ABSTRACT

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

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FEATURES OF GEOLOGICAL STRUCTURE AND ORE-FORMATION MODEL OF GOLD-SILVER-PYRITIC DEPOSITS OF THE ORE-ALTAI TYPE ON THE EXAMPLE OF THE MALEEVSKOYE AND ARTEMYEVSKOYE DEPOSITS

General characteristics of the research. This dissertation is aimed at studying the theory of ore formation and metallogeny, which has a great influence on geological prospecting, geological exploration and forecasting of ore deposits, as well as the study of ore formations and the construction of geological and genetic models of the main industrial types of deposits.

Geological-genetic models make it possible to effectively develop the theory of ore formation and improve forecasting methods. As a result, it becomes possible to carry out targeted metallogenic constructions.

The most striking feature of tectonics and metallogeny of Eastern Kazakhstan is a clear zoning of the northwestern direction in the location of the main structural zones and metallogenic belts. Many geologists tried to explain this phenomenon from different positions. The polymetallic belt is represented by a huge number of endogenous ore occurrences of copper, polymetals, iron and gold. The Leninogorsk, Zyryanovsk and Priirtyshsk ore clusters are the most important mining areas and are characterized by a very high level of knowledge However, the leading role in them is occupied by polymetallic ores, represented mainly by copper, zinc, lead, gold, silver, iron, sulfur.

Keywords: Rudny Altai, VMS, deposit, classification, pyrite-polymetallic, formation model, copper, zinc, lead.

Rationale: The study of Rudny Altai in recent decades has taken place in two main directions: on the one hand, through the study of regional geological structure, tectonics and magmatism; and on the other, through an in-depth comprehensive study of several economically most important ore fields and deposits.

There are real prerequisites for increasing the potential of all industrial types - through the development of new areas, assessment of the flanks and deep horizons of known deposits.

In the message of the Head of State Kassym-Jomart Tokayev dated September 1, 2023, it was noted: «... Geological exploration is an area of particular concern. In 2018, new legislation to manage the mining sector was adopted in order to upgrade the sector. However, it has not been fully effective. As a result, there have been no significant geological discoveries in our resource-rich country for a long time. This situation needs

urgent change. We must modernize the management system of the mining sector as soon as possible.

... Preferential rights to use the subsoil should be granted to investors who undertake geological exploration at their own expense. The time and procedures for project approvals should be halved by introducing comprehensive state expertise and full digitalization of the process».

This once again confirms the relevance of the research presented in this work.

According to the Concept for the development of the geological industry of the Republic of Kazakhstan until 2025, the main steps in the implementation of these tasks should be considered: a revision of developed and mothballed gold-pyrite-polymetallic deposits with their transfer to a more significant economic category with relatively poor ores, but with increased morphology and larger reserves; geological and genetic modeling of ore formation processes based on modern ideas about ore objects. The development of this trend will significantly improve the state of the mineral resource base of polymetallic raw materials, contribute to its reproduction and security.

A general understanding of the models of ore formation of sulfide deposits based on world experience in studying modern submarine sulfide deposits (black smokers) in the Atlantic and Pacific Oceans, as well as well-known ancient sulfide deposits, can give a new impetus to the understanding of the theory of ore formation of these deposits and, ultimately, the identification of promising areas to discover new ore deposits within Rudny Altai.

Goal: studying the processes of ore formation of pyrite deposits of Rudny Altai using the example of Maleevskoe and Artemyevskoe (for completeness of research, data on other deposits, such as Ridder-Sokolnoye, Tishinskoye, Orlovskoye, etc. are taken into account), as well as constructing models for the formation of pyrite deposits of the Rudny Altai type.

An important section of this work is the creation of a publicly accessible “information portal” based on a huge digital geological database of pyrite deposits of Rudny Altai, for subsoil users and future possible investors.

Objectives.

1. A comprehensive study of industrial classifications of pyrite-polymetallic deposits in Eastern Kazakhstan and comparison of the results with world objects and determination of quantitative relationships of the main elements, which will clarify the industrial taxonomy of Rudny Altai deposits.

2. Analysis of the geodynamic conditions of the formation of the Altai ore deposits and clarification of the patterns of distribution of pyrite mineralization across hypsometric relief levels. Studying of zoning of sulfide lenses and their textural and structural features.

