

## ANNOTATION

**Dissertation for the degree of Doctor of Philosophy (PhD) in the educational program 8D07201 – “Geology and exploration of mineral deposits”**

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### **THE STUDY OF THE GEOLOGICAL CONDITIONS AND PATTERNS OF FORMATION OF LEAD-ZINC MINERALIZATION OF THE ALAIGYR DEPOSIT (CENTRAL KAZAKHSTAN)**

**Relevance of this study** - The concept of the state program of the geological exploration for 2021-2025 contains the need to form conditions for sustainable replenishment, development and support the competitiveness of the mineral resource base. Thus, the geological exploration is increased on the territory of the Republic of Kazakhstan. Currently, the main purposes of the geological industry are to ensure a high level of the advanced state geological study of subsurface resources, to replenish and develop the mineral reserves through an effective involvement in development of the fund of near-surface easily accessible deposits, and to develop the research and development works in the field of the geology.

The study of conditions for formation of the lead-zinc mineralization in the volcanogenic-plutonic belt of the Uspensky structural-formational zone is an important geological objective. It is aimed at replenishing of the mineral resource base of polymetals in Kazakhstan. They are used practically in all branches of industry, such as the mining, machine building, structural materials, electronics, power engineering, construction, automotive industry, etc. The study of the geological conditions for their formation contributes to the effective management of the ore mining, economic development of the region's industry, the conducting of the prospecting and exploration works, and exploration of the lead-zinc deposits in Kazakhstan.

It is important to ensure the sustainable mining of these resources with the growing of the global demand for lead and zinc. Based on the long-term demand, it is necessary to assess the reserves of the lead-zinc ore deposits in the world.

The lead-zinc industry is based on the processing of the complex polymetallic lead-zinc ores. These typically contain by-product components such as copper, silver and gold. Lead ores are the source of lead concentrates in 37 countries around the world. The majority (51.6%) of the mining production is concentrated in China, Peru and Australia, the USA, Mexico, Kazakhstan and other countries.

The world's total lead reserves are 202.7 million tonnes. They are focused in Australia (23.1 million tonnes), Kazakhstan (11.5 million tonnes), Russia (9.0

million tonnes), Canada (8.4 million tonnes), the USA (7.8 million tonnes), India (5.3 million tonnes), South Africa (4.6 million tonnes), and China (2.6 million tonnes).

Kazakhstan is one of the world's leading countries in terms of lead and zinc reserves and production. Kazakhstan has major ore districts with polymetallic mineralization: the Central Kazakhstan which includes deposits in the Atasuisky and Uspensky ore districts. Many of them are genetically related to a final (taphrogenic) phase of development of a large orogenic structure of Central Kazakhstan (Devonian volcanic-plutonic belt) and have a period of Late Frasnian-Famennian-Early Carboniferous formation of thick carbonate and carbonate-terrigenous sediments including the significant reserves of the stratiform lead-zinc ores. The polymetallic mineralization of the Uspensky zone reflects the peculiarities of its formation. The tectonic nature of the ore-bearing Uspensky zone and mineralization of this type is a subject of the ongoing debate.

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Based on a scientific and practical point of view, the structural and formation complexes of different ages can provide insight into the geodynamic setting of the Uspenka buckling zone and the conditions of ore formation. It is a basis for prospecting and exploration of the lead-zinc polymetallic deposits of this type in other regions.

**The idea of the work:** The ore-controlling factors, criteria and patterns of formation of the lead-zinc mineralization of the Alaigyr deposit and Alaigyr ore (Central Kazakhstan) are established to forecast the prospecting and exploration on the basis of determination of the nature of ore formation, peculiarities of the structural and tectonic structure of the Uspensky zone.

**The purpose** of the dissertation is to study the geological conditions of formation, to develop factors, criteria and patterns of conditions of formation of Alaigyr mineralization of the lead-zinc deposits, to develop the scientific and methodological bases of the forecasting and prospecting of the lead-zinc deposits in the Uspensky structural-formation zone of Central Kazakhstan and in other similar ores.

