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)	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. The dissertation topic aligns with 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 offer numerous applications, including: - Investigating rollfront genesis mechanisms; - Generating synthetic data to test the accuracy of geomodelling methods; - Providing training data for future neural network-based algorithms to enhance the In-Situ Leaching process; - Developing a geological 3D model to estimate deposit resources using well

			data. Numerical experiments indicate that the proposed method delivers accurate results while requiring significantly fewer exploratory wells, potentially leading to substantial cost savings.
3.	The principle of independence	Self-reliance level: 1) High; 2) Medium; 3) Low; 4) No independence	The research conducted for this dissertation demonstrates a high level of independence and self-reliance, as the author obtained the main results 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 well-established. With the depletion of profitable uranium reserves, the need to reduce exploration costs, and the imperative to improve the accuracy of current geological modeling and resource estimation methods, these issues are critically important. This research examines the formation mechanisms of infiltration-type deposits, proposes a genesis model, and introduces a new streamline-based geostatistical approach for creating 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 thesis content fully reflects the dissertation topic.
		4.3. The purpose and objectives correspond to the topic of the thesis: 1) correspond; 2) partially correspond; 3) do not correspond	The purpose and objectives align with the thesis topic. The purpose of this work is to determine the mechanisms behind the formation of infiltration-type mineral deposits of stratum oxidation

			and develop mathematical and numerical models that accurately represent their formation. Additionally, the study aims to use these findings to create a new geostatistical method for precise reconstruction of geological model as well as reserve estimation.
		4.4 All sections and provisions of the thesis are logically interconnected: 1) completely interconnected; 2) the interconnection is partial; 3) there is no interconnection	All sections and provisions of the dissertation are logically interconnected. Firstly, a review of the current knowledge on rollfront formation is conducted, followed by the development of reactive transport models to imitate the genesis of rollfront deposits. Based on the conclusions derived from this investigation, a new CFD-based geostatistical method is created and validated against conventional methods.
		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	The literature review has covered the current understanding of rollfront formation mechanisms, and new insights have been gained through numerical analysis. Conventional geostatistical methods have been critically evaluated for their applicability to deposits formed through infiltration processes. A comprehensive analysis, incorporating both qualitative and quantitative comparisons, has been conducted to contrast traditional 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)	Conceptually, new research into formation mechanisms was conducted through reactive transport modeling. An innovative geostatistical method has been developed specifically for the

			modeling and reserve estimation of epigenetic mineral deposits of stratum oxidation, which form through the propagation of dissolved minerals through sandstones.
		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 literature review provides insights into established mechanisms governing rollfront formation from both geological and hydrological perspectives. This study extends this understanding through reactive modeling, identifying new hydrodynamic and chemical regimes that impact mineral distribution within geochemical barriers. The incorporation of Computational Fluid Dynamics (CFD) methods has been shown to improve the accuracy of existing geostatistical approaches, particularly in the context of infiltration-type deposits.
		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)	The decisions made in this study are new and justifiable, potentially leading to significant economic benefits. Numerical experiments show that the proposed method is accurate and drastically reduces the need for exploratory wells, resulting in a substantial reduction in expenses.
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 main conclusions are based on scientifically significant evidence and are well grounded.
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;	Within the initial provision, a reactive transport simulation was utilized to explore the genesis of rollfront deposits, enabling the identification of the

		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 7.4 Application level: 1) narrow; 2) medium; 3) wide 7.5 Is it proven in the article? 1) yes; 2) no	interplay between characteristics and the geometry and composition of these deposits. In the subsequent provision, a mathematical model and a synthetic rollfront deposit generation tool were developed for the validation of geostatistical models. Under the third provision, a novel geostatistical approach employing streamlines was formulated to enhance the precision of constructing a geological 3D model of the deposit. Lastly, a software tool for geological modeling and reserve estimation of rollfront deposits was devised in the fourth provision. For all the provisions: 7.1 Is the provision proven? – Yes, reactive transport modeling has shown results comparable to those obtained in laboratory experiments. 7.2 Is it trivial? – No. Interdisciplinary research has been conducted within the work. 7.3 Is it new? – Yes. 7.4 Wide. The scope of application is broad, encompassing discussions on various mechanisms within the work. 7.5 Is it proven in the article? – Yes, Suitable publications have been accomplished, including articles published in journals indexed by the Scopus database.

8.	The principle of reliability Reliability of sources and information provided	8.1 Choice of methodology - is justified or the methodology is described in sufficient detail 1) yes; 2) no	The selection of methodology is well-justified, and its description is detailed adequately.
		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 thesis results were achieved through contemporary scientific research methods and the utilization of computer technologies for data processing and interpretation.
		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	Theoretical conclusions, models, identified relationships and patterns have been proven and fully confirmed by experimental research.
		8.4 Important statements are confirmed / partially confirmed / not confirmed by references to current and reliable scientific literature	Crucial assertions are supported by up-to-date and dependable references.
		8.5 Used literature sources are sufficient/not sufficient for a literature review	The author has undertaken a sufficient literature review.
9	Practical value principle	9.1 The thesis has theoretical value: 1) yes; 2) no	The theoretical significance of the study resides in two aspects: the establishment of a reactive transport model for rollfront formation and the creation of a new streamline-based geostatistical interpolation technique.
		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	The practical significance is evidenced by the deployment of software tools developed from the research outcomes at currently operational industrial sites.
		9.3 Are the practice suggestions new? 1) completely new;	Yes, certain research findings from the present dissertation have been incorporated into software modules

		2) partially new (25-75% are new); 3) not new (less than 25% are new)	actively employed at operational deposits managed by Kazatomprom.
10.	The quality of writing and design	Academic writing quality: 1) high; 2) average; 3) below average; 4) low.	The quality of academic writing is high.

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 awarded the degree of Doctor of Philosophy (PhD) in the specialty of "6D06300 - Mechanics".

Official Reviewer:
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