3. Collection, analysis and systematization of geological material into thematic blocks. Development of a comprehensive structured model aimed at search, evaluation and other work.

The object of research - geological structures of the Rudno-Altai polymetallic belt (Kazakh part), in particular the Zyryanovsky ore district (Maleevskoye deposit) and the Priirtyshsky ore district (Artemyevskoye deposit).

The subjects of research are a model for the formation of VMS deposits and their classification into the main industrial-genetic types of pyrite-polymetallic deposits.

Study highlights:

1. The work proposes a modern unified industrial-genetic classification of Rudny Altai deposits according to J.V.Lydon (1988), which is based on the division of deposits into 2 main types of industrial-genetic deposits (Zn-Pb-Cu and Cu-Zn) based on the volumetric ratios Zn/ (Zn+Pb). The Zn-Pb-Cu type of deposits has a mass ratio of Zn/(Zn+Pb) from 0.70 to 0.80, the Cu-Zn type is more than 0.95.

2. An updated model of the formation of pyrite deposits in Rudny Altai is considered, including a description of: the geodynamic conditions of their formation; petrochemical type of volcanism; stratigraphic and structural control of mineralization; connections of mineralization with rhyolites and subvolcanic formations; forms of ore deposits; features of the mineralogical composition; textural and structural characteristics of ores; zoning of zones of metasomatic alteration of rocks and mineralization.

3. Systematization of spatial data of the studied areas of Rudny Altai, taking into account the categorization of data according to the content of geological information and resources. The possibility, based on these data, to identify criteria for creating predictive and prospecting models for assessing the flanks and deep horizons of existing deposits and identifying new ore occurrences within the Kazakh part of Rudny Altai.

Scientific novelty:

1. The geological and industrial classification of Rudny Altai deposits is considered and described, reduced to a unified form, based on the division of deposits into 2 main types: zinc-lead-copper and copper-zinc.

2. Using modern data on the accumulation of sulfide deposits in modern oceans (Pacific Ocean, Red Sea), a model for the formation of ancient VMS deposits of Rudny Altai is considered.

3. A system for cataloging digital information has been formed, which includes a huge bank of geological data.

Practical value.

1. Based on the study of the experience of foreign researchers, a modern unified geological and industrial classification of pyrite-polymetallic deposits, based on the Cu/Zn ratio, is proposed for consideration, which will help systematize scattered data, and sometimes contradictory data on the geology, tectonics and stratigraphy of Rudny Altai deposits and highlight promising ones plots

2. The modern model of ore formation proposed in the work, adapted to the conditions of the formation of Rudny Altai sulfide deposits, allows us to explain some of the most controversial issues regarding the mechanism of formation of pyrite mineralization in Rudny Altai.

3. Using the examples of specific deposits of the Irtysh, Zyryanovsk and Leninogorsk ore districts, the mechanism of formation of sulfide ore deposits is considered, which can also be used for further prediction of sulfide mineralization in already known and new promising areas.

4. Geological information on the ore districts of Rudny Altai has been systematized, collected into a model of an "information portal." A unified information base containing the economic block will increase the investment attractiveness of objects.

Data and personal contribution of the author.

When writing the dissertation, the works of many geologists were studied, materials from the following scientists were used: M.A. Yudovskaya, P.P. Burov, Kurek N.P., Kayupov A.K., Ivankin P.F., Shcherba G.N., Popov V.V., Cheprasov B.A., Gorzhevsky D.I., Yakovlev G.F., Avdonin V.V., Starostin, M.G. Khisamutdinov, V.M. Chekalin, Kh. A. Bespaev, Yu. I. Demin, N. I. Stuchevsky and many others, including materials from foreign authors. The works of these authors are given in the list of sources used.

The author completed foreign internships: in 2018 (Natural History Museum, London, UK) and in 2020 (FSBI TsNIGRI, Moscow, Russian Federation). During the internship, a lot of work was carried out aimed at the analytical part of the dissertation.

By the author personally:

- An analysis was carried out and a number of monographic, literary and reference data were studied aimed at studying the characteristics of pyrite-polymetallic deposits of the Rudny Altai belt (both the Kazakh and its Russian parts).

