rest of the territory, Hg is dispersed in ores of other metals or forms small ore occurrences. Dispersion halos exist around gold ore and many sulfide deposits. In the Almalik and Altintopkan ore districts with deposits of Pb, Zn, Cu, Mo and others, the mercury content in the ores is low. Some features of its geochemistry were highlighted in early works. Gold deposits have been well studied with the widespread use of geochemical prospecting methods, including Hg dispersion halos. We have studied the distribution of mercury in ores and hydrothermally altered rocks of the arsenic-bismuth deposit Ustarasay in the Pskem ridge, the skarn-iron-scheelite-bismuth deposit - Ingirchak in the Mogoltau ridge, the copper-bismuth ore occurrences of Kizilgut and Pravoberezhny Almalik in the Kurama's ridge, Uzumlek a and Katta-Karabash in the southwestern spurs of the Chatkal ridge, lead-zinc – Lachin-Khany in the Ugam ridge, Kumushkan and Bashkizilsay in the southwestern spurs of the Chatkal ridge, etc. Mercury was determined by spectral approximate quantitative analysis with a sensitivity of 1.10^{-8}% (IMGRE, analyst Z. Lisichkina).

Gold deposits are found in volcanogenic rocks PZ_3. In the Kurama subzone, in the secondary quartzites of Aksagata and Altin-Bel, containing 0.02% Hg, V.P. Boriskin, V.V. Merenkov and K.N. Ponomareva indicated small grains of cinnabar and gold in the breccia cement. In the Kassan subzone, alunite quartzites with cinnabar, gold, arsenopyrite and galena from the Karatepa's ore field (Aktash) and Kashkasu-Shaldir (Kashkasu, Berkbulak, Kizil-Chukur, Taldi-Bulak) were classified by K.T. Mustafin as the alunite - gold - cinnabar formation.

Among the secondary quartzites of Achiktash, Aktamhol and Archasu, G.P. Podznoev established the dissemination of cinnabar together with native gold, sometimes stibnite, and hematite.

A similar formation of cinnabar crystals occurs in the area of modern solfata fields with steam-gas jets in the zone of the Mendeleev volcano on the Kuril Islands [8].

In the North Chatkal subzone, according to T.S. Timofeeva, mercury is present in skarns with gold-copper mineralization (Kurutegerek) in the form of an amalgam of gold and cinnabar. In the Kassan subzone, Hg is present in gold-antimony occurrences.

In the Kurama's subzone, in the gold-bearing near-surface veins of Chadak, Kizilalmasai, Kochbulak, M.I. Moiseeva and others found cinnabar grains. The admixture of 0.01% mercury in the gold of Kochbulak was established by E.A. Markova, and Akturpak - by R.P. Badalova and G.S. Meshaninova. In the early period, based on Hg halos, M.I. Moiseeva recommended searching for gold deposits in this subzone.

Of particular note is the important property of mercury to form impurities in other minerals and dispersion halos around ore bodies of deposits of Au, Ag, Sb, Pb, Zn, Cu, etc. We do not consider the halo geochemistry of mercury in this article. This is an independent direction in the search for ore deposits using geochemical methods. It received widespread development in the second half of the twentieth century, in connection with numerous discoveries of studied gold ore and other deposits in the Chatkal-Kurama Mountains and is reflected in numerous works by G.A. Terekhova, L.A. Bykovsky, D.S. Mukimova, M.A. Abaturova, A.D. Dzhuraev, M.M. Pirnazarov and others (9, 19-22, etc.) who successfully developed the Yanishevsky-Grigoryan-Ovchennikov direction (IMGRE).

These works showed that mercury in epithermal gold deposits of the Chatkal-Kurama Mountains is among the aureole elements (Ag, Au, Sb, Cu, Pb, Zn), and in the vertical range it occupies supra-ore and upper ore levels.

The mercury content in gold deposits of the Kurama's subzone according to the mass spectrometric method was shown by R.I. Koneev and co-authors. For the richest samples it ranges from 0.9 to 6 g/t. (Table 1).

