SCHOOL OF MINING AND GEOSCIENCES
DEPARTMENT OF PETROLEUM ENGINEERING

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REVIEW OF THE OFFICIAL REVIEWER

for the dissertation thesis submitted on the Requirements for the Degree of Doctor of Philosophy (Ph.D.) in Petroleum Engineering (8D07202) by Assel Talgatovna Zholdybaeva
titled "An evaluation of the enhanced oil recovery methods in a high viscosity oil reservoir based on the numerical simulation model of the East Moldabek deposit"

№ n/a	Criteria	Compliance with the criteria (it is necessary to mark one of the answer options)	Justification of the official reviewer position
1.	The dissertation title (at the time of its approval) corresponds to the directions of scientific development and/or state programs	1.1 Compliance with priority directions of science development or state programs: 1) the dissertation was completed within the framework of a project or target program funded from the state budget (specify the name and number of the project or program) 2) the dissertation was completed within the framework of another state program (specify the name of the program) 3) **the dissertation corresponds to the priority direction of science development approved by the higher scientific and technical commission under the government of the Republic of Kazakhstan (specify the direction)**	This Ph.D. thesis aimed to investigate thermal EOR and its associate problems in East Moldabek field in Kazakhstan to solve the problems of the implementation. Therefore, the title of the dissertation corresponds to the priority directions of development of science and state programs for the development of the Oil and Gas sector of the Republic of Kazakhstan.
2.	Importance to science	The work **makes**/does not make a significant contribution to science, and its importance is well **disclosed**/ not disclosed	The presented results contribute to the development of steam/hot water flooding technology and improve knowledge in this field. Its importance is well disclosed in the thesis.
3.	The principle of independence	The level of independence: 1) high; 2) **average;** 3) low; 4) there is no independence	Based on the presented thesis and my discussion with the student, I can say that the work represents the doctoral student's efforts in most of the steps.
4.	The principle of internal unity	4.1 Justification of the dissertation relevance: 1) **justified**; 2) partially justified; 3) not justified	The relevance of this dissertation is justified by its focus on a critical and underexplored challenge in the development of high-viscosity oil reservoirs with high clay content—clay mineral swelling, which is a case in Kazakhstan. This phenomenon significantly impacts reservoir permeability and fluid mobility, thereby reducing the efficiency of thermal enhanced oil recovery methods such as steam injection. Given the substantial reserves of hard-to-recover high-viscosity oil in Kazakhstan, estimated at approximately 0.7 billion tons, addressing this issue is of paramount importance for

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			the country's energy sector. By developing a numerical model that integrates the effects of clay swelling and evaluating the optimal salinity conditions for injected water, this research advances the scientific understanding and practical application of thermal EOR. The study also demonstrates economic benefits through improved recovery strategies.
		4.2 The dissertation content reflects the title of the dissertation: 1) **reflects**; 2) partially reflects; 3) does not reflect	The dissertation content aligns closely with its title, "An Evaluation of the Enhanced Oil Recovery Methods in a High Viscosity Oil Reservoir Based on the Numerical Simulation Model of the East Moldabek Deposit." It focuses on evaluating thermal enhanced oil recovery (EOR) methods, particularly steam and hot water injection, for high-viscosity oil reservoirs. Using the East Moldabek deposit as a case study, the research develops and applies a numerical simulation model to analyze the effects of geological structure, clay swelling, and water salinity on reservoir permeability and oil recovery efficiency. This approach directly addresses the themes outlined in the dissertation title.
		4.3 The purpose and objectives correspond to the title of the dissertation: 1) **correspond**; 2) partially correspond; 3) do not correspond	The purpose and objectives of the dissertation directly correspond to its title. The study aims to optimize thermal EOR methods for high-viscosity reservoirs by evaluating the impact of clay swelling and water salinity on reservoir permeability and oil recovery. The objectives include analyzing clay mineral properties, developing a numerical simulation model, and identifying optimal recovery strategies tailored to the East Moldabek deposit. These goals are reflected in the dissertation.
		4.4 All sections and hypotheses of the dissertation are logically interrelated: 1) **completely interconnected**; 2) the relationship is partial; 3) there is no relationship	All sections and hypotheses of the dissertation are logically interrelated, forming a cohesive framework for evaluating EOR methods in high-viscosity reservoirs. The introduction establishes the significance of addressing challenges like clay swelling and permeability reduction. Subsequent sections analyze the mineralogical properties of the reservoir, investigate the impact of water salinity and thermal processes on permeability, and develop a numerical model for optimizing recovery strategies. The hypotheses, such as the relationship between clay swelling and