- Several trips to field work were made, as well as a visit to the Maleevsky and Artemyeskoye mines, a descent into the mine with sampling for laboratory research. Factual material, photos of samples and mines are presented in the dissertation work.

- the author analyzed the geomechanical conditions and the state of mine workings at the deep levels of the Maleevskoye deposit, and also compiled an explanatory note on quality control of sampling;

- took part in the research work on "Substantiation of the feasibility of mining the Maleevsky and Tishinsky mines based on studies of modifying factors and assessment of mineral reserves of the Maleevsky and Tishinsky deposits"

Main research results. The main provisions of the dissertation work were published in 17 works: of which 6 articles were published in international scientific conferences near and far abroad; 3 in publications included in the list of the Committee for Control of the Sphere of Education and Science of the Ministry of Science and Education of the Republic of Kazakhstan; 3 articles in the journal included in the Scopus database; and 2 articles – in other publications.

In publications included in the list of the Committee for Control of the Sphere of Education and Science:

1. Pyatkova A.P., Mizernaya M.A., Miroshnikova A.P., Pyatkov A.V., Polovko M.P. Patterns of formation of pyrite-polymetallic deposits on the example of the Maleevskoye deposit. Bulletin of East Kazakhstan State Technical University named after. D. Serikbaeva, No. 4(82), December, 2018 – P.32-38. ISSN 1561-4212.

2. Mizernaya M.A., Pyatkova A.P., Dyachkov B.A., Miroshnikova A.P. Prospects for strengthening the mineral resource base of non-ferrous-metals metallurgy in Kazakhstan. Mining Journal of Kazakhstan, No. 6, 2019 – P.8-13.

3. Pyatkova A.P., Mizernaya M.A., Chernenko Z.I., Kuzmina O.N., Miroshnikova A.P. Features of the geological structure and mineralization of the Artemyevskoye gold-silver-pyrite-polymetallic deposit (Rudny Altai). Proceedings of Karaganda State Technical University. No. 1(78) 2020, 187 p. S. – 168-172. ISSN 1609-1825.

In an international scientific publication included in the Scopus:

1. M. Mizernaya, A. Miroshnikova, A. Pyatkova, A. Akilbaeva. The main geological-industrial types of gold deposits in East Kazakhstan. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu (Ukraine), №5, 2019 – pp. 5-10. Scopus, SJR 2016:0,193. ISSN 2071-2227, E-ISSN 2223-2362.

2. M. Mizernaya, B. Dyachkov, A. Pyatkova, A. Miroshnikova, Z. Chernenko. Leading genetic types of base metal deposits of Rudny Altai. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu (Ukraine), №2, 2021 – pp. 11-16. Scopus, SJR 2020:0,375. ISSN 2071-2227. E-ISSN 2223-2362

3. B.A.D′yachkov, M.A. Mizernaya, S.V. Khromykh, A.Y. Bissatova, T.A. Oitseva, A. Miroshnikova, O.N. Kuzmina, N. Zimanovskaya, A. Pyatkova, K. Zikirova, O.V. Ageyeva, Y.T. Yeskaliyev. Geological history of the Great Altai: Implications for mineral exploration. Minerals, 2022, 12(6), p. 744. Scopus, SJR 2022:0,530. ISSN 2075-163X

In materials of international conferences:

1. Pyatkova A.P., Mizernaya M.A., Miroshnikova A.P., Chernenko Z.I. Features of the formation of VMS deposits in Rudny Altai using the example of the Artemyevskoye and Maleevskoye deposits. Correlation of Altaids and Uralides: deep structure of the lithosphere, stratigraphy, magmatism, metamorphism, geodynamics and metallogeny. Proceedings of the Fourth International Scientific Conference. – Ed. SB RAS, Novosibirsk, 2018 – P.120-121. ISBN 978-5-7692-1584-1.

2. Pyatkova A.P., Mizernaya M.A., Dyachkov B.A., Pyatkov A.V., Polovko M.P. Features of the mineral composition of ores from polymetallic deposits of Rudny Altai. Materials of the International scientific-technical conference in honor of the 60th anniversary of the D.Serikbayev EKSTU “The role of universities in creating an innovative economy.” – Ust-Kamenogorsk, 2018 – P.286-291. ISBN 978-601-208-537-2.

