ABSTRACT

PhD Thesis, Degree in Geology and Mineral Exploration (Code 8D07201)

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"REGULARITIES OF FORMATION, FEATURES OF MATERIAL COMPOSITION AND ORE-BEARING CRITERIA OF GRANITOIDS OF THE KALBA-NARYM BELT (EASTERN KAZAKHSTAN)"

General characteristics of the research: The thesis examines the geodynamic conditions, geochronology, and mineralogical and geochemical features of the formation of granitoids of the Kalba-Narym belt and associated pegmatites in order to develop criteria for their ore content, taking into account modern classification standards. As part of the study, a comprehensive analysis of the petrochemical characteristics of granitoids was carried out, the absolute age of the magmatites of the Kalba complex and ore-bearing pegmatites was clarified, and their genetic relationship was established. The study of the mineral composition of pegmatites, focused on the content of Li, K, Rb, Cs, P, Ga and other elements in potassium feldspar and muscovite, allowed us to substantiate the possibilities of using a number of geochemical indicators. In particular, the ratios K/Rb–Cs, K/Rb–Ba, K/Cs–Rb, P–Ga, K/Rb–Li, and Al/Ga–Ga can be used to determine the zonation and ore content of pegmatite bodies.

Relevance of research. In the last decade, the approach to assessing the raw material consumption market has changed dramatically. High-tech industries require more and more new materials and metals from the market. The so-called "critical metals" have come to the forefront of global commodity trade, which include not only economically important metals, but also those whose security and stability of supply pose serious risks. The first in the list of "critical" are rare metals. The dissertation examines the patterns of formation and forecasting criteria for rare metal pegmatites of the Kalba-Narym belt, characterized by high metal content (Ta, Nb, Sn, Li).

The object of research: rare metal pegmatite deposits and ore occurrences (Yubileynoye, Bakennoye, Akhmetkino, etc.).

The subject of research: geodynamic conditions of the formation of pegmatite ore fields, the mineral composition of various types of pegmatites.

Goal of research: development of criteria for the ore content of granitoids of the Kalba-Narym belt (East Kazakhstan) based on modern international classification and new data on age of pegmatites and parent granitoids.

The objectives of research:

1) to study the geodynamic regime of formation of the territory of the Ob-Zaisan folded system, to clarify the geotectonic position, formation patterns and age of rare-metal pegmatites of the Kalba-Narym rare-metal belt (Ta, Nb, Be, Li, Sn, W).

2) to study the age and petrochemical features of magmatites of the Kunushsky, Kalbinsky and Monastyrsky complexes and pegmatites.

3) to conduct thermobarometric studies of granitoids of the Kalba-Narym

batholith.

4) to conduct mineralogical studies of pegmatite ore bodies.

5) to study the systematics of rare metal deposits in the Kalba-Narym zone, to study the geochemical characteristics of the main mineral complexes of ore-bearing pegmatites.

6) to clarify the main search features and localization criteria for rare metal pegmatites within the Kalba-Narym metallogenic zone.

Main research methods: review and analysis of research on rare metal deposits of Kalba-Narym and its global analogues; field work with sampling; complex analytical studies (sample preparation, study of mineral, chemical, and elemental compositions of ores and host rocks, and determination of the U-Pb absolute age of pegmatites).

Study highlights:

1) The granitoids of the Kunushsky complex are represented by low-potassium, high-alumina plagiogranites and M-type leukoplagiogranites, and their formation occurred at temperatures of 805-840 °C. The rocks of the Kalbinsky complex are represented by calcareous-alkaline high- and moderate alumina granodiorites, granites of mixed I-S type, which are characterized by a temperature range of 785-820 °C. The rocks of the monastery complex are represented by high-potassium and calcareous-alkaline, high- and moderate-alumina A-type leucogranites with formation temperatures of 760-785 °C.

2) The results of U-Pb dating of zircons from the pegmatites of the Ognevsky ore field showed that pegmatites were formed about 291 million years ago synchronously with S-I-type granites (Kalbinsky complex).

3) The analysis of Li, K, Rb, and Cs content in feldspar and muscovite can be used to identify lithium-enriched spodumene, petalite, and lepidolite pegmatites. Graphs of the ratios of K/Rb–Cs, K/Rb–Ba, K/Cs–Rb, P–Ga, based on the content of trace elements in potassium feldspar and K/Rb–Cs, K/Rb–Li, Al/Ga–Ga in muscovite, allow us to make the zoning of pegmatites within the ore field or a more extensive ore zone with great accuracy, dividing pegmatites into empty, beryllium, beryl-spodumene, spodumene and albitites.

4) Using the data obtained, the main regional (geotectonic, structural-tectonic) and local (magmatic, geochemical, mineralogical) search features and localization criteria for rare-metal pegmatites within the Kalba-Narym metallogenic zone were clarified.

Scientific novelty:

1. The age, petrochemical characteristics, and temperature regime of ore-bearing granitoid massifs and pegmatite bodies of the Kalba-Narym belt have been clarified based on new analytical data.

2. The nature of the relationship of pegmatite deposits with the host granitoids of Kalba-Narym has been established, and the affiliation of the main pegmatite ore fields of the Kalba-Narym zone to the LCT pegmatite family has been proved.

3. The possibility of using the contents of chemical elements for the zonation of mineralization both within large ore zones and individual ore fields has been established.

Practical value.

The performed researches reveal new opportunities for forecasting and searching for rare metal deposits, which consist in identifying favorable criteria and prerequisites for the formation of rare metal deposits within the territory of the Kalba-Narym belt. There are acts of introduction into production and the educational process.

Factual material and personal contribution of the author.

The dissertation is based on the materials obtained by the author as a result of field expeditionary work on projects of D. Serikbayev East Kazakhstan technical university., in she the author participated.

