ANNOTATION

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

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TITANIUM-ZIRCONIUM PLACER DEPOSITS AND WEATHERING CRUSTS IN EAST KAZAKHSTAN AND THEIR PRACTICAL IMPORTANCE

The general description of the work: dissertation is devoted to the assessment of industrial prospects of rare metal-titanium-zirconium mineralization of Eastern Kazakhstan. During the research, the regularities of formation, material composition, geological and genetic features of titanium-zirconium placer mineralization of the Karaotkel and Satpaev deposits were studied. The practical significance of mineralized deposits of the non-exploited Karaotkel deposit has been studied. For the first time, an analysis of mineral-geochemical features and genetic characteristics of productive sediments was carried out on the actual material, and a source rock of placer mineralization of the Karaotkel deposit was established. Based on the identified search indicators and criteria, the prognostic area for detailed searches of rare metal-titanium-zirconium placer mineralization in the Zaisan depression area of Eastern Kazakhstan was determined.

The keywords: placer, weathering crust, ilmenite, titanium, zircon, zirconium, rare earth elements.

The relevance of dissertation studies is determined by the need to develop the mineral raw material base of titanium and zirconium in Eastern Kazakhstan. Due to the decrease in the possibility of detecting easily accessible placer deposits of titanium and zirconium, in recent years the efficiency of prospecting and exploration operations has sharply decreased. Under these conditions, deep geological research with scientific prognosis is of a great importance, the absence of which leads to unproductive labor costs and investments in prospecting and exploration operations. The explorations of known in the region reference placer deposits of titanium and zirconium, geological and mineral-geochemical features, study of the regularity of their formation with the establishment of a source rock will make it possible to determine the search indicators and criteria for identifying new similar deposits.

The main idea of the study is to determine the geological and genetic model of formation, identify search indicators and criteria, and evaluate the practical significance and prospects of rare metal-titanium-zirconium placer mineralization of Eastern Kazakhstan.

The object of the dissertation research is the rare metal-titanium-zirconium placer deposits − Karaotkel and Satpaev.

The subject of the study: productive sediments of rare metal-titanium-zirconium mineralization.

The purpose of the study: to assess the industrial prospects of rare-metal-titanium-zirconium mineralization of Eastern Kazakhstan on the basis of the research of known industrially significant deposits with the identification of prospective areas and further researches.

The objectives of the research:

1. Review, analyze and evaluate the state of geological exploration of titanium-zirconium placer mineralization deposits in Eastern Kazakhstan.
2. Study geological and structural position, material composition and geological and genetic characteristics of Karaotkel and Satpaev titanium-zirconium placer deposits.
3. Conduct a comparative analysis of mineral-geochemical and genetic characteristics of productive sediments, a study of geological conditions of formation and genetic connection with the bedrocks of the Karaotkel-Preobrazhenka multiphase igneous complex.
4. Determine prognostic and prospecting indicators and criteria of titanium-zirconium placer mineralization in the area of the Zaisan depression with the forecasting of area to identify new deposits.
5. Study the practical significance of heavy mineral sands of the Karaotkel deposit.

The main research methods: review, analysis and evaluation of previous researches, geomorphological studies using geoformation systems programs, field geological studies, laboratory and analytical studies.

The main defended provisions:

1. Analysis of titanium-zirconium placer deposits of Eastern Kazakhstan according to lithological, mineralogical, geochemical characteristics and for the first time calculated genetic indices showed that productive sediments of Karaotkel and Satpaev deposits were formed in transgressive-regressive coastal conditions of the paleo-basin of Zaisan lake during gradual climatic change from temperate-warm and humid (the Upper Cretaceous-Paleogene Period) to the cold and dry (the Neogene Period). They are characterized by a general geochemical trend and the predominance of light rare earth elements over heavy ones, while the Karaotkel placer is distinguished by increased contents of zircon and monazite minerals, high contents of rare earth elements and abnormally high contents of niobium, strontium, lead and bismuth.
2. The source rock of placer mineralization of the Karaotkel deposit is the rocks of the Karaotkel-Preobrazhenka intrusion, which is confirmed by comparative analysis of the chemical compositions of ilmenite, zircon and U-Pb rock dating. The material composition of multiphase hybrid igneous rocks of intrusion contributed to the industrially significant concentration of both basic rare metals and associated components represented by vanadium, scandium, niobium and yttrium, which can bring the deposit into the category of large rare metals in Kazakhstan.