Mercury content in rich samples of gold, gold-silver and gold-copper-molybdenum deposits of the Chatkal-Kurama Mountains
(Koneev et al, 2008)
Table 1

Field	Kochbulak	Kayragach	Kauldy	Akturpak	Kyzyl almasay	Ara bulak	Au-Cu-Mo Kalmakyr
Hg g/t	2,2	6,0	0,9	4,6	3,5	1,03	2,6
Au g/t	84,7	12,7	9,2	29,1	50,7	6,1	5,0
Ag g/t	369,4	53,9	72,4	232,8	675,2	268,1	5,0
Cu g/t	1.43	0,016	0,017	2,5	0,551	0,49	0,55
Number of samples	10	5	5	5	9	14	6

Based on a comparison of the geological conditions of the formation of gold veins and metasomatic rocks in the Kizilalmasay ore field with experimental data on the forms of mercury in different temperature ranges, it was suggested that mercury is found in various forms: free mercury, primary and secondary cinnabar, chloride, fluoride, oxide compounds and isomorphic impurities. However, the mineralogical works of R.I. Koneev, A.Z. Umarov, R.A. Khalmatov did not identify these forms on modern sections (medium and deep horizons).

Mercury in minerals of endogenous deposits of Pb, Zn, Bi, Cu and fluorite. The intrinsic mercury minerals in these deposits have not been identified. The impurity is present in varying quantities in sulfides of Cu, Zn, Fe and Pb in skarn deposits of Pb, Zn, Bi and in hydrothermal low-temperature enriched sulfides. Mercury enters isomorphically into the composition of fahlores, replacing Cu and Zn, into the composition of sphalerite, replacing Zn. The highest Hg contents in fahlore - up to 4.5% were established in carbonate veinlets of Tepar in the Pskem ridge.

In low-sulfide fluorite deposits, more Hg is found in fluorite, calcite, and, less commonly, galena sphalerite (Table 2).

Table 2: Mercury (n.10^{-6}%) in minerals of deposits of the Chatkal-Kurama Mountains (the denominator is the number of samples)

Deposit and source of information	Ore formation (Mineral Ore Type)	Pyrite	Chalcopyrite	Sphalerite	Galenit	Faded ore	Fluorite	Barite
Kalmakir (Badalov, Moiseeva)	Porphyry copper	100 23	30 1	30 9	1300 2			
Dalnyeye (11)	Porphyry copper	6,1 17	2 2		29 1			
Kumyshkan (Badalov, Moiseeva 1966)	Magnesia-skarn-gelenite sphalerite				30 21			
Kurgashinkan (11)	Magnesia-skarn-gelenite sphalerite	1000 10	2000 1	5000 29	100 1			
Karahana (11)	Skarn-galena-sphalerite	38 4		36 2	26 2			
Altyn-Topkan (24) (Enikeev, Fursov 1968)	Skarn-galena-sphalerite	42 37	59 5	43 5	57 15			
Tashgeze (Enikeev, Fursov 1968)	Skarn-galena-sphalerite	87 26	30 2	76 7	80 10			
Chokadambulak B.O. Yesimov	Skarn-magnetite-bismuthinium	30 2		29 1	13 3			
Lashkerek R.L. Dunin-Barkovsky	Quartz-silver-black ore-galena-sphalerite			34 1	34 3			

