

SUMMARY
of dissertation for academic degree of Doctor of Philosophy (PhD) in the
educational program: 8D07201 - "Geology and exploration of mineral
deposits"

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GEOLOGICAL STRUCTURE, MATERIAL COMPOSITION,
CONDITIONS OF FORMATION AND METHODS OF EXPLORATION
OF THE CHROMITE DEPOSIT OF THE SOUTH-KEMPIRSAY MASSIF

The relevance of the work. The message of the Head of State Kassym-Jomart Tokayev to the people of Kazakhstan "Unity of the people and systemic reforms are a solid foundation for the prosperity of the country" indicates the need for a new impulse, especially in terms of geological exploration and integrated study of the subsoil, which is also reflected in the Decree of the Government of the Republic of Kazakhstan dated December 30, 2022 No. 1127 "On approval of the Concept of development of the geological industry The Republic of Kazakhstan for 2023-2027.

Currently, there is no unified concept of the formation of chromium deposits in ultrabasites of folded belts. For several decades, the genesis of ultrabasites and related deposits have been the focus of attention of a large number of domestic and foreign geologists, but despite this, none of the proposed hypotheses has become generally accepted.

The research of the dissertation is aimed at developing the theoretical foundations of the formation of chromium deposits in arrays of ultrabasites of folded belts, as well as at identifying patterns of their placement within large geotectonic structures. The morphology and composition of accessory chromespinels from several lherzolite massifs, the results of a complex mineralogical and microstructural study of relict lherzolites, textural and structural features of chromite ores are proposed.

The relevance of the work is determined by the need to develop scientifically-based criteria for the search for mineralization of chromite deposits of the Main ore field of the Kempirsay massif. The Southern Urals is a classic area of development of ophiolite (alpinotype) hyperbasites, the world's largest chromium deposits associated with massifs of this formation type are located here. At the same time, today in Kazakhstan the problem of creating its own mineral resource base of chromium is more acute than ever. The sharp shortage of commodity ores makes it urgent to raise the issue of involving "poor-type" objects in the development, which are widespread in the Southern Urals, as well as their complex use.

A significant part of the publications of mine geologists who were directly engaged in prospecting and exploration of deposits, which consider various aspects of the structure of chromite deposits, textures and structures of ores, are currently almost not available to a wide range of specialists, since they are "scattered" in a

large number of collections of production meetings and conferences. In this regard, references to the massif in the international geological community are given with references to works carried out in the mode of "geological excursions", often without references to the works of geologists who have devoted many years to studying the massif. Thus, there is an urgent need to conduct a retrospective generalization of the accumulated experience of geologists of the Soviet period in studying the unique Kempirsai deposits with the involvement of new materials obtained by the author of the dissertation.

The purpose of the dissertation is to determine the genesis of chrome mineralization based on the study of the material, petrographic composition, textural and structural characteristics of ores of the South Kempirsay ultramafic massif.

To achieve it , it was necessary to solve the following tasks:

1) to study the material composition, petrographic features, mineralogy of ultrabasic rocks of the massif and chromitic mineralization;

2) to study the microstructural features of primary peridotites and dunites, the relationship of structures and mineral formation;

3) to study accessory mineralization in chromitites of the Yuzhno-Kempirsay deposits;

4) to carry out morphological and material classification of accessory and ore-forming chromespinelids, to determine the mechanisms of their formation;

5) to develop a genetic model of the formation of ore bodies of chromitites of the Kempirsay massif.

The objects of research are chromite deposits of the Yuzhno-Kempirsay massif – Western Kazakhstan.

The subject of the study is the Kempirsai hyperbasite massif, which is one of the members of the hyperbasite belt of the Urals.

Factual material and research methods. The work is based on the results of studies of more than 100 samples of host and ore rocks of the Yuzhno-Kempirsay massif deposit, selected with the direct participation of the author of the work. In the course of the research, the following methods were used: wet chemistry methods - to determine the gross composition of rocks and ores; petrographic and electron microscopic methods are used to study the morphological features and composition of rock-forming minerals, chrome spinelides and accessory minerals of chromium ores; the method of backscattered electron diffraction (EBSD) is used to obtain data on the crystallographic orientation of minerals; the thermogravimetric method is used to study the type of serpentinization of ultramafic rocks.

Scientific novelty:

1. Regular changes of the host ultramafic and chromium ores have been established depending on the degree of depletion of rocks in the lherzolite — harzburgite — dunite series; at the same time, the chromicity of spinelide and the magnesia of olivine are progressively increasing in the direction; the content of impurities (Al, Cr) decreases in pyroxenes. It is shown that the olivine-chromespinel and orthopyroxene-clinopyroxene rocks were formed in the

subsolidus conditions of the upper mantle under conditions of plastic deformation and the formation of new phases of chromspinelide.

2. The stages of formation of chromitites in a single mode of upper mantle uplift, in the form of melts and fluids of various compositions, with the leading role of deformation processes in the formation of massive chromitites and the capture of mineral inclusions, as in the early stages of separation of dunitites and the formation of massive chromites, have been established.

3. A model has been developed for the formation of unique, large chromite complex deposits consisting of several fused bodies that arose during the change of the geodynamic regime in the upper mantle of the region, which was superimposed on numerous single bodies already formed during rifting, which indicates a pre-arc environment for the formation of deposits with "ore bundles" on the surface, defining new requirements for the methodology of their exploration.