			reservoir permeability, are tested through laboratory experiments and integrated into the modeling process. The approach is logical and scientific.
		4.5 The new solutions proposed by the author (principles, methods) are reasoned and evaluated in comparison with the known solutions: 1) there is a critical analysis; 2) **partial analysis;** 3) the analysis is not author opinions, but quotes from other authors (citations)	The solutions proposed by the author are argued and evaluated in comparison with the known solutions. More comparison and discussion however can be added.
5.	The principle of scientific novelty	5.1 Are the scientific results and hypotheses new? 1) **completely novel**; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The scientific results and hypotheses presented in the dissertation are new and contribute to the field of enhanced oil recovery. The research introduces a novel empirical model that examines the impact of water salinity on reservoir permeability, specifically in high-viscosity oil reservoirs with clay-rich formations. Additionally, the development of a three-dimensional digital model that integrates clay swelling processes with thermal EOR methods offers new insights into optimizing oil recovery.
		5.2 Are the conclusions of the dissertation novel? 1) **completely novel**; 2) partially novel (25-75%1 are new; 3) not novel (less than 25% are new)	The conclusions of the dissertation are novel. The research provides new insights into the complex interactions between water salinity, clay swelling, and permeability in oil reservoirs. The development of a comprehensive empirical model and simulation of clay swelling processes during thermal EOR offers an approach to understanding and optimizing recovery strategies.
		5.3 Are technical, technological, economic or managerial decisions novel and justified? 1) **completely novel**; 2) partially novel (25-75% are novel); 3) not novel (less than 25% are novel)	The technical approach, which integrates advanced experimental techniques and computational models to study the effect of water salinity on clay swelling and permeability in oil reservoirs, is a novel contribution to the field, especially for a case in Kazakhstan. From an economic standpoint, the decision to develop models that help optimize EOR processes, reducing costs and improving efficiency, is highly relevant and substantiated by a cost-benefit analysis.
6.	Validity of the main conclusions	All the main conclusions are **based**/not based on scientifically significant evidence or are sufficiently well-founded (for qualitative research and areas of training in the arts and humanities)	The research utilizes rigorous experimental methodologies and advanced computational models to gather data and test hypotheses, ensuring that the conclusions drawn are supported by robust empirical evidence. The conclusions are well-justified, offering new insights into the interactions between

			water salinity, clay swelling, and permeability in oil reservoirs.
7.	The main hypotheses submitted for defense	It is necessary to answer the following questions for each hypothesis separately: 7.1 Is the position proved? 1) **proved**; 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 Level for application: 1) narrow; 2) **average;** 3) wide 7.5 Is it proved in the article? 1) **yes**; 2) no	The hypotheses presented for the defense were proved by laboratory and modeling studies. These hypotheses are new and not trivial. The results of the thesis have been published in a Journal. The conclusions of hypotheses can be applied industry-wide, i.e. the level of application is average.
8.	The principle of reliability The reliability of sources and information provided	8.1 The choice of methodology - is justified or the methodology is described in sufficient detail: 1) **yes**; to some extent 2) no	The methodology chosen for this study is well-justified, as it addresses the specific challenges of high-viscosity oil reservoirs with clay swelling issues. The numerical simulation approach effectively models the complex interactions between reservoir fluids, clay swelling, and thermal EOR methods, providing a comprehensive understanding of the system. Detailed steps of the simulation process, including the incorporation of various salinity levels and steam injection scenarios, ensure the methodology is robust and replicable. However, more details including relative permeability, rock and fluid properties used should be added to the thesis.
		8.2 The results of the dissertation work were obtained using modern research methods and methods of data processing and interpretation using computer technology: 1) **yes**; 2) no	Yes. Modern and up-to-date software was used for the simulation and data analysis. Also, the tools and equipment used in the experimental part are well-known and reliable.
		8.3 Theoretical conclusions, models, identified relationships and patterns are proved and confirmed by experimental research (for areas of training in pedagogical sciences, the results are proved on the basis of pedagogical experiment): 1) **yes**; 2) no	The identified relationships and patterns regarding the impact of clay swelling on permeability and the effectiveness of thermal EOR methods were tested under controlled conditions using laboratory simulations.

		8.4 Important statements are confirmed/**partially confirmed**/not confirmed by references to relevant and reliable scientific literature	This part can be improved and more relevant references to be discussed in the document.
		8.5 The literature sources used are **sufficient**/not sufficient for a literary review	Yes, most of the relevant sources were discussed. I believe that this section can be enhanced a bit.
9.	The principle of practical value	9.1 The thesis has theoretical significance: 1) **yes**; 2) no	By developing a numerical model that reflects the relationship between dynamic process of clay swelling and permeability, the research introduces a novel approach to modeling interactions between thermal methods and reservoir properties. The study also contributes to optimizing steam injection strategies by considering water salinity and its effects on reservoir behavior. These findings enhance existing EOR knowledge and provide a more accurate framework for predicting recovery efficiency in reservoirs with challenging conditions, such as the East Moldabek deposit in Kazakhstan.
		9.2 The dissertation is of practical importance and there is a high probability of applying the results obtained in practice: 1) **yes**; 2) no	The results presented by student (dissertation written in Russian) are of practical importance for the successful application of thermal EOR in fields with high clay content. There is a probability of real application of the proposed methodology.
		9.3 Are the suggestions for practice new? 1) completely new; 2) **partially new (25-75% are new);** 3) not new (less than 25% are new)	Suggestions for the application and practices can be written in more details.
10.	Quality of writing and design	Quality of academic writing: 1) high; 2) **average**; 3) below average; 4) low.	The thesis is written in Russian it was better to be written in English, however it is acceptable scientific and technical language according to the paper published.

Conclusion

Ph.D. student has provided a high level of scientific research that is of high interest and contributes to the collective knowledge of the global community of petroleum engineers. Moreover, the work meets the requirements for the Ph.D. thesis. Therefore, I recommend that the author, Assel Talgatovna Zholdybaeva, be allowed to defend her thesis because she deserves the Doctor of Philosophy (Ph.D.) in the specialty 8D07202 – Petroleum Engineering.

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