

ABSTRACT

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

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"ORIGIN OF GRANITOIDS AND ORE-GENERATING PROCESSES DURING FORMATION OF DELBEGETEI MASSIF"

General characteristics of the research: The dissertation examines the geological structure of the Delbegetei massif, the history of its study. The petrographic, mineralogical and material composition of the five phases of granitoids was studied. The age of formation of the massif was determined, sources and origin of granite magmas were established. The main ore occurrences and deposits of the Delbegetei massif were considered, the processes and stages of ore formation were determined. The results of the study suggest that the Delbegetei granite massif has the potential to discover new rare-metal objects.

Relevance of research.

Relevance is due to the urgent need to strengthen the mineral resource base of rare metals and stone-self-color raw materials necessary for the stable functioning of enterprises in the East Kazakhstan region. Rare metals are one of the key resources that have made possible scientific and technological progress, changing the appearance of the global economy, production and everyday life of people. Rare metals have unique physicochemical properties necessary for the operation of modern technologies. They have become indispensable components for high-tech industries such as microelectronics, renewable energy, the production of batteries and mobile devices, the production of high-temperature alloys and superconductors. Without these elements, future technological advances are impossible, so rare metals are strategically important for economic development.

The object of research: Delbegetei granitoid massif.

The subject of research: Granitoids of various magmatic phases and associated mineralization.

Goal of research: Determine the origin of the granitoids of the Delbegetei massif and identify the main ore-generating processes that occurred during its formation.

The objectives of research:

1. Collect historical data on the Delbegetei massif, analyze data on its deposits and ore occurrences.
2. Collect new actual material for the study object (samples of granites of all phases of the Delbegetei massif).
3. Perform laboratory tests (quantitative and qualitative electron probe microanalysis, determination of rock age).
4. Characterize the geological-structural, petrographic, mineral-chemical and age characteristics of the granitoid formations of the Delbegetei massif.

5. Establish the origin of granitoids of different phases and draw a conclusion about ore-generating processes occurring during the formation of the Delbegetei massif, and the associated mineralization.

Main research methods:

Collection, generalization and analysis of historical material on the geological structure of the Delbegetei massif; field work with sampling of different phases of granitoids; complex of laboratory works (study of thin sections on an electron scanning microscope; study of a monomineral fraction on a microprobe; determination of U-Pb dating of zircon grains on a quadrupole mass spectrometer with inductively coupled plasma and on a magnetic mass spectrometer; measurement of the mass fraction of fluorine in granitoids by a potentiometric method; determination of the isotopic composition of oxygen on a gas mass spectrometer).

Study highlights:

1. The intrusive rocks of the Delbegetei massif are divided into 5 phases: phase I (granosienites), phase II (fine-grained, fine-medium-grained unevenly porphyritic biotite granites), phase III (medium-grained or low-porphyritic biotite granites with miarols; coarse-grained biotite granites), Phase IV (fine- to coarse-grained, fine- to medium-grained, porphyritic biotite granites), Phase V (fine-grained biotite granites and fine- to medium-grained leucocratic granites).

2. Age of the granitoids of the Delbegetei massif. Phase I rocks are 249 ± 2 Ma, Phase III rocks are 247 ± 2 Ma, and Phase V rocks are 240 ± 2 Ma. Based on this, the formation time of the Delbegetei massif corresponds to the Early-Middle Triassic.

3. In the process of forming the Delbegetei massif, the following ore-generating processes are consistently manifested: turmalinization (early stage), responsible for tin mineralization; greisenization (second stage) responsible for tin-beryllium mineralization; albitization (second stage), associated with the formation of tin mineralization; microclinization (third stage), is responsible for the formation of tin-tungsten mineralization; also, the cassiterite dissemination can be confined to quartz veins.

Scientific novelty:

1. Five phases of granitoid introduction were established based on the results of mineral and petrographic studies and their material and mineral composition was determined.

2. The age of formation of the Delbegetei massif has been established (249-239 million years ago, which corresponds to the Early-Middle Triassic).

3. The sequence of manifestation of ore-generating processes in the Delbegetei massif and the associated rare-metal mineralization has been established.

Practical value.

During the dissertation, the origin of granitoids was determined and the main ore-generating processes were established during the formation of the Delbegetei massif, which increases the region's potential for the discovery of new rare-metal deposits.

The results of scientific research were introduced into the production of GEOS LLP, and is also used in lectures and practical classes for bachelors of the educational program "Geology and Exploration of MPI" in the discipline "Geology of mineral deposits."

