Earth science

UDC 552.161:550.42

MINERAL-PETROCHEMICAL AND GEOCHEMICAL FEATURES OF ULTRAMETAMORPHIC PROCESS OF THE FOCUS-DOME TYPE

I.V. Kucherenko

Tomsk Polytechnic University
E-mail: lev@tpu.ru

Distribution of petrogeneous and oregeneous (Au, Ag, Hg) chemical elements in metamorphic zones of the Kedrovskiy focus-dome construction in Northern Transbaikalia is shown and discussed. The conclusion is drawn about absence of substance essential migration during local focus-dome ultrametamorphism.

Introduction

The problem of metal «behavior» in processes of regional zonal metamorphism of high and low facies is initiated by discussion of another problem – sources of ore substance at hydrothermal deposits formation of uranium, gold, antimony and some other metals in powerful carbonaceous terrigenous strata of large sedimentary pools. In the past decades from the late fiftieth of the last century, in the appendix to gold deposits two variants of its solution were formed.

Conception on carrying over gold from high-temperature zones into low-temperature with the subsequent metal fixing in deposits was and is being developed by many experts [1–13 et al.]. Opposite conclusions on inertness of metals in areals of zonal metamorphism are resulted in [14–19]. N.A. Ozerova points out that even such an astatic metal as mercury – the constant gold satellite in deposits does not migrate from metamorphism high-temperature zones [20]. Thus, till this moment the situation of uncertainty remains. At absence of estimation criteria of opposite results reliability, for example, accuracy and reliability of analyses, presented in some works, it is impossible to exclude that nature is diverse in its displays and in this case each variant of the solution is true.

Possibly, not all the factors that defined migration or inertness of metals hundred millions or billions years ago in conditions of zonal regional metamorphism are possible to take into account in experiment or simulation because some of them are unknown or cannot be reproduced, for example, the factor of geological time. Therefore, at experiment statement or definition of simulation initial conditions some admissions, which adequacy to real natural process in some aspects is not obvious, are inevitable. It is clear that results of experiment or simulation not always can serve as a criterion for reliability of obtained conclusions.

In searches of the problem solution alongside with improvement of experiment conditions further accumulation of empirical materials remains relevant. To achieve the designated goal rather a young mature focus-dome constructions are suitable under condition of all metamorphic aureole section availability including that substratum due to which domes in a mode of local zonal ultrametamorphism are formed. In this case there is an opportunity of petro- and oregeneous elements concentration tracking in rocks of metamorphic zones from domes frame up to their nuclear parts exesectioned by magmatites. At all stages of this work reliability of results can be estimated.

The Kedrovskiy mature focus-dome construction corresponds to specified conditions. Materials of its studying in discussed aspect are presented in this article.

As geology of Kedrovskiy dome was described earlier in a number of author's works, for example, in [21], we shall note the main points.

The Kedrovskiy dome is located in Southern-Muiskiy ridge of Northern Transbaikalia in 10...20 km to the West of the river Tuldun mouth falling into the river Vitim in its average current. Its western studied satellite is located in the central part of same name golden-ore deposit, supervised by the Tuldunskiy zone of abyssal fractures in the East frame of the Muiskiy ledge of archean base and combined in the kernel by stock-like deposit of granodiorites and quartz diorites, taking up the area of 3,5×2,5 km, in a frame of ultrametamorphic rocks and formed 335±5 million years ago, as well as the whole dome in powerful Proterozoic Kedrovskiy strata (series) of carbonaceous sand-aleuroshales alternating in a section with layers of marbleized limestones. The deposit falls according to strata lamination on the east at moderate corners. In continuous rocky exposures of latitudinal boards of the river Tuldun stream Pineginskiy

(10 km to the north) it is possible to see gradual transitions of shales through gneissed shales in gneisses and further in migmatites with gradually increasing in volume leucosoms in direction to a magmatic kernel.

1. Mineral-chemical compound of rocks in mineral zones of the Kedrovskiy dome

Carbonaceous two-mica metamorphosed at a level of muskovite-biotite paragenesis feldspar-quartz sand-aleuroshales of the Kedrovskiy series have dark grey up to black color, shale-like structure, inequigranular from coarse-grained aleurite up to fine-grained sandy structure. Schistosity is concordant to lamination. Inherited bedding of rocks striation is caused by alternation of thin (shares of mm) strips combined of feldspar-quartz and micaceous units with orientation of biotite flakes lengthways of schistosity.

The volume of fragmental fraction varies in a wide range, cement was recrystallized, acquired lepidogranoblastic structure and is reconstructed as basal or contacts. Fragmental material from grain periphery sometimes bears only weak traces of dissolution and recrystallization, so fragments kept basic features of their morphology – mainly rounded less often angular forms.

