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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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PATTERNS OF DISTRIBUTION OF RARE METAL DEPOSITS IN CENTRAL KAZAKHSTAN

Abstract. The article considers the main patterns of location in Central Kazakhstan of greisen-quartz-vein tungsten, molybdenum and beryllium deposits, as well as copper-molybdenum-porphyry deposits from which molybdenum is mined as a co-component. We analyzed the patterns of deposit location mainly from three perspectives: 1) magmatic control; 2) distribution over time; 3) structural control. Magmatic control of Cu-Mo-porphyry deposits is determined by their genetic connection with sodium-type orogenic granitoids ($K_2O/Na_2O<0.85$) or kalium-sodium ones (K_2O/Na_2O = 0.85-1.15). The ore-bearing intrusives are specific "porphyry" differentiates of the granodiorite phase, the additional intrusives. Magmatic control of rare metal deposits is determined by their genetic connection with the leucogranite-series intrusives. Both classes of deposits, Cu-Mo-porphyritic and rare-metal ones, are manifested in Central Kazakhstan in multiple occasions: the first class at six age levels (O_1, O_3, S_2, D_3, C_1, C_3), the second class at six levels likewise (S_1, S_2, D_2, D_3, C_3, P_1). Structural control of Cu-Mo-porphyry deposits is determined by their connection with the granodiorite formation bodies, whereas rare metal deposits are located in two tectonic positions: essentially molybdenum deposits are in connection with the late orogenic leucogranite formation, and the most of complex rare metal deposits are confined to synorogenic tectonomagmatic activation zones.
Keywords: Central Kazakhstan, magmatic, structural control, age of rare metal deposits.

Introduction. The article deals with the patterns of location of greisen quartz-vein tungsten, molybdenum and beryllium deposits in Central Kazakhstan. Since only molybdenum is produced from among the named metals in the Central Kazakhstan region during the development of copper-molybdenum-porphyry deposits, a number of deposits of this type are involved in the analysis.

Altogether these types of deposits constitute the vast majority of all rare metal deposits in Central Kazakhstan. Beyond the completed analysis there were individual deposits of tin, niobium, tantalum, and zirconium. All of these are small deposits (rarely up to medium), and often these are large shows of ore classified as small deposits for the future perspective. The deposits considered in the article are shown in figure 1.

We considered the patterns of location of deposits mainly from three perspectives: 1) magmatic control; 2) distribution in time; 3) tectonic association.

1. Magmatic control of mineralization. As will be shown below, each fold system witnesses the formation of Cu-Mo-porphyry deposits (orogenic stage), and after that rare-metal deposits (late orogenic sub-stage) are formed. We will consider the deposits in this priority.

1.1. *Genetic relations of Cu-Mo-porphyry mineralization with magmatism.* Based on the study of about 40 Cu-Mo-porphyry objects, this issue was considered in [1]. It was established that Cu-Mo-porphyry mineralization is genetically related to orogenic calc-alcalic granitoids of predominantly sodium series (K_2O/Na_2O < 0.85), more rarely to potassic-sodium granitoids (K_2O/Na_2O = 0.85-1.15). These connections are established not with the granitoids themselves, but with specific differentiations of the second, granodiorite, phase of the intrusive massifs, which are extremely porphyraceous rock of additional intrusives that complete the second phase and are commonly referred to as "porphyrites". In fact, these ore-bearing rocks can be called porphyrites only figuratively due to their sufficient crystallization. For

