SUMMARY
of dissertation for academic degree of Doctor of Philosophy (PhD) in the specialty: 6D070600 – "Geology and exploration of mineral deposits"

Askarova Nazym Srajadinkyzy

ANALYSIS OF THE GENETIC CHARACTERISTICS OF POLYMETALLIC DEPOSITS OF THE ATASUI TYPE TO SELECT PREDICTIVE CRITERIA

The relevance of the work. In recent years, the close attention of geologists has been generalized to stratiform deposits of non-ferrous metals. Stratiform polymetallic deposits are of great importance in the balance of non-ferrous metals of Kazakhstan, the role of which increases from year to year. The class of stratiform deposits includes an extensive range of ore formations characterized by different roles of sedimentation, diagenetic and epigenetic processes in the formation of ore bodies. A group of stratified ore formations with a decisive role in the localization of sedimentation-diagenetic processes is distinguished. The ore bodies in these deposits are a natural component of the ore-bearing geological formation (the Karatau family of deposits). Other members of stratiform polymetallic deposits include the Atasui family, where epigenetic processes were of great, if not decisive, importance in the formation of industrial mineralization along with sedimentation-diagenetic processes.

Polymetallic mineralization is one of the most common types of mineralization in the earth's crust. Polymetallic deposits of the Atasui type are the most important source of world production of lead and zinc with associated extraction of silver, cadmium and other elements. In Kazakhstan, one of the highly promising regions with stratiform lead-zinc mineralization is the Atasuysky ore district in Central Kazakhstan. Polygenic stratiform ferromanganese and barite-lead-zinc deposits, isolated in an independent genetic Atasui type, are of crucial importance in the mineral resource complex of the Republic of Kazakhstan. They are the largest in the world in terms of barite reserves (about 30% of the world's confirmed reserves), one of the largest in terms of manganese reserves (third in the world, about 10% of confirmed reserves) and large in terms of lead and zinc reserves (one of the largest in the CIS and Kazakhstan). The name of the genetic type is given by the Atasuysky ore district of the Central Kazakhstan, where the largest deposits of this type were first identified and explored.

In Central Kazakhstan, Pb-Zn deposits are mainly concentrated in the Atasuysky ore district. It was here that JSC "Zhairemsky GOK" of the company "KazZINC" started its activity on the development of the fields of Zhairem, Ushkatyn III, Zhomart, etc.

In the context of the development of the polymetallic industry, ore genesis studies are becoming very relevant, and especially those aimed at developing sound predictive criteria for polymetallic mineralization, allowing them to be used in the search and exploration of deposits of the Atasui type.

Replenishment of mineral reserves, including lead-zinc ores, is crucial for the development of the mining and metallurgical industry of Central Kazakhstan.

The tense state of the mineral resource base of the polymetallic industry of the country provides the basis for the development and improvement of scientific and methodological foundations for forecasting and searching for lead-zinc deposits, which determines the relevance of the study. The development of predictive search criteria for polymetallic mineralization in the Atasuysky ore field will allow more efficient identification of such objects within the region.

Long-term previously conducted studies by various authors provide an opportunity for a comprehensive comparison of all available geological, geophysical and geochemical data, which in turn will allow us to develop new and improve existing predictive and search criteria.

Within the framework of the concept of the State Program of Geological Exploration for 2021-2025, the purpose of which is to create conditions for sustainable development and support the competitiveness of the mineral resource base, the scientific world faces the following tasks:

- ensuring the geological knowledge of the territory of Kazakhstan;
- replenishing the mineral resource base (increase in mineral reserves);
- scientific and research support for the geological studying the subsoil.

One of the ways to improve the efficiency of prospecting and exploration is the development of predictive criteria and search features. In this aspect, the territory of Central Kazakhstan (CK) is a major object for studying and conducting geological exploration.

Lead and zinc deposits are the most important raw material source of non-ferrous metallurgy, precious metals production and chemical industry, as well as copper deposits. The ores of these deposits, in addition to the base metals, contain significant amounts of copper, silver, gold, tin, bismuth, antimony, indium, cadmium, as well as barite and fluorite.

Deposits of lead and zinc, divided into genetic, industrial types, are known on all continents (except Antarctica), as well as in some structures of the World Ocean. They are common in a wide age range – from the late Archean to the Quaternary inclusive.

The purpose of the work. To select forecast criteria based on the study of genetic features of polymetallic deposits of the Atasui type for their use in planning and geological exploration in the Central Kazakhstan region.

Research objectives:

1. To analyze the genetic features of polymetallic deposits of the Atasui type;

2. To establish the main ore-generating and ore-localizing geological factors that can be used as predictive and prospecting signs of mineralization

3. On the basis of the selected criteria, to develop the principles of constructing the feature space of polymetallic deposits of the Atasui type;

4. To develop recommendations for predictive prospecting for polymetallic ores of the Atasui type.

Scientific novelty.