Table 1. *Chemical compounds of the Кедровской mature focus-dome structure rocks and containing its two-mica carbonaceous sand-aleuroshales of the Kedrovskiy series*

№	Sample number	Content, mass %														Σ
		SiO_2	Al_2O_3	K_2O	Na_2O	S sulfide	CO_2	CaO	MgO	FeO	Fe_2O_3	TiO_2	MnO	P_2O_5	H_2O^+	
1	C1-50,1	65,45	16,85	2,10	3,72	0,00	0,00	4,49	1,81	2,79	1,09	0,48	0,06	0,16	1,38	100,38
2	C1-55,1	67,24	16,05	2,00	3,92	0,02	0,23	4,07	1,71	3,08	0,61	0,41	0,07	0,14	0,42	99,97
3	C1-56,5	65,71	15,96	2,66	3,64	0,01	0,90	3,51	1,81	2,86	0,86	0,41	0,07	0,15	1,43	99,98
4	C1-57,0	66,94	16,32	3,00	3,36	0,00	0,72	2,38	1,71	1,98	0,70	0,41	0,06	0,14	1,92	99,64
5	C1-59,6	67,46	15,78	2,00	3,92	0,00	0,14	4,21	1,41	2,42	1,02	0,40	0,09	0,12	0,88	99,85
6	C1-82,0	66,32	16,85	1,66	3,82	0,01	0,18	3,93	1,61	2,49	1,35	0,44	0,08	0,14	0,82	99,70
7	КБ1-22	62,50	16,50	1,67	3,90	0,05	0,63	3,91	2,11	2,13	3,39	0,51	0,11	0,25	2,33	99,99
8	K-384	62,92	15,06	3,00	2,82	0,00	0,32	1,12	3,30	4,69	2,38	0,50	0,15	0,13	3,33	99,72
9	K-383	60,61	17,12	3,18	2,92	0,04	0,61	0,84	3,40	4,54	2,79	0,53	0,10	0,14	2,72	99,54
10	K-382	61,25	16,41	3,00	2,82	0,04	0,99	2,09	2,60	5,13	2,13	0,50	0,14	0,13	2,98	100,21
11	K-386	64,11	15,60	3,00	1,54	0,01	0,57	1,12	3,40	4,25	2,95	0,68	0,14	0,13	2,93	100,43
12	K-387	64,74	16,00	3,04	1,81	0,00	0,18	0,84	2,71	5,13	1,43	0,60	0,10	0,15	2,76	99,49
13	K-390	61,12	17,10	3,26	1,81	0,00	0,72	1,39	2,81	5,67	1,21	0,68	0,16	0,12	3,60	99,65
14	K-304	62,87	16,50	2,26	4,84	0,01	0,42	2,66	2,50	4,12	1,02	0,77	0,11	0,27	0,83	99,18
15	K-305	70,95	12,55	1,30	3,72	0,00	0,96	1,68	2,00	3,09	1,36	0,55	0,03	0,23	1,37	99,79
16	K-306	60,46	16,59	2,70	4,24	0,01	0,68	2,80	2,80	4,41	2,29	0,95	0,06	0,10	1,17	99,26
17	K-299	59,72	17,30	2,52	2,42	0,05	0,73	2,66	2,90	5,95	1,61	0,75	0,08	0,27	2,24	99,20
18	K-475	60,12	16,87	3,34	3,34	0,03	0,32	2,51	3,21	5,13	1,97	0,80	0,13	0,09	1,83	99,69
19	K-474	66,64	14,50	1,83	3,18	0,00	0,23	4,47	2,21	2,61	2,13	0,58	0,07	0,16	1,24	99,85
20	K-473	65,16	15,78	1,80	3,46	0,00	0,99	3,63	1,81	2,70	1,79	0,49	0,10	0,22	1,75	99,68
21	K-470	62,96	15,78	2,30	3,34	0,00	0,68	3,77	1,91	3,71	1,15	0,94	0,13	0,18	3,26	100,11
22	K-483	62,68	16,14	2,10	2,18	0,04	0,59	4,75	2,51	4,03	2,87	0,92	0,13	0,26	1,62	100,82
23	K-480	61,85	15,96	2,96	2,92	0,00	0,23	2,79	3,14	4,76	2,16	0,93	0,15	0,17	1,54	99,56
24	K-479	63,63	15,96	2,48	3,00	0,00	0,32	3,07	2,61	4,67	1,68	0,88	0,21	0,19	1,37	100,07
25	K-604	59,90	17,50	3,70	1,45	0,01	0,54	1,12	3,22	6,17	2,34	0,72	0,08	0,28	2,48	99,51
26	K-599	59,90	18,85	2,60	2,60	0,05	0,77	1,82	1,55	5,36	2,35	0,92	0,07	0,20	2,93	99,97
27	КП-20	74,52	10,75	2,79	0,79	0,50	0,00	0,67	0,73	1,45	1,47	0,34	0,04	0,05	5,83	99,93
28	K-508	72,56	13,81	3,10	2,86	0,00	0,09	0,79	1,21	2,02	1,59	0,41	0,05	0,40	1,54	100,43
29	K-507	69,35	13,99	4,10	2,76	0,00	0,09	0,67	1,45	3,04	1,73	0,46	0,06	0,41	2,27	100,38
30	K-506	68,92	14,16	4,18	2,48	0,01	0,40	0,67	1,45	2,67	1,82	0,45	0,05	0,26	2,24	99,76
31	K-505	71,36	12,55	3,00	2,66	0,04	0,66	1,01	1,37	2,39	2,13	0,36	0,06	0,28	0,88	98,75
32	K-504	71,61	14,34	2,70	3,20	0,00	0,22	0,56	1,13	1,93	1,53	0,38	0,04	0,39	1,64	99,67
33	K-402	77,26	12,73	0,64	4,96	0,00	0,18	0,84	0,30	1,42	0,66	0,31	0,05	0,03	0,35	99,73
34	K-157	60,53	16,14	2,30	3,34	0,00	0,22	2,13	2,74	3,96	3,59	0,69	0,13	0,19	3,07	99,03
35	K-159	70,91	13,81	1,40	4,30	0,01	0,44	1,80	1,61	1,29	1,76	0,34	0,06	0,40	1,71	99,84
36	K-162	69,27	13,27	2,48	2,50	0,00	0,22	1,23	2,02	3,68	1,66	0,45	0,11	0,39	1,68	98,96
37	K-164	66,05	14,70	1,90	3,50	0,00	0,35	2,47	1,29	3,40	2,61	0,60	0,14	0,41	1,77	99,19
38	K-176	65,30	15,79	3,80	2,90	0,00	0,31	0,79	1,94	3,40	2,61	0,51	0,05	0,33	1,95	99,68
39	K-177	66,33	15,60	3,80	2,50	0,00	0,62	1,12	1,94	3,04	3,01	0,50	0,06	0,24	1,85	100,61
40	K-178	65,96	15,06	2,86	2,90	0,00	0,35	1,12	2,02	3,31	3,87	0,50	0,09	0,43	2,18	100,65
41	K-184	65,41	15,06	2,76	2,00	0,00	0,92	1,23	2,66	4,60	1,60	0,45	0,06	0,43	2,74	99,92