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Tepar (9)	Quartz-carbonate-chalcopyrite-black ore		0,3-0,006%			4,5%		
Lachin-Khana (E.A.Dunin-Barkovskaya)	Quartz-barite-fluorite-galena-sphalerite			0,02 %	0,002%	0,002%		
Sarykan (I.P. Zarevich)	Carbonate-galena-sphalerite			10/5				
Vozrojdyonnoye (V.D.Domoryad, M Maksudov)	Carbonate-galena-sphalerite			0,1/11				
Kanimansur (24)	Fluorite-silver bismuthine-galena-sphalerite				53/3		1/2	
Chibargata (24)	Quartz-barite-fluorite						1-5/4	4
Badam (24)	Quartz-barite-fluorite			10/2	52/1		1-55/5	11/4
Dudesai (E.A. Dunin-Barkovskaya)	Quartz-barite-fluorite						1-160/8	1000/2
Kyzyl-Baur (24)	Quartz-fluorite						1-1/3	
Chashli (24)	Quartz-fluorite						1/3	
Naugarzan (24.11)	Galena-sphalerite-fluorite			34/1	29/9		1/3	

RESULTS AND DISCUSSION

The distribution of mercury in ores and host metasomatites at the Lachin-Khana, Tana-Berdy deposits in the Ugam Range, Kumushkan and in the South-Western spurs of the Chatkal Range was studied.

The Lachin-Khana deposit is represented by galena-sphalerite ore in quartz-sericite-carbonate metasomatic rock, formed in zones of tactonic disturbances in carboniferous limestones and overlying volcanogenic sediments of acidic and intermediate composition.

Vein-metasomatic mineralization is represented by quartz-carbonate rock with inclusions and nests of galena, sphalerite, fluorite, barite, formed during the replacement of limestone, and quartz-pyrite-marcasite-kaolin rock with nests and veinlets of galena, sphalerite, fahlore, chalcedony, barite and fluorite - according to effusives. The ores are semi-oxidized and contain a variety of supergene minerals Pb, Zn, Cu, As, Ag, etc. In a section composed of limestones through the ore body, hydrothermally altered volcanic rocks, mercury correlates with Zn, Pb, As, Fe S_2 and Tl in 40 furrow samples. Its maximum concentration - 6.10-4% accompanies the richest areas of ores / Zn - up to 13%, Fe S_2 - up to 11%, Pb - up to 7%. In silicified, kaolinized and pyritized volcanic rocks with impregnation of sphalerite and iron disulfides there is from 7.10-6 to 5.10-4% mercury, and with distance from the ore body - in kaolinized volcanic rocks with impregnation of pyrite - from 5.10-5 to 1.10-5%. The connection of mercury with Zn, Pb, As is due to its presence in hundredths in sphalerite, galena, fahlore, goslarite and, sometimes, plumboyarosite. Mercury was apparently introduced by low-temperature hydrothermal solutions simultaneously with Pb, Zn, Ba, F, Cu, Tl and other ore components.

In the neighboring Tana-Berdi deposit, barite-galena ore bodies located in the crushing zone of limestone C_1 and dolomite D contain 0.03-0.06% Hg.

The Kumushkan Pb-Zn deposit has ore pillars, lenses and disseminated mineralization (galena, sphalerite, pyrite, less often faded ore, chalcopyrite) confined to zones of serpentinization and brusitization of dolomite and limestone in contact with stocks of quartz porphyry and granite porphyry C_3-P_1. In altered rocks, the mercury content is low, in disseminated ores it increases slightly, in massive Pb-Zn ore (galena with pyrite or sphalerite with galena) it increases up to 5-6 times compared to altered rocks (Table 3). The Hg concentration increases sharply only in massive galena-sphalerite ore with a copper content of 0.02-0.03%.

CONCLUSION

In the Chatkal-Kurama region, two sources of mercury are identified for endogenous deposits: mantle, subcrustal for antimony-mercury and gold-antimony mineralization, and from host rocks - for mercury found as an impurity in endogenous ores and halos of lead-zinc, bismuth, etc. deposits.

The formation of a mercury halo around endogenous ores Bi, Pb, Zn, Cu, etc. seems to us to be in three ways: 1 - distillation from the host rocks, 2 - borrowing from them, 3 - input from underlying rocks and dispersion around the ores.

In the studied region, Hg halos are most significantly manifested around ore bodies; Pb, Zn, Au, being in the contour of other chemical elements, carry an informative search feature and can be used independently during geochemical searches.

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