REVIEW
of the official reviewer for dissertation work
Aizhulov Daniar Yersenovich on the theme «The study of geological and hydrological processes of roll-front type deposits genesis» presented for the degree of Doctor of Philosophy (PhD) in the specialty «6D06300 - Mechanics».

№	Criteria	Eligibility (one of the options must be checked)	Justification of the position of the official reviewer
1.	The topic of the thesis (as of the date of its approval) corresponds to the directions of development of science and/or state programs	1.1 Compliance with priority areas of science development or government programs:	Compliant
		1) The thesis was completed within the framework of a project or target program financed from the state budget (indicate the name and number of the project or program) 2) The thesis was completed within the framework of another state program (indicate the name of the program) 3) The dissertation corresponds to the priority direction of the development of science, approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (indicate the direction)	1) The thesis was completed within the framework of the project of grant funding for scientific research from the Ministry of Education and Science of the Republic of Kazakhstan, 2020-2022, AP08051929 "The study of the mechanisms of ore genesis and development of high accuracy digital technology to contour ore bodies in rollfront type mineral deposits", project number GR 0120PK00058. 2) – 3) The topic of the dissertation corresponds to the priority "Scientific research in the field of natural sciences"
2.	Importance for science	The work makes/does not make a significant contribution to science, and its importance is well disclosed/not disclosed	The research findings have numerous applications, such as investigating rollfront genesis mechanisms at different deposit sites, generating synthetic data to test the accuracy of geomodelling methods, providing training data for future neural network-based algorithms designed to enhance the In-Situ Leaching process, and developing a geological 3D model to estimate deposit resources using well data. According to the numerical experiments conducted, the proposed method yields accurate results while requiring a substantially reduced

			number of exploratory wells. This reduction could lead to significant cost savings.
3.	The principle of independence	Self-reliance level: 1) High; 2) Medium; 3) Low; 4) No independence	The level of independence and self-reliance is high, since the main results of the research conducted within the framework of the dissertation work were obtained by the author independently.
4.	The principle of inner unity	4.1 Justification of the relevance of the thesis: 1) Justified; 2) Partially justified; 3) Not justified.	The relevance of this dissertation is thoroughly justified. Given the depletion of "cheap" uranium reserves, the imperative to reduce exploration costs, and the necessity to enhance the accuracy of current geological modeling and resource estimation methods, these issues are of high importance. The research investigates the formation mechanisms of rollfront deposits, proposes a genesis model, and introduces an innovative geostatistical method for generating high-precision geological models.
		4.2 The content of the thesis reflects the topic of the thesis: 1) Reflects; 2) Partially reflects; 3) Does not reflect	The content of the thesis reflects the topic of the dissertation in full.
		4.3. The purpose and objectives correspond to the topic of the thesis: 1) correspond; 2) partially correspond; 3) do not correspond	The goal of this work is to uncover the mechanisms behind the formation of rollfront mineral deposits in order to develop mathematical and numerical models that accurately represent their formation. Furthermore, the study aims to use these findings to create a new geostatistical method for precise geomodeling and reserve estimation of these deposits. The purpose and objectives correspond to the topic of the thesis
		4.4 All sections and provisions of the thesis are logically interconnected: 1) completely interconnected;	All sections and provisions of the dissertation are logically interconnected.

		2) the interconnection is partial; 3) there is no interconnection	
		4.5 The new solutions (principles, methods) proposed by the author are reasoned and evaluated in comparison with the known solutions: 1) there is a critical analysis; 2) partial analysis; 3) the analysis does not represent one's own opinions, but quotes from other authors	While the current understanding of rollfront formation mechanisms has been reviewed in the literature, new insights have been gained through numerical analysis. Conventional geostatistical methods have been critically evaluated for their applicability to infiltration-type deposits. A thorough analysis, incorporating both qualitative and quantitative comparisons, has been conducted to contrast conventional methods with the proposed approach.
5.	Scientific novelty principle	5.1 Are the scientific results and provisions new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	A principally new investigation into the formation mechanisms was conducted through the modeling of reactive transport. A conceptually novel geostatistical method has been developed specifically for the modeling and reserve estimation of epigenetic mineral deposits, which are formed through the infiltration of valuable components through permeable media.
		5.2 Are the dissertation findings new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The processes of rollfront formation have been thoroughly examined in various overseas and Soviet literature, and the characteristics influencing rollfront distribution derived in current research are logically sound. However, a new reactive transport model can be utilized for multiple purposes, including synthetic data generation and geomodelling of rollfronts. The new geostatisical method has demonstrated that the application of CFD models can enhance the accuracy of resource estimation and geological modeling.