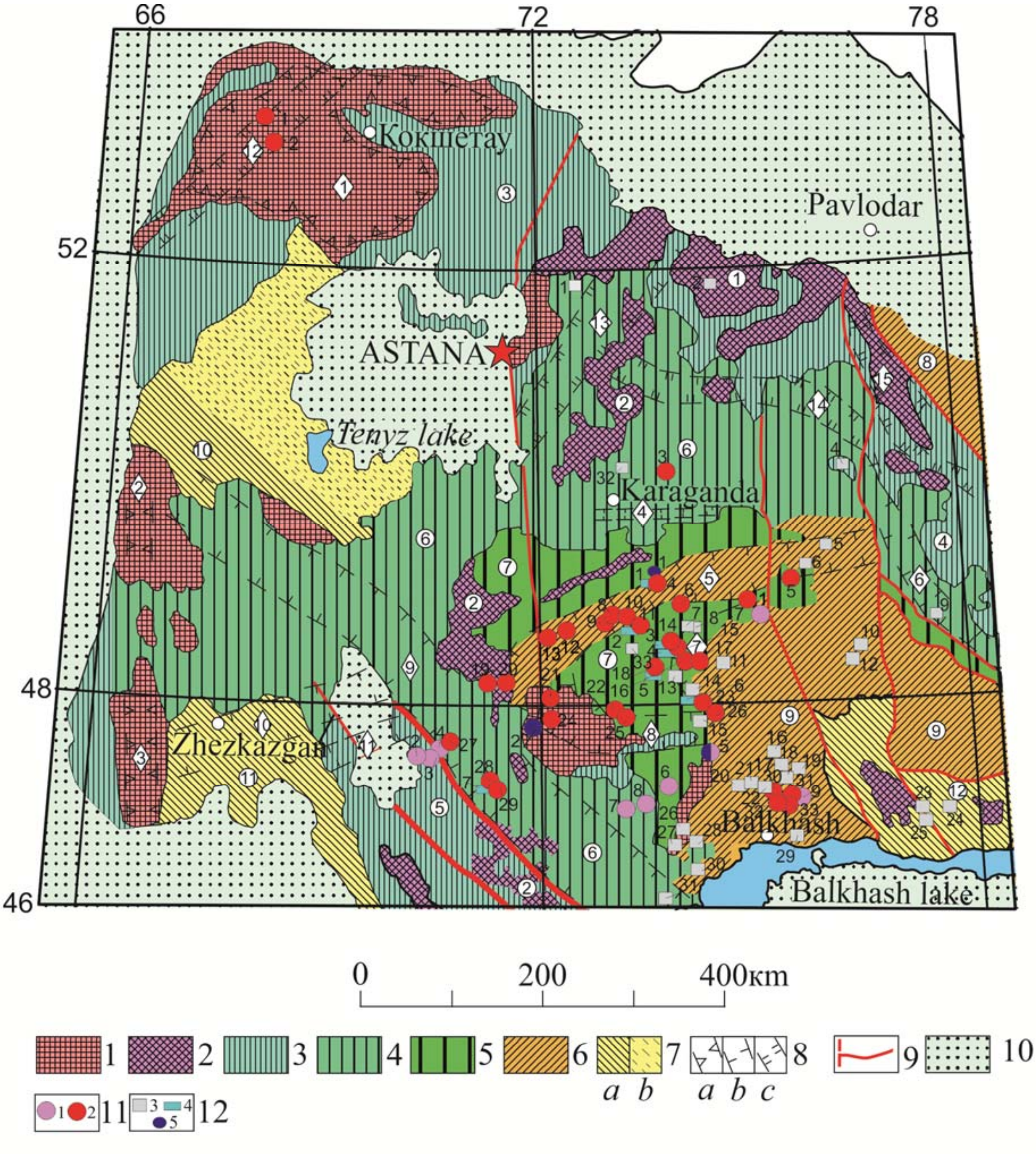

Figure 1. Diagram of location of rare metal deposits of Central Kazakhstan
Compiled by V.I. Serykh and A.N. Kopobayeva. Tectonic zoning according to [2].

Legend: **1** - projections of Precambrian basement. **2-7** - Paleozoic folded areas (figures in circles): **2** - Salair (Bozshakol - 1, Yereymentau-Burubaitalsky Rift - 2, etc). **3** - Early Caledonian (Stepnyakskaya - 3, Chingiz-Tarbagatay - 4, Chu-Balkhash - 5), **4** - Middle Caledonian (Central Kazakhstan - 6), **5** - Late Caledonian (Zhamansarysu - 7), **6** - Early Hercynian (Zaisanskaya - 8, Dzungaro-Balkhashskaya - 9), **7** - Late Hercynian (South Teniz -10, Zhezkazgan-11, Sayak-12), **8** - zones of tectonomagmatic activation (TMA) (figures in rhombuses): a) Caledonian (Kokshetau - 1, Arganatanskaya - 2, Ulytauskaya - 3), b) Early Hercynian (Spasskaya - 4, Uspenskaya - 5, South-Chingiz - 6, East-Zhamansarysu - 7, Akbastau-Akzhal - 8, Zhailma-Karaobinskaya - 9, Uitas-Zhezkazgan -10, Kenzhebai-Zhamanaybat-11) c) Late Hercynian (Chaglinskaya - 12, Koitas - 13, Bayanaulskaya - 14, Tleumbetskaya - 15). **9** - the main faults. **10** - platform cover. **11** - deposits: 1) molybdenum, 2) tungsten, tungsten-molybdenum, complex; **12**-3 - copper-molybdenum, **12**-4 - placers, **12**-5 - beryllium.