Note. 1) Samples: 1–7 – quartz diorites and granodiorites of the central stock; 8–26 – framing the stock of magmatic rocks almandine-two-mica migmatites and gneisses; 27 – gneissed in the area of gradual transition of ultrametamorphical rocks into metamorphic shales carbonaceous sand-aleuroshale; 28–41 – two-mica carbonaceous sand-aleuroshales of the Kedrovskiy series (Proterozoic), containing focus-dome construction. 2) All rock samples were selected in a subzone of weak change (no more than 10 % of neogenic minerals) of near-ore frontal zone (ore-containing) metasomatic aureole of the Kedrovskiy ore field. 3) Full chemical silicate analyses of rocks were exesectioned in CL PGO «Zapsibgeologiya» (Novokuznetsk) under supervision of I.A. Dubrovskaya

In fragmental fraction and cement participate albite – oligoclase up to andesine (up to 50 wt. %), quartz (up to 50 wt. %) and brown biotite (up to 20 wt. %) with impurity of plates equilibrium with muscovite biotite, crystals of microcline, pale-green tourmaline, drop-like and scaly excretion of graphite with participation of magnetite, zircon and apatite fragments.

Thus, rocks represent metamorphosed (biotite, muscovite, tourmaline) arcose sandstones and aleurolites with preserved structure elements of sedimentary rocks.

In the area of gradual transition into gneisses rocks lose shape of «normal» carbonaceous shales and acquire more massive structure. Fragmental structure of sedimentary rocks is more and more transformed in lepidogranoblastic one due to collective recrystallization, integration and formation of new minerals of high-temperature paragenesis including microcline, diopside (+2*V*=60°, *C*:*Ng*=42°, optic. sign +, *Ng*=1,714, *Np*=1,682), almandine (1,827<N<1,834) in accretion with variable quantity of brown-green biotite, muscovite, quartz, oligoclase-andesine (№ 29, 31, 45) with impurity of sphene, graphite, apatite, zircon, magnetite. Similar structure and content acquire «normal» gneisses and formed due to limestones calciphyres where diopside is diagnosed on the following crystallooptical constants: +2*V*=60°, *C*:*Ng*=38°, optic. sign +, *Ng*=1,718, *Np*=1,686. Content of calcite reaches up to 50 wt. %. Gneisses texture differs in complexity of pattern resembling microfolded forms and emphasizes different quantitative parities of gneisses melanocratic substratum and migmatite melt leucocratic substratum down to shadow migmatites which gradually transform into «normal» granodiorites and quartz diorites kernels.

