REVIEW

of the doctoral dissertation
by **Gylym Kairatovich Sapinov**
entitled "**A Study on the Real-Time Spatial Localization of Seismic Events in Underground Mines**",
submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (PhD)
in the educational program 8D07202 – Mining Engineering

No.	Criteria	Compliance with the criteria (please select one option)	Justification of the official reviewer's position
1.	The dissertation topic (as of the date of its approval) corresponds to the directions of scientific development and/or state programs	1.1 Compliance with priority areas of scientific development or state programs:	The topic of the dissertation fully corresponds to one of the current priority areas of scientific development in the Republic of Kazakhstan for 2024–2026 — "Ecology, Environment, and Rational Use of Natural Resources," which includes goals related to safety and sustainable development of extractive industries and the rational use of natural resources. Specifically, the research contributes to: – Monitoring geoecological processes in underground environments; – Reducing risks during mineral extraction; – Implementing digital technologies to enhance the safety and environmental sustainability of the mining industry.
		1) The dissertation was carried out within the framework of a project funded by the state budget;	
		2) The dissertation was carried out within the framework of another state program (specify the name of the program);	
		3) The dissertation corresponds to a priority area of scientific development approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (specify the area).	
2.	Scientific significance	The work makes a substantial **contribution** to science, and its significance is well articulated	The dissertation makes a significant contribution to the development of geomechanics, applied seismology, and the safety of underground mining. The proposed approach to real-time seismic wave velocity prediction, accounting for the changing conditions of the rock mass, enhances the theoretical understanding of wave

			propagation and strengthens the foundation of seismic monitoring methods. The importance of the research lies in increasing the accuracy of event localization and its potential for preventing hazardous geodynamic phenomena in deep mines.
3.	Principle of independence	Level of independence: **1) High;** 2) Medium; 3) Low; 4) No independence.	The dissertation demonstrates a high degree of the author's independence. The PhD candidate formulated the research problem, developed the methodology, conducted laboratory and numerical studies, and implemented a machine learning approach without external authorship or delegation. The structure of the dissertation, the consistency of the argument, and the coherence of scientific reasoning indicate personal involvement in each stage of the work — from hypothesis formation to validation of results. The quality and depth of the analysis confirm that the dissertation was completed independently.
4.	Justification of the dissertation's relevance	4.1 Justification of the relevance of the dissertation: **1) Justified;** 2) Partially justified; 3) Not justified.	The dissertation addresses a highly relevant and timely research problem. In the context of modern mining, ensuring accurate localization of seismic events is essential for operational safety and risk mitigation. The author explores a topic that aligns with global trends in the digitalization of underground monitoring and geotechnical control. The research offers applicable solutions for real-time velocity modeling, which can be integrated into active seismic monitoring systems used in deep mines.
		4.2 The content of the dissertation reflects the topic of the dissertation: **1) Reflects;** 2) Partially reflects; 3) Does not reflect.	The content of the dissertation fully corresponds to its title. All sections of the work are focused on solving the problem of real-time spatial localization of seismic events in underground mining conditions. The structure is logically built around this topic and includes theoretical justification, laboratory testing, numerical modeling, and the development of an adaptive algorithm. The coherence between the dissertation content and its title

			confirms the correctness of the chosen topic.
		4.3 The aim and objectives correspond to the topic of the dissertation: **1) Correspond;** 2) Partially correspond; 3) Do not correspond.	The research objectives and tasks formulated in the dissertation are directly aligned with the stated topic. Each task logically contributes to the overall aim of improving real-time localization of seismic events in underground environments. The dissertation clearly demonstrates how each objective is addressed through experimental work, modeling, or algorithm development. The consistency between the tasks and the achieved results confirms the internal logic and focus of the study.
		4.4 All sections and propositions of the dissertation are logically interconnected: **1) Fully interconnected;** 2) Partially interconnected; 3) Not interconnected.	The structure of the dissertation is logically consistent. Each chapter follows a clear sequence, beginning with the theoretical foundations and progressing through experimental studies, numerical simulations, and the formulation of conclusions. The transition from one stage to another is justified and smooth. The internal logic of the dissertation is preserved throughout, and no sections contradict or duplicate each other. This indicates a well-organized and methodically developed scientific work.
		4.5 The new solutions (principles, methods) proposed by the author are substantiated and evaluated in comparison with known solutions: **1) Critical analysis is present;** 2) Partial analysis 3) The analysis consists of quotations from other authors rather than original opinions.	The dissertation introduces new scientific and methodological solutions. The proposed approach to adaptive modeling of seismic wave velocities differs significantly from traditional static models by incorporating real-time changes in rock mass conditions. The author compares the developed method with existing approaches and highlights its advantages in terms of accuracy and practical implementation. References to relevant scientific literature support the originality of the proposed solution.
5.	Principle of Scientific Novelty	5.1 Scientific results and propositions	The dissertation presents scientifically substantiated results, several of which are original and contribute to the