example, the grain size in the rock of the Kounrad ore-bearing stock is 0.02-0.10 mm, and those in the Baysky stock is even 0.05-0.20 mm. Of course, these are not volcanic and not subvolcanic porphyrites. If we still call it "porphyrites", then only adding the definition "plutonic porphyrites". This is confirmed by geological relations (mineralization intersects post-ore aplite veins), the same absolute age of the ore-forming intrusive complex and ore-bearing porphyraceous rocks, the same petrochemical type (sodium granodiorites - sodium "porphyrites", potassic-sodium granodiorites - potassic-sodium "porphyrites"), the greatest water content of granodiorite magmas [3], wide development of acid leaching processes in the abovementioned and other types of rocks and by other common features.

The study [1] assumed the possibility of the connection between individual Cu-Mo-porphyraceous occurrences with subalkaline granitoids. However, further elaboration on the composition of such rocks and their bonds with Cu-Mo-porphyraceous ores did not confirm these assumptions.

1.2. *Genetic relations of rare metal deposits with magmatism.* Due to the fundamental paper [4], a fairly stable opinion was established that the Hercynian rare metal deposits are genetically related to the ultra-acidic intrusives (SiO_2 > 73%); in today's nomenclature they are subgranites, leucogranites, and alkali-feldspar leucogranites (table 1).

Table 1 – The average chemical composition of leucogranite family rocks, weight % [5]

Rocks	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	Loi
Orogenic granitoids *													
Diorites	55.29	0.84	16.90	2.92	5.23	0.17	4.38	7.41	3.09	1.44	0.20	0.23	1.67
Quartzitic diorites	60.86	0.67	16.45	2.22	3.97	0.11	2.74	4.75	3.61	2.34	0.20	0.14	1.31
Grano-diorites	65.47	0.53	15.77	1.67	3.18	0.09	1.76	3.71	3.84	2.56	0.16	0.18	0.96
Plagio-granites	70.14	0.31	14.81	1.27	2.15	0.06	0.99	2.12	4.49	2.48	0.12	0.32	0.73
Granites	70.54	0.33	14.52	0.96	2.28	0.06	0.84	1.97	3.73	3.77	0.12	0.11	0.58
Late-orogenic granitoids													
Subgrani-tes *	73.94	0.20	13.50	0.85	1.47	0.05	0.45	1.16	3.37	4.50	0.06	0.10	0.36
Leucogra-nites	75.20	0.15	13.04	0.63	1.44	0.05	0.23	0.73	3.52	4.66	0.04	0.10	0.24
* Subgranites are intermediate rocks between granites and leucogranites.													

Table 2 – The average chemical composition of granitoids of tectonomagmatic activation resonance zones, weight % [5]

Rocks	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	Loi
Granitoids, synchronous, orogenic stage													
Diorites	55.29	0.84	16.90	2.92	5.23	0.17	4.38	7.41	3.09	1.44	0.20	0.23	1.67
Quartz monzo-diorites	61.68	0.66	15.79	2.20	3.95	0.10	2.66	4.40	3.26	3.59	0.20	0.10	1.09
Monzo-granodiorites	65.83	0.51	15.26	1.69	2.83	0.07	1.92	3.47	3.20	4.03	0.18	0.55	0.65
Monzo-granites	70.89	0.32	14.29	1.09	2.09	0.05	0.71	1.81	3.22	4.30	0.11	0.16	0.57
Granitoids, synchronous, late orogenic stage													
Leucogranites	75.20	0.15	13.04	0.63	1.44	0.05	0.23	0.73	3.52	4.66	0.04	0.10	0.24
Alkali-feldspar leucogranite	75.55	0.12	12.77	0.41	1.00	0.04	0.21	0.41	3.66	4.59	0.04	0.09	0.31

Over time, the opinion on the connection of rare metal deposits with ultra-acidic magmas in Balkhash region solidified and was confirmed by facts. It was found that mineralization is associated with each intrusive phase of leucogranite complexes, i.e. it actually got inside the intrusive complex and its connection with the complex became obvious. The correlation of intrusive phases and rare metal mineralization is shown in figure 2.