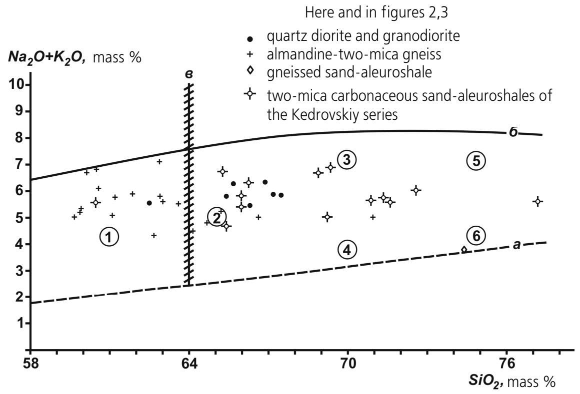

Fig. 1. *Position of two-mica carbonaceous sand-aleuroshales of the Kedrovskiy series, ultrametamorphites and magmatites of the Kedrovskiy focus-dome structure on diagram SiO_2 – (Na_2O+K_2O). The bottom borders of magmatic rocks chemical compounds distribution (a), moderately alkaline magmatic rocks (б); border of division of magmatic rocks on groups based on silica content with «field of uncertainty». Distribution areas of different kinds of magmatic rocks: 1) quartz diorites, 2) granodiorites, 3) granites, 4) low-alkaline granites, 5) leucogranites, 6) low-alkaline leucogranites. Borders of magmatic rocks chemical compounds distribution are borrowed from [22]*

Quartz diorites and granodiorites differ in massive structure and average-crystalline (up to 5 mm) hypidiomorphogranular structure. In their structure prevail oligoclase-andesine (№№ 22–36, up to 60 vol. %), quartz (up to 15 vol. % in quartz diorite and up to 20 vol. % in granodiorite), brown biotite. Secondary minerals – green horn amphibole (–2*V*=84°, *C*:*Ng*=16°, optic sign –, *Ng*=1,678, *Np*=1,654) with relicts of early augite, potassic feldspar (ingranodiorites). Accessories – apatite, magnetite, zircon, sphene.

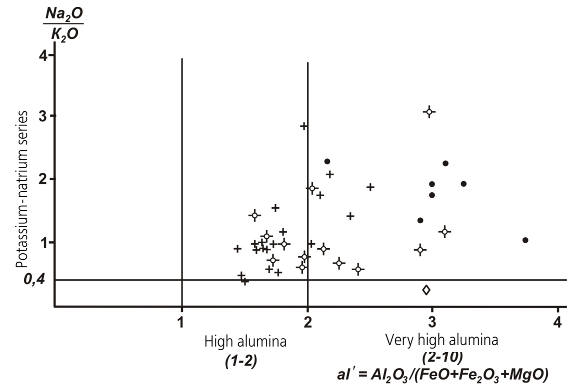

Fig. 2. *Position of two-mica carbonaceous sand-aleuroshales of the Kedrovskiy series, ultrametamorphites and magmatites of the Kedrovskiy focus-dome structure on diagram Na_2O/K_2O – $al'= Al_2O_3/(MgO+FeO+Fe_2O_3)$. Symbols in Fig. 1*

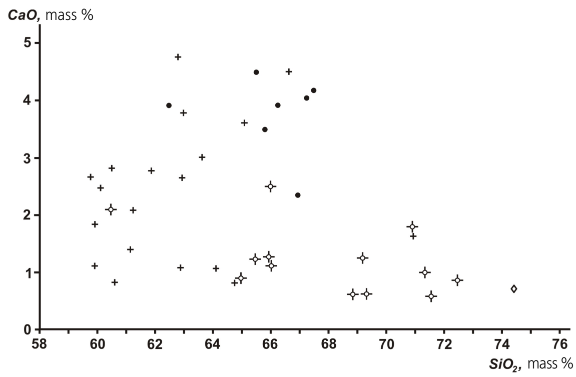

Fig. 3. *Position of two-mica carbonaceous sand-aleuroshales of the Kedrovskiy series, ultrametamorphites and magmatites of the Kedrovskiy focus-dome structure on diagram SiO_2 – CaO*

Chemical compounds and petrochemical parameters of rocks are shown in Table 1 and in Figures 1–3.

Significant variations of silica content (Fig. 1) are peculiar to shales and gneisses formed at their expense. Figurative points of these rocks compounds are only partially combined, but basically form independent fields. On the contrary, figurative points of magmatic rocks compound are included in comparatively compact group under silica compound occupying an intermediate position between shales and gneisses. Total (general) alkalinity of all rocks is approximately identical and corresponds to average igneous rocks of a normal row.

On the diagram (Fig. 2) figurative points of all rocks are distributed rather compactly, – rocks correspond to potassium-natrium petrochemical series but possess moderate index of leucocraticity usually not exceeding 3. Fields of shales and gneisses are combined; granodiorites are more isolated in direction of increase in leucocraticity.