3. Studies of orographic plans and sections of the Zaisan depression area revealed that all the manifestations of titanium-zirconium mineralization known at the present stage of exploration are located mainly at altitude levels of 400-600 m, which is recommended as a geomorphological search criterion when detecting titanium-zirconium placer deposits.

4. The formation of the titanium-zirconium mineralization of the Karaotkel and Satpaev deposits was multi-stage, the main of which are: the establishment of the multi-phase hybrid Karaotkel-Preobrazhenka intrusive in the Lower Permian Period, the development of the crust of intensive chemical weathering in the Upper Cretaceous Period, repeated erosion and re-deposition of weathering crust in the Paleogene and Neogene Periods, the accumulation of heavy minerals: ilmenite, zircon, etc. took place in the favorable coastal zones of the paleo-basin of Zaisan lake.

5. On the basis of the identified favorable search criteria common to industrial rare metal-titanium-zirconium placer deposits, the prognostic area recommended for detailed exploratory research for rare metal-titanium-zirconium placer mineralization is identified.

The scientific novelty:

1. For the first time, the absolute age of the zircon of the Karaotkel deposit was determined; a comparative analysis was made on the composition of ilmenite and zircon placer with the igneous rocks of the Karaotkel-Preobrazhenka multiphase intrusion. As a result of genetic link studies, for the first time, a source rock of rare metal-titanium-zirconium mineralization of the Karaotkel deposit was established on the actual material.

2. For the first time, a comparative analysis of the productive sediments of the Karaotkel and Satpaev deposits was made on mineral-geochemical features: data on the multi-element composition of productive deposits and micro-dimensional minerals were obtained; on actual material there are increased content of rare earth elements and abnormally high content of niobium, strontium, lead and bismuth.

3. For the first time, the depositional settings of productive sediments of the Karaotkel and Satpaev deposits were determined on the actual material according to the genetic index calculation system. Productive sediments in the area of deposits (the Upper Cretaceous crust of weathering, the North Zaisan formation of the Paleogene Period and the horizons of the Aral formation of the Neogene Period) were formed in the transgressive-regressive coastal zone during a gradual climatic change from temperate-warm and humid (the Upper Cretaceous Paleogene Period) to cold and dry (the Neogene Period).

The practical significance.

One of the important strategic tasks of the development of the Republic of Kazakhstan is attracting investments in the geological industry, the potential of which is significant for new discoveries. In Eastern Kazakhstan, a lot of ore occurrences and points of placer mineralization are known, including titanium and zirconium, which, due to the relatively low content of ore minerals and limited distribution, are not of practical importance. The importance of scientific studies on the search of new deposits is due to the following factors: the only producer of titanium products in the country is located in the region – Ust-Kamenogorsk Titanium-Magnesium Plant JSC; in the south, the region borders with one of the world's main importers of mineral concentrates − the People's Republic of China.

Dissertation research of geological features of the known regional reference placer deposits of titanium and zirconium are aimed at determining effective indicators and criteria for search of new similar deposits. The research results can be used in prospecting for placer mineralization of titanium and zirconium in the Zaisan depression area of Eastern Kazakhstan.

The practical approval of the work. The main provisions of the dissertation were reported and discussed at 5 international conferences:

1) international scientific and practical conference dedicated to the 70th anniversary of the Great Victory (1941-1945), Notes of the Ust-Kamenogorsk branch of the Kazakh Geographical Society, 2015. Ust-Kamenogorsk, Republic of Kazakhstan.

2) international meeting on the geology of placers and deposits of weathering crust, Perm State National Research University, 2015. Perm, Russian Federation.