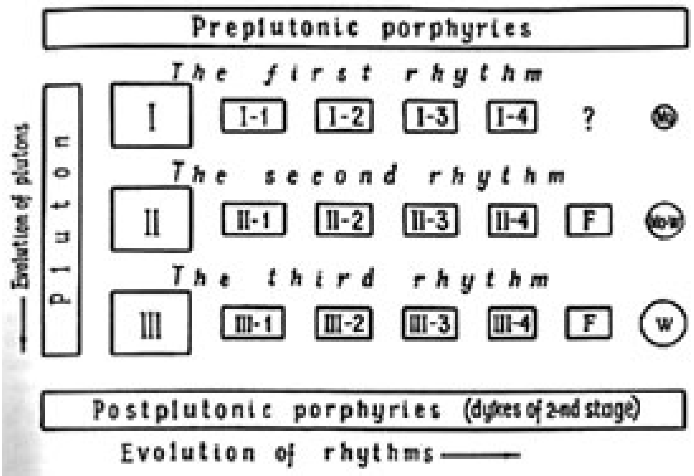

Figure 2 –
General sequence of formation
of leucogranite plutons [6].
I, II, III – the main intrusives;
I-1, II-1, III-1 – additional intrusives;
I – 2÷4, II – 2÷4, III – 2÷4 –
sheet-like bodies, dikes and
veins of aplitoid leucogranites and aplites;
F – dikes of fluid-saturated granite-porphyrites
and microcline-albite granites;
Mo, W – ore deposits

Table 3 – Periodicity of occurrence of copper-porphyry and rare metal deposits
in the polycyclic folded area of Central Kazakhstan (according to [7], with some additions and clarifications)

Megacycle	Cycle	Orogenic stage		Synorogenic activation of the consolidated frame	
		orogenic stage	**late-orogenic sub-stage**	**synchronous with orogenic stage**	**synchronous with late-orogenic sub-stage**
		The ore-bearing intrusive complex (q. diorites, Na-granodiorites, plagiogranites), age; *Cu-Mo-porphyry deposits (age)*	**Rare-metal intrusive complex (subgranites, leucogranites), age; *Rare-metal deposits (age)***	**The ore-bearing intrusive complex (sq. monzodiorites, K-Na and K-granodiorites, K-granites), age; *Cu-Mo-porphyry deposits (age)***	**Rare-metal intrusive complex (leucogranites, alkaline-feldspar leucogranites), age; *Rare-metal deposits (age)***
Caledonian	Initial (Salair)	Bozshakolsky, O_1; ***Bozshakol (O_1)***	?	?	?
	Early Caledonian (Taconian)	Krykkuduksky, O_3; ***Koktaszhal, Kyzyltu (O_3)***	Karabulak (Zhamankoitassky),S; ***ore occurrences W, Mo, Bi (S_1)***	Zerendinsky, O_3-S_1; ***Cu-Mo ore occurrences in Shat-sky anticlinorium*** *(S_1)*	Zolotonoshsky, S_2; ***Bayan – W, Mo, Sn, Syrymbet – Sn,*****W,Bi *(S_2)***
	Middle Caledonian (Erian)	Karamendinsky, chetsky (S_2-D_1); ***Nurkazgan (S_2)***	Kilchinsky, Korneevsky, D_2; ***Shalgiya, Bugul-Mo, Ulyanovskkoye – W, Mo; an others (D_2)***	*	*
	Late Caledonian (Breton, Telbessky)	Zhangeldinsky, D_3; ***Shetshoky (D_3)***	Kyzylespinsky, D_3; ***ore occurrences Mo,Sn, Bi (D_3)***	*	*
Hercynian	Early Hercynian (Saursky)	Balkhashsky, C_1; ***Konyrat, Borly, Besshoky and others (C_1)***	East Kounrad, C_{2-3}; ***East Kounrad-Mo, North Kounrad – Be, Mo, Zhanet, Karatas -IV – Mo (C_3)***	Toparsky, C_{1-2}; ***Almaly, Bayskoe, Ozernoe – Cu-Mo (C_2)***	Kaldyrminsky, Kuinsky, C_3-P_1; ***Upper Kayrakty - W, Katpar - W, Mo, Koktenkol - Mo, W, Karaoba – W,Sn,Bi, Be; and others (P_1)***
	Late Hercynian (Sayaksky)	Kungeysayaksky, C_{2-3}; ***Berkara (C_3)***	Besobinsky, P_1; ***ore occurrences Arkharly – W,Mo (P_1)***	*	*