3. Pyatkova A.P., Pyatkov A.V., Polovko M.P., Nugumanova A.N., Mizernaya M.A. Gold-silver-pyrite-polymetallic type of deposits is the leader in gold mining in Eastern Kazakhstan. Creativity of the young - innovative development of Kazakhstan: Materials of the IV International Scientific and Technical Conference of Students, Masters and Young Scientists. 2018. – Ust-Kamenogorsk: EKSTU. pp. 401-405. ISBN 978-601-208-523-5

4. Pyatkova A.P., Mizernaya M.A., Dolgopolova A., Pyatkov A.V. Features of the localization of ore zones and the main PTR of the Shubinskoye deposit. The subsoil of Kazakhstan is the basis for the stability and prosperity of the country: Materials of the International scientific and practical. Conf. dedicated to the 120th anniversary of K.I. Satpayeva, 2019. – Ust-Kamenogorsk, EKSTU, 2019– P.134-136. ISBN 978-601-208-552-5.

5. Pyatkova A.P., Mizernaya M.A., Miroshnikova A.P., Amralinova B.B. Geochemical specialization of ores of the Artemyevskoye polymetallic deposit. Proceedings of the international scientific and practical conference "Integration of science, education and production - the basis for the implementation of the Nation's Plan" (Saginov Readings No. 12), June 18-19, 2020. Part 2/MES RK, KSTU. – Karaganda: Publishing house KSTU, 2020. – 932 p. P.87-88.

6. A.Pyatkova., A. Mizerny, A. Miroshnikova, M. Mizernaya, G. Nurshyikova, A. Akilbaeva, Z. Chernenko. Gold - sulphide mineralization of Rudny Altay (Kazakhstan). The International Scientific Conference "Challenges in Applied Geology and Geophysics: 100th Anniversary of Applied Geology." - AGH University of Science and Technology, Krakow, Poland, 2019.

7. Mizernaya M.A., Dyachkov B.A., Bisatova A.E., Pyatkov A.V., Chernenko Z.I. Geological and structural conditions of formation and ore content of Devonian volcanogenic complexes of Rudny Altai. "CORRELATION OF ALTAIDS AND URALIDS: deep structure of the lithosphere, stratigraphy, magmatism, metamorphism, geodynamics and metallogeny." Proceedings of the fifth international scientific conference – Ed. SB RAS, Novosibirsk, 2020– P.75-76. ISBN 978-5-7692-1671-8.

8. A. Pyatkova., M. Mizernaya, B.Dyachkov. Geological and structural conditions of formation and ore content of Devonian volcanogenic complexes of Rudny Altay. The XVI International Forum-contest of students and young scientists "Topical Issues of Rational Use of Nat-ural Resources". - Saint Petersburg Mining University, Saint-Petersburg, Russia, June 17-19, 2020.

9. Mizernaya M.A., Zikirova K.T., Aitkazyev T.M., Pyatkova A.P., Kuzmina O.N., Oitseva T.A., Pyatkov A.V., Ageeva O.V. Features of the formation of endogenous mineralization of deposits in the Leninogorsk ore district, Rudny Altai. Scientific and methodological basis for forecasting and searching for deposits of diamonds, precious and non-ferrous metals. Collection of abstracts of reports of the XII International Scientific and Practical Conference. Moscow. – M.:, 2023. P. 237-330.

Structure and volume: The thesis consists of Introduction, 6 chapters, Conclusion and the bibliography. The total volume of the thesis is presented on 192 pages, contains 66 figures, 16 tables, 136 titles in the bibliography and 3 Appendices.

The first section describes the general geological structure of Rudny Altai.

The second section is devoted to the geological and structural position of the three main ore districts of Rudny Altai and their history of exploration.

The third section describes the research methodology.

The fourth section provides an overview of the genetic and industrial classifications of VMS deposits, and also presents the modern taxonomy of Rudny Altai deposits.

The fifth section examines in detail the conditions for the formation of pyrite-polymetallic deposits of Rudny Altai, stratigraphic control, structure, forms and mineral composition of VMS ore deposits of Rudny Altai deposits.

The sixth section describes a model for systematizing spatial geological data of Rudny Altai using the example of the Maleevskoye deposit.

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