In ratio of silicity – calcicity (Fig. 3) rocks of all kinds are noticeably differentiated. Shales are referred to low and moderately calcic but high-siliceous, gneisses possess low and moderated calcicity and low silicity, granodiorites are moderately siliceous, but distinguished in high calcicity.

2. Distribution of oregeneous elements in mineral zones of the Kedrovskiy dome

Content in rocks of geochemically closely connected metals – gold, silver, mercury, forming in ores a natural alloy is analyzed. As well as for chemical silicate analysis, samples were selected at distant periphery of large-volume near-ore metasomatic aureole of the Kedrovskiy ore field where changes of rocks are minimal occurred basically due to internal resources (except for CO_2) and, hence, content of petro- and oregenous elements are close to those in the initial unchanged rocks [21, 23]. This, in particular, can be seen on the example of almandine-two-mica gneisses and migmatites which part of samples was possible to select from unchanged rocks outside of the aureole (Table 2). Only in a subzone of the external zone intensive change the content of silver in comparison with content of metal in a subzone of weak and moderate change is noticeably raised in shales. This selection is not involved in the comparative analysis.

Content of gold, dispersion of its distribution are low in all rocks – in carbonaceous shales, gneisses and migmatites, granodiorites and quartz diorites. Content of silver according to clark is higher by one or one and a half and also dispersion of its distribution is comparable in shales and granodiorites but slightly lowered in gneisses and migmatites. Gold-silver correlation does not exceed 0,06. High direct correlation connection of gold with silver and mercury is fixed accordingly in granodiorites and carbonaceous shales. Mercury, similarly to silver, contains in comparable quantities in shales and magmatites but lowered – in gneisses and migmatites at slightly varying dispersion.

Table 2. *Distribution parameters estimation of oregeneous elements and correlation connections of gold with oregeneous elements in rocks of the Kedrovskiy focal-dome structure and containing its carbonaceous sand-aleuroshales of the Kedrovskiy series*

Elements	Distribution parameters	Mineral zones of near-ore metasomatic aureoles {number of samples}				
		Zero (unchanged rocks outside of the aureole)	External			
			Mineral subzones of weak, moderate, intensive change			
			Weak	Moderate	Weak+moderate	Intensive
Quartz diorites and granodiorites of the central deposit						
Au	$\overline{x_г}(\overline{x})$				0,7(0,8) {25}	0,8(1,0) {6}
	$t(s)$				1,4(0,4)	2,1(1,1)
Ag	$\overline{x_г}(\overline{x})$				19,8(26,0) {25}	27,1(28,7) {6}
	$t(s)$				1,9(27,0)	1,4(11,9)
	$r(sr)$				**0,55**(0,16)	**0,93**(0,05)
	Au/Ag				0,035	0,03
Hg	$\overline{x_г}(\overline{x})$				18,0(19,3) {25}	24,2(29,3) {6}
	$t(s)$				1,5(7,9)	2,0(19,5)
	$r(sr)$				-0,15(0,23)	-0,41(0,34)
Almandine-two-mica gneisses and migmatites of deposit frame						
Au	$\overline{x_г}(\overline{x})$	0,7(0,7) {9}	0,7(0,8) {19}	0,9(1,0) {13}		1,1(1,2) {12}
	$t(s)$	1,4(0,2)	1,5(0,3)	1,6(0,7)		1,5(0,5)
Ag	$\overline{x_г}(\overline{x})$	16,8(19,9) {9}	13,5(17,9) {19}	14,7(17,5) {13}		16,0(19,7) {12}
	$t(s)$	1,8(13,1)	1,9(20,0)	1,9(10,0)		1,9(14,8)
	$r(sr)$	0,22(0,32)	0,01(0,23)	0,13(0,27)		-0,02(0,30)
	Au/Ag	0,04	0,05	0,06		0,07
Hg	$\overline{x_г}(\overline{x})$	10,2(12,3) {9}	13,4(22,1) {19}	14,9(19,9) {13}		24,3(35,9) {12}
	$t(s)$	1,9(8,8)	2,6(25,0)	2,0(20,7)		2,5(34,3)
	$r(sr)$	-0,07(0,33)	**0,39**(0,19)	-0,20(0,27)		-0,01(0,30)
Carbonaceous sand-aleuroshales (muscovite-biotite paragenesis)						
Au	$\overline{x_г}(\overline{x})$		1,2(1,6) {37}	0,7(1,5) {15}		1,1(1,7) {23}
	$t(s)$		2,1(1,5)	2,9(2,7)		2,7(1,6)
Ag	$\overline{x_г}(\overline{x})$		26,7(32,1) {37}	23,3(26,0) {15}		56,6(91,7) {23}
	$t(s)$		1,9(20,9)	1,6(13,9)		2,6(116,6)
	$r(sr)$		0,001(0,2)	**0,79**(0,11)		0,22(0,21)
	Au/Ag		0,04	0,03		0,02
Hg	$\overline{x_г}(\overline{x})$		18,0(26,3) {37}	28,3(34,7) {15}		22,0(30,4) {23}
	$t(s)$		2,8(20,7)	2,1(18,7)		2,2(27,0)
	$r(sr)$		**0,35**(0,16)	**0,50**(0,22)		0,20(0,21)