3) international scientific and technical conference dedicated to the 60th anniversary of the founding of East Kazakhstan State Technical University named after D. Serikbaev “The Role of Universities in the Establishing of an Innovative Economy”, 2018. Ust-Kamenogorsk, Republic of Kazakhstan.

4) international conference on the Problem of geology and subsoil development: works of the XXII International symposium named after academician M.A. Usov of students and young scientists, dedicated to the 155th anniversary of the birth of academician V.A. Obruchev, 135th anniversary of the birth of academician M.A. Usov, founders of the Siberian Mining and Geological School, and 110th anniversary of the first graduation of mining engineers in Siberia, 2018. Tomsk, Russian Federation.

5) international conference: Exploration of mineral deposits MDSG AGM 2017–2018, Brighton University, 2018. Brighton, England.

Publications. In total, 12 works were published on the topic of the dissertation, including:

- 3 in scientific publications, including the international information resources Web of Science (Clarivate Analytics) and Scopus (Elsevier).

1) Suiekpayev Y.S., Sapargaliyev Y.M., Dolgopolova A.V., Pirajno F., Seltmann R., Khromykh S.V., Bekenova G.K., Kotler P.D., Kravchenko M.M., Azelkhanov A.Z. Mineralogy, geochemistry and U-Pb zircon age of the Karaotkel

Ti-Zr placer deposit, Eastern Kazakhstan and its genetic link to the Karaotkel-Preobrazhenka intrusion // Ore Geology Reviews. – 2021. – Vol. 131. – Article 104015. Impact Factor 3,809. Квартиль по геологии – Q1 (91 процентиль).

2) Suiekpayev Y., Sapargaliyev Y., Bekenova G., Kravchenko M., Dolgopolova A., Seltmann R. Mineralogical and geochemical features of satpaev Ti-Zr placer deposit, East Kazakhstan // News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. – 2019. – Vol. 1, Iss. 433. – P. 6–22.

3) Suiekpayev Y., Sapargaliyev Y., Dolgopolova A., Seltmann R., Raspopov A., Bekenova G. Predictive estimate of Ti-Zr placer deposits in mesozoic and cenozoic sediments at nw margins of the Zaysan basin, East Kazakhstan // News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. – 2019. – Vol. 2, Iss. 434. – P. 6–14.

- 3 in scientific publications recommended by the Committee:

1) Кравченко М.М., Дьячков Б.А., Суйекпаев Е.С., Сапаргалиев Е.М., Азельханов А.Ж., Ойцева Т.А. Перспективы укрепления и развития сырьевой базы титанового производства в Восточном Казахстане. Вестник Пермского университета. – Пермь, 2016. Вып.1(30). – С. 78-87. DOI: http://dx.doi.org/10.17072/psu.geol.30.78.

2) Суйекпаев Е.С., Сапаргалиев Е.М., Кравченко М.М., Азельханов А.Ж. Поисковые направления по выявлению титанциркониевых россыпей озерного происхождения на территории Восточного Казахстана. Вестник Восточно-Казахстанского государственного технического университета им. Д. Серикбаева, 2018. – Вып. №4. – Усть-Каменогорск. – С. 45-51. ISSN 1561-4212.

3) Сапаргалиев Е.М., Азельханов А.Ж., Кравченко М.М., Суйекпаев Е.С., Дьячков Б.А. Перспективы практического значения комплексного освоения бедных титан-циркониевых россыпей и кор выветривания Казахстана. Недропользование. Пермский национальный исследовательский политехнический университет. 2021. Т. 21, № 1. – С.19-24. http://dx.doi.org/10.15593/2712-8008/2021.1.3.

- 6 in works of international conferences:

1) Дьячков Б.А., Черненко З.И., Фролова О.В., Матайбаева И.Е., Суйекпаев Е.С. Геологическое строение и полезные ископаемые Буранского участка, Северное Призайсанье. Материалы международной научно-практической конференции К 70-летию Великой Победы (1941-1945). Записки Усть-Каменогорского филиала Казахского Географического общества. – Усть-Каменогорск: Шыгыс Полиграф, январь 2015. – Вып. 9. – С. 94-104.