		1) New;	advancement of knowledge in the field. The author proposes a method for predicting seismic velocities using laboratory and numerical data integrated through machine learning algorithms. The scientific provisions formulated in the work are logically derived and supported by experimental validation. These results are applicable in real-time seismic monitoring systems and reflect a high level of methodological rigor.
		2) Partially new (25–75% are new);	
		3) Not new (less than 25% are new).	
		5.2 Are the conclusions of the dissertation new?	The conclusions formulated in the dissertation are new and stem directly from the research results. They summarize the author's original contributions to the understanding of how seismic wave velocities are influenced by changes in rock mass conditions. The conclusions are not derived from existing literature but are based on independently obtained experimental and modeling data. They offer insights that can serve both theoretical advancement and practical application in underground seismic monitoring.
		1) New;	
		2) Partially new (25–75% are new);	
		3) Not new (less than 25% are new).	
		5.3 Are the technical, technological, economic, or managerial solutions new and substantiated?	The dissertation offers new and well-substantiated technical and methodological solutions. The author proposes an approach that combines laboratory testing, numerical simulation, and machine learning to construct adaptive velocity models for seismic monitoring. This integration of methods is innovative and addresses the limitations of static velocity models used in traditional systems. The proposed solutions are not only theoretically sound but also practically applicable in modern mine safety systems.
		1) New;	
		2) Partially new (25–75% are new);	
		3) Not new (less than 25% are new).	

6.	Validity of the Main Conclusions	All the main conclusions are / are not based on scientifically significant evidence or are sufficiently well substantiated (for qualitative research and disciplines in the arts and humanities).	The conclusions presented in the dissertation are valid and well supported by the research findings. They are based on a complete cycle of scientific investigation, including theoretical analysis, laboratory experiments, numerical modeling, and the use of machine learning. Each conclusion corresponds to the research tasks and is logically derived from empirical and computational data. The coherence between results and conclusions confirms the reliability and scientific integrity of the work.
7.	Key Provisions Submitted for Defense	The following questions must be answered for each provision individually: 7.1 7.1 Is the provision proven? **1) Proven;** 2) Rather proven; 3) Rather not proven; 4) Not proven. 7.2 Is the provision trivial? **1) Yes;** 2) No. 7.3 Is the provision new? **1) Yes;** 2) No. 7.4 Level of applicability: 1) Narrow; 2) Medium; **3) Broad.** 7.5 Is the provision proven in a publication? **1) Yes;** 2) No.	Three provisions were submitted for defense. Responses regarding Provision 1: 7.1 **Proven** 7.2 Not trivial 7.3 New 7.4 Broad applicability 7.5 Proven in publication Responses regarding Provision 2: 7.1 **Proven** 7.2 Not trivial 7.3 New 7.4 Broad applicability 7.5 Proven in publication Responses regarding Provision 3: 7.1 **Proven** 7.2 Not trivial 7.3 New 7.4 Medium applicability 7.5 Proven in publication