Table 4 – List of rare metal deposits

No. on the diag-ram	Name, category of the deposit	The main (associated) components	Age	No. on the diag-ram	Name, category of the deposit	The main (associated) components	Age
Copper-molybdenum porphyry deposits				32	Volframovye Sopki – S	Mo, W	C_3
8	Almaly - M *	Cu (Mo, Bi, Au)	C_2	20	Vysotnoye – S	W (Bi, Be, Mo)	C_3-P_1
14	Altuayt - S	Cu, Mo (Pb, Zn, Bi, Ag)	C_2	19	Dolinnoye (Sarybyurat) – S	W (Mo, Be, Bi)	C_3-P_1
26	Anomaly-6 (Karatas-6 C) -S	Cu (Zn Mo Au)	C_1 ?	29	Karaoba – L	W (Mo, Sn, Be)	C_3-P_1
16	Auyzbaky - S	Cu, Mo	C_2	8	North and North-East Katpar – L	W, Mo (Bi, Cu, Be)	C_3-P_1
6	Bayskoe - M	Cu, Mo	C_2	9	North Katpar (residual) – S	W	P_2
23	Berkara-S	Cu, Mo (W, Bi)	C_3				
12	Besshoky - S	Cu, Mo (Pb)	C_2	12	Koktenkol South, North and Intermediate – L	Mo, W (Bi, Be, Cu)	C_3-P_1
2	Bozshakol - L	Cu (Mo, Au, Ag, Co)	O_1	13	Koktenkol Intermediate (in the weathering crust) – L	W (Bi, Cu)	P_2
20	Borly 3. - S	Cu (Mo)	C_2	30	North Kounrad– M	Be, Mo (W, Bi)	C_3
21	Borly - M	Cu (Mo, Ag, Au, Re)	C_2	33	South Kounrad – S	Mo, W	C_3
25	Zhambas C. - S	Cu (Mo, Au)	C_3	27	Kuu – M	W	C_3-P_1
15	Zhekeduan - S	Cu (Mo, Ag, Au)	C_2	21	NW Kyzyltau – S	W (Mo, Bi)	C_3-P_1
9	Zapadnoye - S	Cu, Mo	C_2	24	SE Kyzyltau – S	W, Mo (Be, Bi, Mo)	C_3-P_1
27	Karatas-1,2 - S	Cu, Mo (Fe)	C_1 ?	4	Nurataldy – S	W (Bi)	C_3-P_1
28	Karatas-4 - M	Mo (Cu)	C_3	7	Saran – M	W, Mo (Bi)	C_3-P_1
19	Kaskyrkazgan - S	Cu, Mo (Au)	C_2	18	Seltey – S	Mo (W, Bi)	C_3-P_1
18	Kenkuduk - S	Cu, Mo (W)	C_2	31	Scorpion – S	W, Be (Mo,Bi)	C_3
17	Kepsham - S	Cu, Mo	C_2	28	Solnechnoye – S	W (Be, Bi, Mo, Sn, f)	C_3-P_1
4	Koktaszhal – M	Cu (Mo, Au)	O_3	1	Syrymbet – L	Sn (Ta, Nb, Zn, Cu, Bi, W)	D_3
				5	Tayshek – M	Bi (W, Be, Mo)	P_1
11	Korgantas – S	Cu, Mo (Pb, Ag, Au)	C_2	17	Uzynbulak – S	Mo, W (Bi)	C_3-P_1
22	Kounrad- L	Cu (Mo, Au, Re, Se, Te)	C_2	3	Ulyanovskoye – M	W, Mo (Bi)	D_2
1	Kyzyltu – S	Cu, Au (Mo, W)	O_3	15	South Zhaur– M	W (Mo)	C_3-P_1
24	Moldybay–S	Cu (Co, Mo)	P_2		Placers		
32	Nurkazgan – L	Cu, Mo (Ag, Hg)	D_1-S_2	6	Akchatauskaya – S	W	
5	Ozernoe – M	Cu (Mo, Bi, Ag)	C_2	3	Baynazarskaya– S	W	Q_{1-4}
7	Olginskoye – S	Cu (Mo, Bi)	C_2	2	Upper Kayraktinskaya – M	W	Q_{2-4}
29	Pribrezhnoye – M	Cu, Mo (Au, Re)	C_2	7	Karaobinskaya– S	Sn, W	Q_{3-4}
31	Saryshagan – M	Cu	D_1	1	Nurataldinskaya – S	W	Q_{3-4}
30	Sokurkoy Mednoye – S	Cu, Mo (Zn, Pb, Au)	C_2	5	Selteyskaya– S	W	Q_{3-4}
13	Tolagay – S	Cu, Mo	C_3-P_1	4	South Zhaur– S	W (Mo)	Q_{1-2}
10	Shatyrsha – S	Cu, Mo	C_2	Molybdenum deposits			
33	Shetshoky – S	Cu, Mo	D_3	7	East Akkuduk – S	Mo (Cu, W)	P_1
Essentially tungsten, tungsten-molybdenum, complex deposits				8	West Akkuduk – S	Mo (Cu, W)	P_1
22	Akbiik – M	W (Bi, Mo)	C_3-P_1	6	Biryuk Molibdenovoye– S	Mo (Cu, Pb, Zn)	P_1
10	Akmaya – M	W (Bi, Mo)	C_3-P_1	2	Bugul – M	Mo	D_2
25	Aksarly – S	W (Be, Bi, Mo)	C_3-P_1	5	Zhanet – L	Mo, Be (W, Bi, fl, TR)	C_2
23	Akchatau – S	W (Mo, Be)	P_1	1	Iyulskoye – S	Mo (W, Cu, Pb, Ag)	C_3-P_1
26	South-East Akchatau–S	W (Mo, Be, Sc, Li)	P_1	9	East Kounrad. – L	Mo	C_3
14	Bainazar – M	W (Mo, Bi)	C_3-P_1	3	Sarytas – S	Mo	D_2
16	Batystau – L	W, Mo (Be, Sn)	C_3-P_1	4	Shalgiya– S	Mo	D_2
2	Bayan	W, Bi, (Mo, Cu, Ag)	D_1	Substantially beryllium deposits			
6	Belkoytas – S	W (Bi, Be)	C_3-P_1	2	Darat – S	Be (W, Mo)	C_3-P_1
11	Upper Kairakty – L	W (Bi, Mo, Be)	C_3-P_1	1	Nurataldy – L	Be (Mo, Bi, W)	C_3-P_1
*Deposits: L – large, M – medium, S – small.							