- Predictive criteria of belonging of polymetallic deposits to the Atasui type have been established, the main of them are: confined to Famen and Vise deposits (D3fm1 – C1v1); stratiform lens-formation form of bodies; confined mineralization to basalt-siliceous-carbonate sites and ore nodes with complex tectonic structure and linear zones of ore-bearing rocks; stage zonality of hydrothermal mineralization from a single deep source (tectonic faults of the base of structures and syngenetic faults); spatial relationship of polymetallic mineralization intensity with ferromanganese; relationship of paragenetic associations of mineralization of typomorphic minerals of the distribution of rare earth and rare elements with the stages of hydrothermal polymetallic mineralization; stages and zonality of lead deposition in association with barium, less often with copper and zinc in association with iron and manganese due to the separation of their ore genesis;
- A mathematical model linking the change in the hydrothermal flux density and the concentration of the heavy sulfur isotope δ34S from the textural and structural factors of ore-bearing rocks (limestones) in polymetallic mineralization, which can be used as a genetic sign of the formation of polymetallic ores of the Atasui type in limestones with varying degrees of fracturing, as well as a regular increase in silver with an increase in lead in lead-barite ores of the Zhayrem deposit (determination coefficient 58%);
- The Zhailma volcanic depression was formed by a powerful eruption of large volumes of rhyodacite-rhyolite volcanites from the large stratovolcanoes Severny Zhayrem, Ustanynzhal, as well as the parasitic crater Zhayrem during Devonian magmatism, which formed volcanogenic-cluster formations that were eroded, the remaining trachyriolites and trachybasalts of dyke and extrusive facies created a complex base of the mulda, which is filled with products of rhyolitic volcanism, which in the final (taphrogenic stage) accumulated during the Late Famennian – early carboniferous transgressions are powerful carbonate-terrigenous sediments that have undergone mineralization.

Protected scientific provisions:

- Based on a detailed study of the mineral composition of paragenetic ore associations; the presence of impurity elements in ores; textural and structural factors of mineralization and host rocks; stages of hydrothermal mineralization; tectonic faults forming the structural-formation zone during the activation of tectonic movements in the Hercynian epoch; mosaic-block structures of the Zailma graben –

syncline; the forecast criteria determining the belonging of the deposits of the Uspensky ore belt and the Atasuysky ore district of Central Kazakhstan to the deposits of the Atasuysky type, based on genetic characteristics, which include: a narrow age interval of ore formation (D3fm1 – C1v1); stratiformity of ore bodies formed in marine carbonaceous-siliceous-carbonate deposits; spatial relationship of polymetallic mineralization with iron-manganese; complex Pb-Zn-Ba composition of ores (Karazhal, Bolshoy Ktai, Zhumart, Kamys, Shointas, Tarsai, Atabai, etc.; polymetallic – Zhayrem, Bestobe, Ushkatyn, Kayrakty, etc.); stage zonality of hydrothermal mineralization with various mineral associations and typomorphic minerals with not significant near-ore changes; the timing of mineralization with tectonically complicated sites; localization of folded and post-folded intrusions near ancient volcanic apparatuses; the timing of mineralization to linear contact zones of block structures, reflected in the form of geophysical local anomalies of various amplitudes, which is determined by the shape, depth of occurrence of ore bodies and their sizes; the generality of the formation of Fe+ Mp+Zn mineralization at the first stage, and at the second, at the later stage – Ba+Pb, Cu+Ba.

The feature space formed is the basis for the use of image recognition software in geology based on the identified complex geological and geophysical criteria of deposits of the Atasui type.

- A mathematical model has been developed for changing the flow density of hydrotherms containing the sulfur isotope δ34S, linking the kinematic viscosity of a solution moving in limestones along nanostructured cracks and capillaries with surface tension in which mineralization takes place, describing the formation of secondary fracturing in limestones that occurs when solutions form polymetallic mineralization in various textural and structural types – at the first (initial) stage, thinly interspersed mineralization is formed, then, with an increase in the pressure of the hydrothermal flow, striped textures are formed in the nanopore and capillaries due to the growth of secondary cracks, which subsequently form large cracks with branching of thin cracks, creating conditions for nest-like, large-striped mineralization.

- Correlation analysis of the content of silver and lead in lead-barite ores (the second stage of hydrothermal mineralization forming the sphalerite-galena-barite association) of the Zhairem deposit indicates a close correlation of these elements, which gives reason to recommend complex ore processing with the extraction of Pb, Ba, Ag.