8.	Principle of Reliability	8.1 Reliability of sources and information provided	The methodology selected for the dissertation is well justified and clearly described. The research combines theoretical modeling, laboratory experiments, numerical simulations, and data-driven analysis using machine learning techniques. Each stage is logically explained, with proper references to equipment, software, and analytical tools. The methodology ensures transparency and reproducibility, making it adequate for solving the stated scientific problem.
	Is the chosen methodology substantiated or sufficiently described?	**1) Yes;**	
		2) No.	
		8.2 Were the results obtained using modern scientific research methods and data processing and interpretation techniques using computer technologies?	The results of the dissertation were obtained using up-to-date scientific methods and modern digital tools. The research involved advanced laboratory equipment, numerical simulations using FLAC3D software, and data analysis supported by machine learning algorithms. This combination of physical modeling and computational approaches reflects current standards in geomechanics and ensures both precision and innovation in the conducted studies.
		1) Yes;	
		2) No.	
		8.3 Are theoretical conclusions, models, identified relationships, and patterns proven and confirmed by experimental studies?	The theoretical conclusions and identified patterns in the dissertation are confirmed by experimental data. The author conducted a series of controlled laboratory experiments to study how wave velocities vary with changes in the rock mass, including fracturing and filling conditions. The experimental results align with the theoretical assumptions and are further supported by numerical modeling. This cross-validation confirms the reliability of the conclusions.
		1) Yes;	
		2) No.	
		8.4 Are important statements confirmed / partially confirmed / not confirmed by references to up-to-date and credible scientific literature?	All key statements and theoretical propositions presented in the dissertation are supported by references to up-to-date and credible sources. The work is based on an extensive body of scientific literature, including more than 90 publications from international peer-reviewed journals. The author consistently

			relies on modern scientific approaches, properly cites the sources reflecting the current state of the research problem, which demonstrates a thorough understanding of the subject and academic integrity.
		8.5 Are the used sources of literature sufficient / insufficient for a literature review?	The literature used in the dissertation is sufficient for a comprehensive scientific review. The reference list includes fundamental works, recent publications from international databases (such as Scopus and Web of Science), and relevant research on seismic monitoring and geomechanics. This scope of sources reflects a deep understanding of the topic and allows the dissertation to be positioned within the context of modern scientific discourse.
9	Principle of Practical Value	9.1 Does the dissertation have theoretical significance?	The dissertation offers clear theoretical significance by expanding the scientific understanding of how seismic wave velocities are affected by the evolving conditions of underground rock masses. It contributes to the development of adaptive modeling techniques in geomechanics and improves theoretical approaches to wave propagation analysis. These results strengthen the scientific basis of underground monitoring and can be used as a reference for future academic research.
		1) Yes;	
		2) No.	
		9.2 Does the dissertation have practical significance, and is there a high probability of applying the obtained results in practice?	The dissertation demonstrates clear practical significance, with a high potential for industrial application. The developed approach to adaptive velocity modeling can be implemented in real-time seismic monitoring systems for underground mines. This will allow more accurate localization of seismic events and improve safety measures in mining operations. The research outcomes are relevant to both engineering practice and system design for geotechnical risk management.
		1) Yes;	
		2) No.	
		9.3 Are the practical proposals new?	The practical proposals presented in the dissertation are original and have not been previously applied in the context of

		1) Completely new; 2) Partially new (25–75% are new); 3) Not new (less than 25% are new).	underground seismic monitoring. The integration of laboratory testing, numerical modeling, and machine learning for adaptive velocity estimation represents a novel technological approach. These proposals offer real improvements to existing monitoring systems and can serve as a foundation for further development of intelligent safety technologies in the mining industry.
10.	Quality of Writing and Formatting	Academic writing quality 1) **High;** 2) Medium; 3) Below average; 4) Low.	The academic writing quality of the dissertation is high. The text is coherent, well-structured, and written in a clear scientific style. Terminology is used correctly, and the logical flow of arguments is preserved throughout the work. The language is concise and informative, and all parts of the dissertation are stylistically aligned. Formatting, grammar, and citation standards meet academic norms and contribute to the overall professionalism of the document.

Conclusion:

The dissertation of Gylym Kairatovich Sapinov titled "A study on the real-time spatial localization of seismic events in underground mines", completed under the educational program 8D07202 – Mining Engineering, is an original and independent scientific research project of current relevance. The work is based on a thorough methodological framework and includes theoretical, experimental, and computational components. The dissertation demonstrates scientific novelty, practical significance, and a high level of academic quality.

In accordance with the requirements of the Committee for Quality Assurance in Education and Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan,

I recommend awarding Gylym Kairatovich Sapinov the degree of Doctor of Philosophy (PhD) in the educational program 8D07202 – Mining Engineering.

Reviewer
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