The vast majority of leucogranite plutons, sufficiently exposed by erosion, are two-phase ones, while in the last decade of the 20th century several three-phase plutons have been mapped: Kyzyltau, Karaoba, Kuu, Donetsky [4]. A specialist in rare metal deposits in Kazakhstan G.N. Shcherba at first considered only the II-nd phase to be ore-bearing, but later he and his staff came to the conclusion about the possibility of a two-fold occurrence of the postmagmatic process: in the plutons of Akchatau and Zhanet, quartz veins and veinlets with molybdenite were identified, which complete the I-st phase, but the main ore-generating capacity was considered to be of the II-nd phase. The established correlations of ores with the main intrusive phases indicate that each phase may be ore-bearing. The I-st phase suggests really significant molybdenum mineralization. In particular, molybdenum mineralization in the pluton Karaoba (Molybdenum site) and Kuu (Komsomolskoye show of ore) is intersected by aplite dykes of the 2nd phase. Intrusives of the second phase are inherent with complex rare metal deposits (in Kuu pluton the main vein of the Kuu field is intersected by the II phase intrusive and its vein differentiations, aplites). The third phase of the plutons Kyzyltau, Karaoba and Kuu is associated mainly with tungsten deposits. Under favorable conditions (above the protrusions of the mantle) tin is added to these rare metals.