Note. Here and in Table 3: $\overline{x_г}(\overline{x})$ – average accordingly geometrical and arithmetic content, mg/t; t – standard multiplier; s – standard deviation of mg/t content; r – factor of pair linear correlation of elements with gold, above significance value is designated by bold font; sr – standard deviation of correlation coefficient. Content of Au and Ag was defined by the nuclear-absorption method (sensitivity 0,1 mg/t) in the laboratory of nuclear-physical methods of analysis of OIGGandM the Siberian Branch of the Russian Academy of Science (Novosibirsk, analyst – V.G. Tsimbalist). Content of Hg was defined by nuclear-absorption method (sensitivity 1,0 mg/t) in CL PGO «Berezovgeologiya», (Novosibirsk city) under supervision of N.A. Charikov. Estimation of analytical works quality is exesectioned in [23]. Calculations were exesectioned by N.P. Orekhov

2. Discussion of results and conclusion

Formation of the late-Paleozoic Kedrovskiy focus-dome structure anticipates formation of huge Angaro-Vitimskiy granitoid batolite located somewhat to the south and, possibly, is connected with its formation under the influence of mantle plume – the generator of high-temperature fluid-heat-carriers. Ultrametamorphic process was accompanied by substratum local fusion with magmatic kernel formation of focus-dome construction. Gradual transitions from kernel magmatic rocks through migmatites into gneisses, and the latter through gneissed carbonaceous shales into two-mica metamorphic shales prove the formation of the Kedrovskiy dome due to local ultrametamorphism and palingenesis of the carbonate-terrigenous Kedrovskiy strata. It allows for estimation of chemical compound evolution and geochemical features of the initial substratum during ultrametamorphism.

Taking into consideration an origin of ultrametamorphic derivatives, it would be expected that their chemical composition is inherited from shales up to magmatites which, however, is expressed not by all petrochemical parameters. It is revealed in preservation of rather narrow interval of all rocks general alkalinity fluctuations and in conformity to its normal alkalinity level of granodiorites and quartz diorites. Complete succession in chemical composition of gneisses and migmatites from shales is expressed also in an accessory of those and other rocks to potassium-natrium petrochemical series and in a narrow interval of index changes of their petrochemical leucocraticity. Low silicity of gneisses and migmatites as compared to other rocks in the majority of tests, judging by presence in the sample and high-siliceous ultrametamorphites is most likely to be caused, on the one hand, by wide variations of silica content in initial rocks

Table 3. *Distribution parameters estimation of oregeneous elements and correlation connections of gold with oregeneous elements in ultrametamorphic rocks of the of the Archean base Muyskiy ledge of the Siberian cratone (in volume of the Irokindinskiy ore field)*