As part of the preparation of the dissertation, the author completed foreign scientific internships at specialized scientific institutions — the Institute of Geology and Mineralogy of the Siberian Branch of the Russian Academy of Sciences (Novosibirsk, Russia) and the Museum of Natural History (London, UK).

The internships included the performance of work aimed at conducting analytical research. The author analyzes monographic, reference and scientific publications on rare metal deposits of the Kalba-Narym zone, as well as foreign analogues. Based on the interpretation of the analytical data, the author formulated predictive and prospecting criteria that contribute to improving the efficiency of exploration work.

Approbation of work and publications.

The results of the work have been published in 14 articles; 7 - are in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Bulletin of the D. Serikbayev East Kazakhstan technical university, Bulletin of the Kazakh National Research Technical University named after K.I. Satpayev, Mining Journal of Kazakhstan), 7 – are in a journal included in the Scopus and Wed of Science database (Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, Geology of Ore Deposits, Minerals, Lithos, Visnyk of Taras Shevchenko National University of Kyiv geology).

Publications in international scientific journals included in the database of Scopus and Wed of Science:

1) Geochemical characteristics and metallogeny of Herzin granitoid complexes (Eastern Kazakhstan) // Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, Ukraine – 2020. – Vol. 1. –P. 5–10. https://doi.org/10.33271/nvngu/2020-1/005

2) New data on non-traditional types of East Kazakhstan rare metal ore // Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, Ukraine. – 2020. – Vol. 4. – P. 11–16 https://doi.org/10.33271/nvngu/2020-4/011

3) Specific Features of Geotectonic Development and Ore Potential in Southern Altai (Eastern Kazakhstan // Geology of Ore Deposits – 2021.–Vol. 63(5) – P. 383–408. DOI 10.1134/S1075701521050020.

4) Mineralogical Tracers of Gold and Rare-Metal Mineralization in Eastern Kazakhstan // Minerals. – 2021. –Vol. 11(3), 253. – P 1–23. https://doi.org/10.3390/min11030253

5) Geology, Mineralogy, and Age of Li-Bearing Pegmatites: Case Study of Tochka Deposit (East Kazakhstan) // Minerals. – 2022. – Vol.12(12), 1478. – P.1-17. https://doi.org/10.3390/min12121478

6) Petrogenesis of A-type leucocratic granite magmas: An example from Delbegetei massif, Eastern Kazakhstan // Lithos. – 2024. – Vol.482–483 – P. 1-16. https://doi.org/10.1016/j.lithos.2024.107696

7) Ongonite dikes of Eastern Kazakhstan and the specificity of their ore content. // Visnyk of Taras Shevchenko National University of Kyiv-geology (Ukraine). – 2020. – № 1(88). – P. 61-68. https://doi.org/10.17721/1728-2713.88.09

Research results and key issues were reported and discussed at international conferences:

- The main types of rare metal deposits of the Kalba-Narym granitoid belt and their practical assessment. The V-th International Scientific Conference "Correlation of Altaids and Uralides, deep structure of the lithosphere, stratigraphy, magmatism, metamorphism, geodynamics and metallogeny" (Novosibirsk, 2020).

- On the geological and genetic model of the formation of deposits with a superimposed type of rare metal mineralization (using the example of the Cherdoyak deposit). The mineral resource base of diamonds, precious and non—ferrous metals - from forecast to production. Collection of abstracts of the I-th Youth Scientific and Educational Conference (Moscow. 2020).

- Types of lithium-bearing deposits and criteria for their forecasting (East Kazakhstan). Materials of the VIII-th International Scientific and Technical Conference of Students, Undergraduates and Young Scientists (Ust-Kamenogorsk, 2021).

- Geological structure and evaluation criteria of the apogranitic rare metal site of Central Kalba (East Kazakhstan). Notes of the Ust-Kamenogorsk branch of the Kazakh Geographical Society. Issue 15. The International Year of Peace, Trust and Sustainable Development. Proceedings of the International scientific and technical conference (Ust-Kamenogorsk, 2021).

- Magmatism and rare metal mineralization of Kalba (East Kazakhstan). Petrology and ore content of magmatic formations proceedings of the scientific conference, in memory of the corresponding member of Academy of Sciences of the USSR and RAS Polyakov G.V. and Prof. Vladimirov A.G. (Novosibirsk, 2022).

- Thermochronology of rare metal deposits associated with post-collisional granites of the Kalba-Narym belt (East Kazakhstan). Petrology and ore content of magmatic formations: proceedings of the scientific conference, in memory of the corresponding member of Academy of Sciences of the USSR and RAS Polyakov G.V. and Prof. Vladimirov A.G. (Novosibirsk, 2022).

- Stages of rare-metal magmatism in the Kalba-Narym belt (East Kazakhstan). Age and correlation of magmatic, metamorphic, sedimentary, and ore-forming processes. Proceedings of the VIII Russian Conference on Isotope Geochronology (St. Petersburg, 2022).

Structure and volume.

The thesis is presented on 181 pages and includes an Introduction, seven sections, a Conclusion, a list of 155 references, 98 figures, 13 tables and 8 appendices.

The first section examines the state of the mineral resource base of rare and rare earth elements in the Kazakhstan region.

The second section is devoted to the research methodology.

The third section examines the features of the geological structure, tectonics and magmatism of the Kalba-Narym belt.

The fourth section describes the features of the mineral composition of the pegmatites of the Kalba-Narym belt.

The fifth section presents the modern classification of rare metal pegmatites.

In the sixth section, rare-metal pegmatites of the Kalba-Narym belt are considered.

The seventh section examines the main search features and localization criteria for rare metal pegmatites in the Kalba-Narym zone.

In conclusion the main results of the dissertation research are presented.