2. Distribution of mineralization in time. Academician of Kazakh Academy of Sciences G. N. Shcherba believed that these deposits were associated exclusively with the Hercynian cycle, and this opinion dominated for a long time. However, subsequent accumulation of information about the age of rare metal deposits and ore-bearing intrusives did not confirm this conclusion essentially, although in terms of the number of rare metal objects the Hercynian cycle proved to be the most abundant (> 65% of the total).

Table 3 shows the cyclic distribution of rare metal deposits in Central Kazakhstan with ore-bearing complexes and examples of typical deposits.

Table 4 contains a complete list of deposits examined in this paper, indicating their scale and specific age. The age of the deposits is determined by the radiological data of mineralization, but most often by geological and radiological data for ore-bearing intrusives, the nature of the relationship of rare metal mineralization with which is described in Section 1.

3. Structural control of deposits

3.1. *The tectonic association of copper-molybdenum-porphyry deposits* is completely determined by their magmatic control, a genetic bond exclusively with the orogenic granodiorite formation (see Section 1). This formation is associated with the formation of each fold system, which was repeated six times in the history of geological development of the region (see table 2).

3.2. *Primary rare metal deposits are located in two tectonic positions,* in connection with late orogenic ultra-acidic granitoids and in tectonomagmatic activation zones.

3.2.1. The structural association of essentially molybdenum deposits is determined by their connection with the leucogranite formation of the late orogenic sub-stage. This formation is known in 5 tectonic cycles (see table 2). Essentially molybdenum deposits are found in two cycles, Middle Caledonian (Shalgiya, Bugul, Sarytas, etc.) and Early Hercynian (East Kounrad, Zhanet, West and East Akkuduk, etc.). In the remaining three cycles, Early Caledonian, Late Caledonian, and Late Hercynian, there are only shows of ore.

3.2.2. Structural control of the distribution of rare metal deposits. The overwhelming majority of rare metal deposits and, above all, essentially tungsten and complex deposits (W, Mo, Be, Bi), are associated with the synorogenic zones of tectonomagmatic activation. Such TMA zones are found in two cases and are associated with the beginning of Caledonian and Hercynian megacycles, when as a result of destruction of the Karelian platform, and then after destruction of the epicaleldon platform, the interiors of the platforms were most deeply opened and maximum release of endogenous energy occurred. As a result, the Caledonian and Hercynian TMA zones were formed (figure 1). Caledonian deposits Bayan and Syrymbet are spatially confined to the Chaglinsky TMA zone located within the Precambrian Kokchetavsky protrusion. However, the age of these deposits requires further refinement.

Most of the deposits are located in the Early Hercynian TMA zones. In Uspenskaya TMA zone: Belkoytas, Upper Kayrakty, North Katpar, Koktenkol, Nurataldy, Saran, Tayshek, Dolinnoye, Vysotnoye; in East Zhamansarysu TMA zone: Akchatau, Bainazar, Batystau, Seltey, Uzynbulak, South Zhaur, Iyulskoye; in Akbastau-Akzhal zone of TMA: Aksarly, North-West Kyzyltau, North-East Kyzyltau, Darat; in Zhailma-Karaobinskaya zone of TMA: Karaoba, Solnechnoye, Kuu.

Conclusion. The study found that rare-metal deposits of Central Kazakhstan are in three tectonic positions: 1) orogenic (Cu-Mo-porphyry) in connection with the orogenic granodiorite formation; 2) late orogenic (essentially molybdenum) in connection with the ultra-acidic granites of the late orogenic sub-stage; 3) activating (essentially tungsten, complex, essentially beryllium) in connection with the ultra-acidic granites of the synorogenic Early Hercynian tectonomagmatic activation zones.

1. The maximum number of indigenous rare metal deposits is concentrated in the synorogenic Early Hercynian tectonomagmatic activation zones (about 70% of the known deposits), which is due to the most favorable combination in these zones of all ore-controlling factors: magmatic, structural factor and host medium factor [4, p. 182-197].

2. We recommend conducting further forecasting and prospecting aimed at expanding raw materials in Central Kazakhstan within the tectonomagmatic activation zones, primarily in the synorogenic Early Hercynian zones.