Protected scientific provisions:

1. Ultramafic rocks of the Kempirsai massif are restite from partial melting of the upper mantle of the Ural paleobassin, represented by rocks of the lherzolite-harzburgite-dunite series, in this direction the chromicity of spinelide, the magnesia of olivine is progressively increasing; the content of impurities (Al, Cr) decreases in pyroxenes. The closure of exchange reactions between olivine and chromite in restite occurred in the temperature range of 700–8500C, pressure of 15-22 kbar and at oxygen fugitivity of $-1.04 \dots ++2.8 \text{ FM Q}$, which corresponds to the conditions of the upper mantle of the pre-arc basin. Secondary changes in mantle rocks during the ascent to the upper crust horizons are mainly limited by low-temperature (looped) serpentinization.

2. The general direction of the evolution of chromite mineralization, which is the basis for the study of structural and textural features, includes several stages:

- the stage of formation of chromspinelides due to the deformation decay of pyroxenes;
- the stage of formation of idiomorphic chromspinelids in dunitites;
- the stage of formation of interspersed ores inside dunite bodies as a result of differentiation in the plastic flow of restite;
- the stage of transformation of interspersed ores into massive ores at high temperatures and pressure;

3. The formation of unique chromium deposits in the southeastern part of the Kempirsai massif is associated with the most fully manifested cycle of differentiation of mantle material, which included partial melting of the lherzolite substrate, plastic flow of the restyitic dunite-harzburgite association and, at late stages, the change of the geodynamic regime from riftogenic to subduction. During these processes, chromite grains captured inclusions of various compositions, including native minerals, sulfides, sulfoarsenides with the leading role of base metal minerals (Fe, Ni, Co, Cu) and platinoids. among which the main role belongs to refractory (Os, Ir, Ru). The features of the composition and localization of inclusions indicate in favor of their restite origin during solid-phase differentiation with a subordinate role of fluid mass transfer.

Practical significance:

The developed model of the formation of deposits of the Yuzhno-Kempirsay group makes it possible to type deposits according to the relative role of formation mechanisms, determine the geodynamic situation of mineralization formation and predict the structural and material characteristics of ores, will increase the efficiency of the search and exploration of chromite deposits to replenish the mineral resource base of chrome ores.

The results obtained by the author in the study of accessory mineralization in chromitites will be used to assess the ore potential of the deposits of the Yuzhno-Kempirsay massif. The regularities of the composition, mineralogy and microstructure of chromitites and host ultramafites established by the author will be used in the future when studying new promising areas for chromite mineralization in the practice of the geological exploration organization "ERG Exploration" LLP.

The results of the study were introduced into the educational process during lectures and practical classes on the discipline "Petrography" at the Department "Geology and Exploration of mineral deposits", the NAO named after Abylkas Saginov, in the discipline "General Geology" on the topic "Geological structure, material composition, conditions of formation and methods of exploration of the chromite deposit of the Yuzhno-Kempirsay massif" in the educational process of D.Serikbayev EKSTU University.

The final result of the research is the construction of a model for the formation of unique ore deposits of chromitites in the southern part of the Kempirsai massif; the establishment of patterns of mineralogical and geochemical composition and accessory mineralization of various deposits; quantitative assessment of the conditions for the formation of ore-bearing association (temperature, pressure, oxygen fugitivity); interpretation of the paleogeodynamic conditions of the formation of rocks and ores of the massif.

The author's personal contribution consisted in collecting, processing, systematization, generalization and interpretation of actual and stock materials; conducting field work with sampling for analytical studies of impurity elements; conducting laboratory studies on a scanning electron microscope to identify mineral forms; substantiating the relevance of research work; writing dissertation chapters and articles on the topic of dissertation work.

Approbation of works and publication. The main provisions of the dissertation work:

- at the seminar of the Department "Geology and exploration of mineral deposits "NAO"Karaganda Technical University named after Abylkas Saginov";

- at the X All-Russian Youth Geological Conference "Geology, Geoecology and resource potential of the Urals and adjacent territories", Ufa, October 24-27, 2022;

- at the International scientific conference "Metallogeny of Ancient and Modern Oceans", Miass, 2022;

- at the international scientific and practical conference "Integration of science, education and production - the basis for the implementation of the National Plan" (Saginovsky Readings No. 14), Karaganda, 2022.

A scientific internship was completed in the period from November 06 to November 20, 2022 at the Institute of Geology of the Ufa Federal Research Center of the Russian Academy of Sciences under the guidance of a foreign scientific consultant D. Savelyev D.E. During the scientific internship, a field trip was conducted to the areas of the Southern Urals massif. Received a certificate of successful completion of a scientific internship.

The main provisions of the dissertation work are published in 4 articles in journals indexed in the Web of Science (Clarivate) and Scopus systems, and 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 Kazakhstani and foreign international conferences.

Structure and scope of the dissertation: The dissertation is presented on 108 pages of a computer set and consists of an introduction, six chapters, a conclusion and a list of sources used, including 199 titles. The dissertation is illustrated with 21 figures, 1 table and 11 appendices.

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