2) Кравченко М.М., Суйекпаев Е.С., Сапаргалиев Е.М., Дьячков Б.А., Азельханов А.Ж. Перспективы укрепления минерально-сырьевой базы титанового производства в Восточном Казахстане. Материалы международного совещания по геологии россыпей и месторождений кор выветривания (24–28 августа 2015 г.). Пермский государственный национальный исследовательский университет. – Пермь, 2015. – С. 113–114.

3) Суйекпаев Е.С., Кравченко М.М., Сапаргалиев Е.М., Азельханов А.Ж. Ti-Zr россыпи и коры выветривания Восточного Казахстана. Материалы международной научно-технической конференции, посвященной 60-летию образования ВКГТУ им. Д. Серикбаева «Роль университетов в создании инновационной экономики». Издательство ВКГТУ им. Д. Серикбаева, 2018. – С. 299-306.

4) Суйекпаев Е.С., Кравченко М.М., Сапаргалиев Е.М. Прогнозная оценка россыпей титана Восточного Казахстана. Материалы международной конференции по Проблеме геологии и освоения недр: труды XXII Международного симпозиума имени академика М.А. Усова студентов и молодых ученых, посвященного 155-летию со дня рождения академика В.А. Обручева, 135-летию со дня рождения академика М.А. Усова, основателей Сибирской горно-геологической школы, и 110-летию первого выпуска горных инженеров в Сибири. – Томск: Издательство Томского политехнического университета, 2018. – С. 193-194.

5) Suiekpayev Y., Sapargaliyev Y., Kravchenko M., Dolgopolova A., Seltmann R., Azelhanov A. Ti-Zr placers and weathering crusts of the Karaotkel and Satpaev deposits, Kazakhstan. England. Mineral Deposits Studies. Group AGM 2017-18 Sallis Benney Lecture Theatre, Grand Parade, University of Brighton 3rd to 5th January 2018. https://cpb-euw2.wpmucdn.com/blogs.brighton.ac.uk/dist/f/3340/ files/2017/10/MDSG 2017-web-abstract-volume-1b62gf6.pdf.

6) Suiekpayev Y., Sapargaliyev Y., Kravchenko M., Dolgopolova A., Seltmann R., Azelhanov A. Ti–Zr placers and weathering crusts of the Karaotkel and Satpaev deposits, Kazakhstan. Applied Earth Science. Transactions of the Institutions of Mining and Metallurgy. ISSN: 2572-6838 (Print) 2572-6846 (Online) Journal homepage: https://www.tandfonline.com/loi/yaes21. https://doi.org/10.1080/257 26838.2019.1607203.

The structure and scope of the dissertation.

The dissertation is presented on 88 pages and consists of an introduction, 7 sections, a conclusion and a list of cited references, including 107 titles. The dissertation is illustrated by 33 figures, 24 tables.

The first section is dedicated to the modern state of exploration of titanium-zirconium placer mineralization, the history of prospecting and exploration of titanium-zirconium placers in Eastern Kazakhstan.

The second section is dedicated to the regional geological characteristic of the titanium-zirconium deposits of Eastern Kazakhstan and the geological structure of the Karaotkel and Satpaev deposits.

The third section is dedicated to the research methods.

The fourth section is dedicated to the research of material composition and genetic characteristics of productive sediments of Karaotkel and Satpaev deposits.

The fifth section is dedicated to the research of genetic connection of productive sediments of the Karaotkel deposit and the complex of igneous rocks of the Karaotkel-Preobrazhenka multiphase intrusion.

The sixth section is dedicated to geological and geomorphological analysis of the Zaysan depression area with a prognostic assessment of titanium-zirconium placer mineralization.

The seventh section is dedicated to assessing the practical significance of the titanium-zirconium placer of the Karaotkel deposit.

The summary presents the main conclusions and significance of dissertation research.