To achieve the purpose it is necessary to solve **the research objectives:**

1. The geodynamic situation should be studied. A critical analysis of previously existing ideas about the position of the Uspensky structural-formation zone in the tectonic structures of Central Kazakhstan should be conducted;

2. The material composition, petrographic features, mineralogy of the main rocks of the Alaigyr deposit of the Uspensky structural-formation zone should be studied;

3. The ore-controlling factors, criteria and features of lead-zinc mineralization of the Alaigyr ore based on the genetic and mineralogical features, and the degree of influence of volcanism on formation of Alaigyr deposits within the Uspensky ore district should be substantiated;

4. The prognostic-metallogenic features of Alaigyr mineralization based on the ore-formation typing of the lead-zinc deposits of volcanogenic-plutonic belt should be established. The influence of the hydrothermal processes on formation of ores of Alaigyr mineralization should be determined.

**The object of this study** is the lead-zinc volcanogenic-hydrothermal formation of Alaigyr deposit in the structural-formation complexes of Uspensky structural-formation zone and its connection with mineral composition of Alaigyr deposit.

**The subject of this study** is the geological structure, genesis, features of mineral composition of lead mineralization of the Alaigyr deposit.

**The factual material and research methods.** The author conducted a comprehensive analysis of stock materials of earlier studies of the geological structure of the Uspensky ore zone and the Alaigyr deposit as part of the sections: Eastern, Middle (Central), Western. The granulometric analyses, mineralogical and chemical studies of the selected ore types were performed. The material composition, physical, mechanical and technological properties of ores was studied. The system analysis of the geological and geophysical data and their statistical processing was conducted.

#### **Scientific novelty**

1. The Alaigyr genetic type of deposits was identified. Its peculiarity was the lead monomineral mineralization of sulphide ores. They had a nonuniform distribution of veinlet-impregnated ores of the volcanogenic-hydrothermal formation, and acid volcanics of the Givetian-Frasnian stage. They were controlled by steeply dipping, less frequently gently sloping crushing zones in the arches of brachyanticline or volcano-dome folds. Their spilite-siliceous-terrigenous and sedimentary rocks were dislocated and crumpled into small folds during the Permian-Hercynian orogeny.

2. The conditions of formation of polymetallic mineralization of Alaigyr deposit were established in different-age structural-formational complexes of ancient and young platforms, median massifs (microcontinents) of volcanic-plutonic belt, in zones of tectonomagmatic activation associated with deep faults and subvolcanic intrusions.

3. The ore-controlling factors, criteria and patterns of the Alaigyr ore location were determined. They were based on the genetic, mineralogical features, stratigraphic and lithological position of mineralization. It was associated with effusives: quartz porphyries and their tuffs, including sedimentary and terrigenous-sedimentary rocks of coastal and moderate deep-sea facies. The conditions included the hypergenic leaching and intensive metasomatism of the host rocks (silicification, potassium feldspatization, chloritization, baritization).

#### **The defended scientific provisions:**

1. The lead-zinc volcanogenic-hydrothermal formation of the Alaigyr deposit was genetically related to intense magmatic activity during the Famennian period of the Devonian. As a result, deep faults, schistosity and folding were developed. They manifested themselves under a high pressure and intense magmatic activity. Carbonate accumulations broken by intrusions were formed during the period of

the tectonic-magmatic activation. Their thickness increases eastward within the Kaindinsky zone. Industrial reserves of Alaigyr ores were formed in Famennian deposits, overlain by Carboniferous volcanics. The formation of the ore-bearing structure was associated with processes of the active volcanic activity. It caused the formation of a large volcanic depression. An analysis of location of the volcanic-intrusive formations detected that they arose within the Hercynian zone of the tectonic-magmatic activation, when granitoids of an increased basicity of a contrasting basalt-plagioclitic volcanism were developed.

2. The formation of the Alaigyr monomineral mineralization was associated with the subvolcanic intrusion in zones of the increased fracturing in underlying of acidic Frasnian volcanic rocks. They were controlled by the steeply dipping crushing zones. They were confined to the arch parts of brachyanticlinal or volcano-dome folds of the second and third orders.

The hydrothermal-metasomatic changes in the near-ore zone (sericitization, silicification, carbonatization, chloritization, baritization and albitization) were a factor to determine the mineralization. It was associated with the deep ore-controlling faults and deep active sources of magmatism (possibly plumes). They determined the development of fold belts and associated deposits suitable for the porphyry genetic type.

The Alaigyr mineralization was identified, and its peculiarity was a tiered structure. The upper tier was represented by sheetlike deposits of the hydrothermal-metasomatic ores. The lower tier consisted of the steeply dipping hydrothermal-metasomatic and fissure-vein bodies. They might be concentrates of mineralization of the hypovolcanogenic facies. This structure of deposits was one of the features of the genesis of Alaigyr mineralization.