Elements	Distribution parameters	Mineral subzones of weak, moderate, intensive change of the external zone of near-ore metasomatic aureoles {number of samples}		
		weak	moderate	intensive
Granites of magmatic melt				
Au	$\overline{xг}(\bar{x})$	0,6(0,7) {28}	0,6(0,7) {10}	0,6(0,7) {17}
	$t(s)$	1,6(0,4)	1,4(0,2)	1,4(0,2)
Ag	$\overline{xг}(\bar{x})$	47,9(70,3) {28}	58,9(77,2) {10}	47,3(54,8) {17}
	$t(s)$	2,4(71,6)	2,4(50,2)	1,8(27,3)
	$r(sr)$	0,18(0,27)	−0,08(0,35)	0,28(0,28)
	Au/Ag	0,01	0,01	0,01
Hg	$\overline{xг}(\bar{x})$	20,6(24,1) {28}	21,8(28,3) {10}	16,2(30,1) {17}
	$t(s)$	1,7(16,6)	2,2(20,9)	2,5(55,1)
	$r(sr)$	−0,15(0,27)	**–0,58**(0,24)	−0,20(0,29)
Almandine-diopside-two-feldspar gneisses				
Au	$\overline{xг}(\bar{x})$	0,7(1,1) {29}	0,6(0,7) {48}	0,7(0,7) {29}
	$t(s)$	2,1(1,8)	1,5(0,3)	1,5(0,3)
Ag	$\overline{xг}(\bar{x})$	35,7(43,9) {29}	50,0(55,9) {48}	60,3(85,3) {29}
	$t(s)$	1,8(36,8)	1,7(25,3)	2,2(95,1)
	$r(sr)$	**0,73**(0,12)	0,02(0,20)	0,38(0,22)
	Au/Ag	0,02	0,01	0,01
Hg	$\overline{xг}(\bar{x})$	17,1(22,0) {29}	15,6(18,2) {48}	19,3(34,4) {29}
	$t(s)$	2,0(17,0)	1,7(11,5)	2,4(56,5)
	$r(sr)$	-0,07(0,19)	**–0,36**(0,13)	−0,10(0,18)
Almandine-two-mica gneisses				
Au	$\overline{xг}(\bar{x})$	0,5(0,6) {30}	1,2(1,4) {17}	1,9(2,5) {15}
	$t(s)$	1,3(0,2)	1,7(0,7)	2,4(1,7)
Ag	$\overline{xг}(\bar{x})$	36,2(43,1) {30}	33,3(42,4) {17}	42,5(52,4) {15}
	$t(s)$	2,2(19,3)	2,3(25,9)	2,0(32,5)
	$r(sr)$	0,12(0,33)	**0,61**(0,19)	−0,32(0,26)
	Au/Ag	0,01	0,036	0,04
Hg	$\overline{xг}(\bar{x})$	19,4(21,4) {30}	21,2(23,4) {17}	17,0(19,7) {15}
	$t(s)$	1,6(9,5)	1,6(10,0)	1,7(11,8)
	$r(sr)$	−0,46(0,26)	−0,23(0,29)	0,19(0,28)
Calciphyres				
Au	$\overline{xг}(\bar{x})$	0,9(1,2) {25}	0,9(1,4) {23}	0,9(1,0) {6}
	$t(s)$	2,1(1,7)	2,3(1,9)	1,8(0,6)
Ag	$\overline{xг}(\bar{x})$	42,5(53,4) {25}	30,9(36,1) {23}	44,4(47,6) {6}
	$t(s)$	2,2(32,1)	1,9(20,2)	1,5(20,8)
	$r(sr)$	**0,75**(0,17)	0,09(0,37)	**0,80**(0,16)
	Au/Ag	0,02	0,03	0,02
Hg	$\overline{xг}(\bar{x})$	23,8(29,6) {25}	21,6(32,4) {23}	32,5(39,6) {6}
	$t(s)$	2,0(19,9)	2,3(35,3)	2,1(25,5)
	$r(sr)$	−0,36(0,33)	−0,54(0,27)	−0,06(0,45)

and, on the other hand – by inclusion in sample of random variables of gneisses and migmatites samples formed due to low-siliceous shales. Peculiar to magmatic rocks moderated silicity and compared with other rocks high value of petrochemical leucocraticity index is consequence of absorption by palingenic melt of not only siliceous rocks, but also by limestones of the Kedrovskiy strata and its increase in calcicity (Fig. 3).

All this forms the basis for assumption on ultrametamorphic and magmatic substratum of the Kedrovskiy dome as reflecting in general view chemical compound of carbonate-terrigeneous bearing strata.

Content of the triad metals, dispersion parameters of their distribution, gold-silver correlation in rocks of all mineral zones of the Kedrovskiy dome are quite comparable, which emphasizes the absence of attributes of their migration in the aureole in general and from high-temperature zones into low-temperature. It is equally necessary to ascertain the similarity in values of content and distribution of gold and mercury in ultrametamorphic and magmatic rocks of the Kedrovskiy dome and the Archean substratum of the Siberian cratone Muyskiy ledge (Table 3), content similarity of gold in rocks of the Kedrovskiy dome and in similar formations of the Central anticlinorium of the Yenisei [24, 25] and Leninskiy [26] areas. Higher content of silver in rocks of the Archean base in the Muyskiy ledge compared with rocks of the Kedrovskiy dome is connected, possibly, with geochemical features of the initial for Archean ultrametamorphic rocks substratum.