Factual material and personal contribution of the author.

The dissertation research was carried out on the basis of the School of Earth Sciences, East Kazakhstan Technical University named after D. Serikbaev. The basis of the dissertation work is the author's personal materials collected during field work in 2021-2024, and the results of research work on state budget topics and targeted program financing, in which the author of the dissertation took part:

1) 2020-2022 - AP08856325 "Development of the scientific and methodological basis for forecasting and searching for deposits of critical metals within the Kazakhstan part of the Greater Altai and Rocky Mountains (Colorado)."

2) 2021-2023 - BR10264558 "Scientific assessment of the investment attractiveness of Kazakhstan's structures promising for the identification of mineral deposits."

3) 2023-2025 - AP19676805 "Forecasting and assessment of the prospects for rare metal mineralization of the batholith belts of East Kazakhstan (North-West Kalba and adjacent areas of the Ore Altai)."

4) 2024-2026 - AP23486908 "Prospects for the development of the mineral resource base of critical metals on the example of southeastern Kalba."

Approbation of work and publications.

The results of the work were published in 20 articles and theses, of which 3 articles in journals included in the Scopus database (News of the Academy of sciences of the Republic of Kazakhstan, Minerals, Lithos), 2 articles in publications recommended by the Science and Higher Education Quality Assurance Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Mining Journal of Kazakhstan, University Proceedings journal of KSTU), 15 theses in the materials of international conferences.

In international scientific publications included in the Scopus database:

- T.A. Oitseva, B.A. D'yachkov, O.N. Kuzmina, A.Y. Bissatova, O.V. Ageyeva. Li-bearing pegmatites of the Kalba-Naryn metallogenic zone (East Kazakhstan): mineral potential and exploration criteria. News of the Academy of sciences of the Republic of Kazakhstan, 2022. P. 83-90. <https://doi.org/10.32014/2022.2518-170X.144>.

- B.A. D'yachkov, M.A. Mizernaya, S.V. Khromykh, A.Y. Bissatova, T.A. Oitseva, A.P. Miroshnikova, O.V. Frolova, O.N. Kuzmina, N.A. Zimanovskaya, A.P. Pyatkova, K.T. Zikirova, O.V. Ageyeva, Y.T. Yeskaliyev. Geological History of the Great Altai: Implications for Mineral Exploration. Minerals, 2022. <https://doi.org/10.3390/min12060744>.

- S.V. Khromykh, O.A. Khokhryakova, N.N. Kruk, E.N. Sokolova, P.D. Kotler, S.Z. Smirnov, T.A. Oitseva, D.V. Semenova, A.V. Naryzhnova, A.S. Volosov, O.N. Kuzmina, M.A. Mizernaya, X.Y. Larionova, S.S. Aitbayeva, A.Y. Bissatova, O.V. Ageyeva, Z.Z. Kapzhaparova, A.D. Senko. Petrogenesis of A-type

leucocratic granite magmas: An example from Delbegetei massif, Eastern Kazakhstan. *Lithos*, 2024. P. 1-16. <https://doi.org/10.1016/j.lithos.2024.107696>.

In publications recommended by the Science and Higher Education Quality Assurance Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan:

- Б.А. Дьячков, Н.А. Зимановская, С.С. Айтбаева, О.В. Агеева. Особенности геологического строения и критерии прогнозирования литиеносных пегматитов Восточного Казахстана. *Горный журнал Казахстана*, №6 (194), 2021 г. С. 8-14. <https://doi.org/10.48498/minmag.2021.194.6.001>

- Т.А. Ойцева, О.В. Агеева. Оңтүстік-шығыс Қалба геотектоникалық және металлогендік орны. *Труды КарГТУ*, № 4, 2025 г.

Research results, issues of the main provisions were reported and discussed at international conferences:

Structure and volume.

The thesis is presented on 158 pages and includes an Introduction, seven sections and a Conclusion, a list of 91 references, 63 figures, 10 tables and 2 appendices.

The first section presents a geological outline of the West Kalba structural-formation zone of East Kazakhstan.

The second section is devoted to the internal structure of the Delbegetei granite massif.

The third section considers the mineral and petrographic composition of the granites of the Delbegetei massif.

The fourth section describes the material composition of the granites of the Delbegetei massif.

The fifth section considers the age and sources of granites of the Delbegetei massif.

The sixth section presents ore mineralization of the Delbegetei massif.

The seventh section is devoted to the processes and stages of ore formation.

The conclusion contains the main conclusions of dissertation research.