		5.3 Technical, technological, economic or management decisions are new and reasonable: 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	Technical, technological, economic or management decisions are new and reasonable. Research findings suggest a potentially significant positive economic impact from applying the results of the present study. Numerical experiments indicate that the proposed method produces accurate results while substantially reducing the number of exploratory wells needed. This reduction can lead to considerable cost savings in well construction. With capital expenditures for exploratory well construction typically ranging from $15,000 to $20,000 USD per well, the overall costs for a block that would traditionally require 100 exploratory wells could be reduced by approximately $1,000,000 USD when the number of wells is decreased to 20.
6.	The validity of the main findings	All main conclusions are/are not based on scientifically significant evidence or well-grounded (for qualitative research and areas of training in the arts and humanities)	All the primary conclusions are grounded in scientifically sound evidence and are well substantiated.
7.	The main provisions for the defense	It is necessary to answer the following questions for each provision separately: 7.1 Is the provision proven? 1) proven; 2) rather proven; 3) rather not proven; 4) not proven 7.2 Is it trivial? 1) yes; 2) no 7.3 Is it new? 1) yes; 2) no	Under the first provision a reactive transport simulation was employed to investigate the formation of rollfront deposits, facilitating the determination of the relationship between various characteristics and the geometry and content of these deposits. 7.1 Is the provision proven? – Yes, reactive transport modeling has demonstrated results comparative to the laboratory experiment. 7.2 Is it trivial? – No, geological, hydrodynamic and chemical had to be accounted for by the model. 7.3 Is it new? – Yes, the study of this kind has

		7.4 Application level: 1) narrow; 2) medium; 3) wide 7.5 Is it proven in the article? 1) yes; 2) no	not been yet conducted. 7.4 Application level is wide, various mechanisms have been discussed in the work. 7.5 Is it proven in the article? – Yes, appropriate publications have been made, including a paper published in a journal indexed by Scopus database. Under second provision a mathematical model and a tool for generating synthetic rollfront fields for verification of geostatistical models has been created. 7.1 Is the provision proven? – Yes, reactive transport modeling has demonstrated results comparative to the laboratory experiment. 7.2 Is it trivial? – No, geological, hydrodynamic and chemical had to be accounted for by the model. 7.3 Is it new? – Yes, the tool of this kind does not exist. 7.4 Application level is wide, various applications have been discussed in the work. 7.5 Is it proven in the article? – Yes, appropriate publications have been made, including a paper published in a journal indexed by Scopus database. Under third provision a new geostatistical method, utilizing streamlines, devised to construct a geological 3D model of the deposit with increased accuracy has been developed. 7.1 Is the provision proven? – Yes, a comparative analysis has been conducted with conventional methods. 7.2 Is it trivial? – No, CFD together with geostatistics have been considered during the research.

			7.3 Is it new? – Yes, a principally new method has been developed. 7.4 Application level is wide, various applications have been discussed in the work. 7.5 Is it proven in the article? – Yes, appropriate publications have been made, including a paper published in a journal indexed by Scopus database. Under fourth provision a software tool for geological modeling and reserve estimation of rollfront deposits has been created. 7.1 Is the provision proven? – Yes, provision has been proven appropriately. 7.2 Is it trivial? – No, CFD together with geostatistics have been considered during the research. 7.3 Is it new? – Yes, a principally new method has been developed. 7.4 Application level is wide, various applications have been discussed in the work. 7.5 Is it proven in the article? – Yes, appropriate publications have been made, including a paper published in a journal indexed by Scopus database.
8.	The principle of reliability Reliability of sources and	8.1 Choice of methodology - is justified or the methodology is described in sufficient detail 1) yes; 2) no	Choice of methodology is justified and the methodology is thoroughly described in sufficient detail.

	information provided	8.2 The results of the thesis were obtained using modern methods of scientific research and methods of processing and interpreting data using computer technologies: 1) yes; 2) no	The results of the thesis were obtained using modern methods of scientific research and methods of processing and interpreting data using computer technologies.
		8.3 Theoretical conclusions, models, identified relationships and patterns have been proven and confirmed by experimental research (for areas of training in pedagogical sciences, the results have been proven on the basis of a pedagogical experiment): 1) yes; 2) no	Scientific provisions have been proven in full.
		8.4 Important statements are confirmed / partially confirmed / not confirmed by references to current and reliable scientific literature	Yes, important statements are backed by current and reliable references.
		8.5 Used literature sources are sufficient/not sufficient for a literature review	A sufficient literature review has been conducted by the author.
9	Practical value principle	9.1 The thesis has theoretical value: 1) yes; 2) no	Theoretical significance of the work lies in: creation of reactive transport model of rollfront formation and development of fundamentally new geostatistical method targeted at geomodelling of infiltration type epigenetic deposits.
		9.2 The thesis is of practical importance and there is a high probability of applying the results obtained in practice: 1) yes; 2) no	Yes, a more precise geological model could enhance production efficiency,
		9.3 Are the practice suggestions new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	Yes, some of research outcomes obtained from the current dissertation have been integrated into software modules that are actively utilized at real deposits managed by Kazatomprom.
10.	The quality of writing and	Academic writing quality: 1) high;	Academic writing is of high quality.

	design	2) average; 3) below average; 4) low.	

Conclusion: I believe that the dissertation of Aizhulov D.Y. on the topic "The study of geological and hydrological processes of roll-front type deposits genesis" fully satisfies the requirements for dissertations for the degree of Doctor of Philosophy (PhD), and its author, Aizhulov D.Y. deserves to be awared the degree of Doctor of Philosophy (PhD) in specialty of "6D06300 - Mechanics".

Official Reviewer:
Doctor of physical and mathematical sciences, professor,
head of the department of mathematical modeling of
Samarkand State University named after Sharof Rashidov
Khuzhayorov Bakhtiyor
(place of work, academic title)

(signature)

Bakhtiyor Khuzhayorov
(full name)

The signature of prof. B. Khuzhayorov is certified.

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