REFERENCES

1. Petrov B.V., Krendelev F.P., Bobrov V.A. et al. Behavior of radioactive elements and gold at metamorphism of sedimentary rocks of the Patomskiy uplands // Geochimiya. – 1972. – № 8. – P. 947–956.
2. Buryak V.A. About gold-bearing ability of sedimentary strata and gold behavior in them during the process of metamorphism and granitization // Geology and Geophysics. – 1978. – № 6. – P. 142–146.
3. Davydchenko A.G. Substance migration in metamorphism zones. – Moscow: Nedra, 1983. – 123 p.
4. Zlobin V.A., Tsimbalist V.G. Ignition effect and problem of gold mineralization formation in black-shale strata // Genetic Models of Endogenic Ore-formations. – V. 2. – Novosibirsk: Nauka, 1983. – P. 162–169.
5. Zabiyaka I.D., Zabiyaka A.I., Vernikovskij V.A. et al. Role of regional metamorphism in gold concentration in pre-Cambrian rocks of the Taimyr // AS of the USSR reports. – 1983. – V. 269. – № 6. – P. 1430–1433.
6. Komarov U.V., Kopylov E.N., Belogolovkin A.A. et al. The Baikal metaarch (structure, magmatism, metallogeny). – Novosibirsk: Nauka, 1984. – 120 p.
7. Belevtsev Ja.N. Development of the metamorphogenetic ore-formation theory // Regional Metamorphism and Metamorphogenetic Ore-formation / Edited by Ja.N. Belevtsev. – Kiev: Naukova dumka, 1984. – P. 5–33.
8. Valasis A.G., Коваль V.B. Thermal domes, zonal metamorphism and oregenesis // AS of the USSR reports. B Series. – 1987. – № 7. – P. 11–15.
9. Korikovskiy S.P. Metamorphic ore-forming systems // Endogenous Sources of Ore Substance. – Moscow: Nauka, 1987. – P. 80–89.
10. Roslyakov N.A., Kalinin U.A. Geochemistry and auric ability of green-shale strata MNR // Relevant Questions of Siberian Geology: Materials of the Scientific Conf. devoted to the 100-th anniversary of Tomsk State University, Tomsk, December 13–15, 1988. – V. 1. – Tomsk: Tomsk State University Press, 1988. – P. 224–226.
11. Vaulin O.V., Kirsanov A.V. Influence of regional metamorphism on migration of oregeneous elements in carbonaceous deposits of the Turkestanskiy ridge // West Uzbekistan. – 1990. – № 43. – P. 105–110.
12. Azhgirej D.G., Svetlov S.A., Gurejkin N.J. et al. Connection of gold mineralization with plutonic metamorphism in miogeocycline area of the Southern Tyan-Shan // Ores and Metals. – 2000. – № 4. – P. 47–52.
13. Parada S.G. Formation conditions and mineralization of black-shale complexes of the Amuro-Ohatskaya folded area. – Rostov-na-Donu: Rostov State University Press, 2004. – 48 p.
14. Lee L.V. About connection of golden-ore deposit formation with processes of progressive regional metamorphism in the Yeniseiskiy range // Ore-bearing Ability and Metallogeny of the Yeniseiskiy Range Structures. – Krasnoyarsk: Krasnoyarsk Publishing House, 1974. – P. 102–113.
15. Choreva B.Ja. Large-scale mapping of metamorphogenetic thermal anticlines (at searches of golden-ore deposits) // Geology and Geophysics. – 1987. – № 11. – P. 67–73.
16. Blueman B.A. Golden-ore «black-shale» formation: the mutual relations model of regional metamorphism, granite- and ore-formation // Ore-formation and Genetic Models of Endogenous Ore Formations. – Novosibirsk: IGandG SO AS of the USSR, 1988. – P. 135–141.
17. Makrygina V.A., Razvozzhaeva E.A., Martichaeva D.H. Organic substance and microelements during metapelite metomorphism process (Chamar-Daban, Southwest Pribaikalye) // Geochemistry. – 1991. – № 3. – P. 358–369.
18. Dolzhenko V.N. Gold-bearing strata of the Kyrgyzstan Pre-Cambrian and Paleozoic // Geochemistry. – 1993. – № 11. – P. 1620–1628.
19. Mironov A.G., Bahtina O.T., Zhmodik S.M. et al. New type of gold mineralization in stratiformed pyrrhotite ores of the East Sayana // RAS Reports. – 1999. – V. 365. – № 6. – P. 798–801.
20. Ozerova N.A. Mercury and endogenous ore-formation. – Moscow: Nauka, 1986. – 232 p.
21. Kucherenko I.V. Geochemical features of near-vein metasomatism in quartz diorites and granodiorites of the Kedrovskiy golden-ore deposit focus-dome construction (Northern Transbaikalia). P. 1. Bedding conditions and identification of magmatic rocks // Bulletin of the Tomsk Polytechnic University. – 2006. – V. 309. – № 2. – P. 41–45.
22. Andreeva E.D., Baskina V.A., Bogatikov O.A. et al. Magmatic rocks. – P. 2. – Moscow: Nauka, 1985. – 767 p.
23. Kucherenko I.V., Orechov N.P. Gold, silver, mercury in gold-bearing apogneissed and aposhaled near-ore metasomatic aureole of the beresite formation // Bulletin of the Tomsk Polytechnic University. – 2000. – V. 303. – № 1. – P. 161–169.
24. Nozhkin A.D., Krendelev F.P., Mironov A.G. Gold in magmatism and metamorphism processes on the example of Northeast of the Yenisei range // Gold and Rare Elements in Geochemical Processes. – Novosibirsk: Nauka, 1976. – P. 54–70.
25. Sazonov A.M. Mineralogo-geochemical attributes of gold mineralization metamorphogenetic genesis of Middle Siberia // Distinction Criteria of Meamorphogenetic and Magmatogene Hydrothermal Deposits. – Novosibirsk: Nauka, 1985. – P. 47–53.
26. Buryak V.A. Metamorphism and ore-formation. – Moscow: Nedra, 1982. – 256 p.

Received on 12.12.2006