3. The obtained prognostic-metallogenic factors and patterns were based on ore-formational typing of lead-zinc deposits of the volcanogenic-plutonic belt to identify the Alaigyr deposits within the Uspensky structural-formational zone.

Establishment of such patterns allow to allocate the structural zones and the prospective areas of mineralization, to substantiate recommendations on direction of the prospecting and exploration operations in the area, to specify and develop ore-formational typing of deposits in the Central Kazakhstan.

The spatial occurrence of mineralization in zones of the volcanic activity was due to the fact that ore-bearing solutions moved along the deep supply channels of fissure structures in the volcanic formations. They had the high chemical activity. They formed in the acidic volcanics (quartz porphyries) and zones with increased permeability. Thus, ore deposition associated with the structural features of the organization of rocks was observed. Hence, the geochemical connection between the ore bodies and volcanic processes emphasizes the connection between cracks of volcanic origin and routes of penetration of ore solutions into these zones.

#### **The practical significance:**

The analysis of the geodynamic, lithological and structural conditions of the Uspensky structural-formation zone established the conditions of formation of polymetallic mineralization of the Alaigyr deposit in different-age structural-formation complexes of the ancient and young platforms, median massifs of the

volcanic-plutonic belt, and in zones of tectonomagmatic activation. The ore-controlling factors, main features, criteria and patterns of Alaigyr ore location on presence of mineralization of the Alaigyr lead-zinc mineralization were determined using the complex interpretation of the geological studies.

The results of scientific study were implemented in production at Geotek LLP, Azimut LLP, in the educational process of NJSC “Karaganda technical university named after Abylkas Saginov” at the Department of geology and exploration of mineral deposits. They are used in lectures and the practical classes for undergraduates in the educational program 7M07202 “Geology and mineral exploration” in the following discipline “Mineral deposits of Kazakhstan”.

**The final result of the research** is the established geodynamic setting of the lead mineralization of the Alaigyr deposit. The ore-bearing structure associated with the processes of active volcanic activity was formed. The Alaigyr mineralization was identified. The ore-controlling factors and patterns based on the ore-formational typing of lead-zinc deposits of the volcanogenic-plutonic belt were obtained to identify the Alaigyr deposits within the Uspensky structural-formational zone.

**Author’s personal contribution:** the sampling and core material; processing of systematization, generalization and interpretation of the actual and stock materials; conducting of field work with the sampling; conducting of the laboratory studies of the material, mineral, granulometric composition of rocks and ores, substantiation of the relevance of this study; establishment of patterns of mineralization formation based on the ore-controlling factors, criteria and features of mineralization.

**Publications and approbation of this study:**

Based on the results of this study, 14 scientific articles including 2 papers in publications included in the database Scopus, 1 article in the journal included in the database Web of Science (impact factor 0.3) and 3 articles in the scientific publications recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan and 2 patents for invention RK (Annex B) were prepared and published.

The scientific-experimental and practical results of this study were reported and discussed at 6 international, republican and university scientific conferences:

In Russia - The XXV International scientific symposium of students and young scientists named after Academician M.A. Ussov “Problems of geology and subsoil development” (Tomsk, 2021);

In Ukraine - The XVI International scientific conference “Monitoring of geological processes and ecological condition of the environment” (Kyiv, 2022).

In Kazakhstan - at the international conferences “Saginov readings No. 13” (Karaganda, 2021), “Saginov readings No. 15” (Karaganda, 2023), The XII International scientific and practical conference “Global science and innovations 2021. Central Asia”, (Astana, 2021);

At seminars of Department of geology and exploration of mineral deposits at NJSC “Karaganda technical university named after Abylkas Saginov”;

At seminars of Department of Navoi state mining institute in Uzbekistan. Scientific internship from April 04 till April 18, 2022 in Navoi state mining institute in Uzbekistan, during this internship an article was written in Journal of advances in engineering technology. Vol.2(4) (Tashkent, 2022). The mineral composition, chemical, granulometric composition of rocks were studied. An advice was received on the topic of the thesis from doctor of technical sciences Alikulov Sh.Sh.

**Structure and scope of the thesis.** This thesis includes 148 pages of computer typesetting and consists of an introduction, three chapters, conclusion and a list of used references including 110 titles. The thesis is illustrated with 69 figures, 10 tables and has 2 appendices.

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