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ОРТАЛЫҚ ҚАЗАҚСТАНДАҒЫ СИРЕКМЕТАЛДЫ КЕНОРЫНДАРДЫҢ ОРНАЛАСУ ЗАҢДЫЛЫҚТАРЫ

Аннотация. Мақалада Орталық Қазақстандағы грейзен-кварц-желілік вольфрам, молибден, бериллий, сонымен қатар молибден қосымша компонет ретінде өндірілетін мыс-молибден-порфирлі кенорындарының орналасу заңдылықтары қарастырылған. Кенорындардың орналасу заңдылықтарының анализі негізінен үш тұрғылықтан қарастырылған: 1) магмалық бақылау; 2) уақытта таралуы; 3) құрылымдық бақылау. Cu-Mo-порфирлі кенорындардың магмалық бақылауы орогенді граниттік натрийлі қатармен ($K_2O/Na_2O < 0.85$) немесе калийнатрийлі қатармен ($K_2O/Na_2O = 0.85$-1.15) генетикалық байланыспен анықталады. Өзіндік кентасушы интрузиялар – гранодиоритті өзгеше фазаның «порфирлі» дифференциатты қосымша интрузиялар болып саналады. Сирек кездесетін металдар кенорындарының магмалық бақылауы лейкогранитті интрузияларымен генетикалық байланысымен анықталады. Кенорындардың екі класы – Cu-Mo-порфирлі және шын сирек кездесетін металдар кенорындары Орталық Қазақстанда бірнеше рет танылады: бірінші класс – алты жастық кезеңде (O_1, O_3, S_2, D_3, C_1, C_3), екіншісі – тағы да алтыда жастық кезеңде (S_1, S_2, D_2, D_3, C_3, P_1). Cu-Mo-порфирлі кенорындар құрылымдық бақылау гранодиоритті формация денелерімен байланысымен анықталады. Ал сирек кездесетін кенорындар екі тектоникалық позицияда орналасады: айтарлықтай молибденді кенорындар кешорогенді лейкогранитті формациямен байланыста болады, ал кешенді сирекметалды кенорындардың көбісі синорогенді тектоникалық-магмалық активизациялық аудандарға тұтастырылады.

Түйін сөздер: Орталық Қазақстан, магмалық, құрылымдық бақылау, сирекметалды кенорындардың жасы.

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ЗАКОНОМЕРНОСТИ РАЗМЕЩЕНИЯ РЕДКОМЕТАЛЛЬНЫХ МЕСТОРОЖДЕНИЙ ЦЕНТРАЛЬНОГО КАЗАХСТАНА

Аннотация. В статье рассмотрены основные закономерности размещения в Центральном Казахстане грейзеново-кварцевожильных вольфрамовых, молибденовых и бериллиевых месторождений, а также медно-молибден-порфировых месторождений, из которых добывается молибден в качестве попутного компонента. Анализ закономерностей размещения месторождений осуществлен, в основном, с трех позиций: 1) магматический контроль; 2) распределение во времени; 3) структурный контроль. Магматический контроль Cu-Mo-порфировых месторождений определяется их генетической связью с орогенными гранитоидами натрового ряда ($K_2O/Na_2O<0.85$) или калинатрового ряда ($K_2O/Na_2O=0.85$-1.15). Собственно рудоносными интрузиями

являются специфические «порфировые» дифференциаты гранодиоритовой фазы – дополнительные интрузивы. Магматический контроль редкометалльных месторождений определяется их генетической связью с интрузиями лейкогранитового семейства. Оба класса месторождений – Cu-Mo-порфировые и собственно редкометалльные – проявлены в Центральном Казахстане многократно: первый класс – на шести возрастных уровнях (O_1, O_3, S_2, D_3, C_1, C_3), второй – тоже на шести (S_1, S_2, D_2, D_3, C_3, P_1). Структурный контроль Cu-Mo-порфировых месторождений определяется их связью с телами гранодиоритовой формации. А редкометалльные месторождения располагаются в двух тектонических позициях: существенно молибденовые месторождения находятся в связи с позднеорогенной лейкогранитовой формацией, а большинство комплексных редкометалльных месторождений приурочены к синорогенным зонам тектоно-магматической активизации.

Ключевые слова: Центральный Казахстан, магматический, структурный контроль, возраст редкометалльных месторождений.

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