- The average composition of sedimentary rocks of the Devonian volcanogenic-plutonic belt of the DVPB coincides in composition with the rocks of the Zailmin graben-syncline of the Atasuysky ore district; mineralization of almost all deposits is associated with volcanic rocks of the Zailmin volcanic graben-syncline, which were formed by subsidence of a chain of volcanic chambers of ancient volcanoes (Severnaya Zhayrem, Ustanynzhalsky, Zhayrem) that spewed significant masses of

acid magmatic material. All this gives grounds for the possible finding of deposits of the Atasui type on the graben-synclines of the entire Zhailminskaya mulda, the ore formation of which was formed by the penetration of deep ore-bearing solutions along the faults formed by these volcanoes, as well as by extracting useful components from the host rocks formed by the collapse of the walls of ancient calderas. This hypothesis is confirmed by the already discovered deposits of Bogach, Tur, Karsyadyr, Aidarli graben syncline.

The validity and reliability of scientific statements, conclusions and recommendations is confirmed:

- correct formulation of geological research tasks, application of methods of mathematical physics, mathematical statistics and modern correlation and regression analysis;
- satisfied convergence of the results of correlation analysis (determination coefficient 58%) and a significant amount of data on the chemical composition of ores;
- positive results of practical use.

The scientific significance of the work consists in the selection of predictive criteria for deposits of the Atasui type with reliability and complexity of characteristics for their use in the search and exploration of polymetallic deposits within the Atasui ore belt and the Uspenskaya TMA zone with similarities in geological structure, close mineral associations, genetic traits.

Practical significance of the work. The results of the conducted research are recommended for use by GEOTEK LLP in organizing and conducting predictive prospecting operations for barite-lead-zinc ores of the Atasui type for the development of the mineral resource base of non-ferrous metallurgy, barite. The ores of the Zhayrem deposit, except Pb and Zn, can be used to extract copper and silver.

The personal contribution of the author of the dissertation in the performance of research consisted in the formulation of research objectives, in the collection, processing, systematization, generalization and interpretation of factual material; in conducting field work with the selection of samples for further analytical research; in substantiating the relevance of research work; in substantiating predictive criteria for the search for polymetallic deposits.

Approbation. The main provisions of the dissertation work were reported: at the International scientific and practical conferences "Saginovsky readings" (Karaganda 2019, 2020, 2021).

In the period from November 7 to November 21, 2019, during a scientific internship at the MGRI Russian State Geological Exploration University named after S. Orzhokinidze, Moscow, under the guidance of Doctor of Geological and Mineralogical Sciences, Professor Viktor Vasilyevich Dyakonov, a report on the topic of the dissertation was made. Received a certificate of successful completion of a

scientific internship. During the training period, reports were made at the technical meeting of GEOTEK LLP, at scientific seminars of the Department of GEMD.

The results of the work were introduced into the educational process during lectures and practical classes on the discipline "Forecast and search for MD" at the Department "Geology and exploration of mesopotamia of minerals" NPJSC "Karaganda Technical University named after Abylkas Saginov".

Publications: the main provisions of the dissertation work have been published in 13 scientific papers, 4 of which are in publications recommended by the Committee for Control in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 5 – in the proceedings of Kazakhstan and foreign international conferences and 4 articles included in the database of Scopus and Clarivate Analytics. The results of the study have been introduced into the practice of geological exploration organizations of GEOTEK LLP.

The structure and scope of the dissertation. The dissertation is presented on 160 pages of a computer set and consists of an introduction, six sections, a conclusion and a list of sources used, including 156 titles. The dissertation is illustrated with 48 figures and 10 tables.

Acknowledgments. The author expresses deep gratitude to scientific consultants, Doctor of Geological and Mineralogical Sciences Serykh V.I., Doctor of Technical Sciences, Professor Portnov V.S., PhD Kopobaeva A.N., for their help in choosing a scientific direction, valuable recommendations and assistance in mastering research methods, scientific support, valuable advice and comments, as well as for support and advice throughout the entire time of studying and writing a dissertation.

The author expresses special gratitude and deep appreciation to the foreign scientific consultant, Doctor of Geological and Mineralogical Sciences, professor of the Department "General Geology and Geological Mapping" of the MGRI of the Russian Geological Exploration University named after S. Orzhokinidze V.V. Dyakonov for valuable recommendations and scientific support, assistance in organizing and methodological assistance in carrying out the work, for organizing and helping in passing scientific internships abroad.

The author thanks for the help and support provided by teachers and staff of the Department "Geology and Exploration of Mineral deposits" of the NPJSC "Karaganda Technical University named after Abylkas Saginov" on the basis of which research was conducted, recommendations were received and a dissertation work was written.