# Skoltech
Skolkovo Institute of Science and Technology

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Mohammad Ebadi

**PhD Program:** Petroleum Engineering

**Title of Thesis:** Fluid transport in tight rocks: multi-scale AI-driven characterization paradigm

**Supervisor:** Associate Professor Dmitri Koroteev

**Name of the Reviewer: Dimitri Pissarenko**

| I confirm the absence of any conflict of interest | |
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| | **Date: 26-08-2021** |

*The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.*

*If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.*

### Reviewer's Report

The thesis manuscript presented by Mohammad Ebadi entitled "Fluid transport in tight rocks: multi-scale AI-driven characterization paradigm" consists of Introduction and of five sections articulated around five journal publications. The Introductions gives a clear and well structured, yet somewhat concise, overview of modern challenges and of state-of-the-art techniques in the domain of digital rock and multi-scale flow simulation. A special emphasis is made on low permeability rocks, such as shales, since fluid flow and storage mechanisms in such rocks differ significantly from those considered in classical models, and simulation tools need to be chosen and adapted consequently. The first part of the Introduction treats the macroscopic approach to the problem. Particle Swarm Optimization technique and Adaptive Neural Network applied for solving macroscopic flow equations demonstrate good examples of an original approach by the candidate to tackling classical computational fluid dynamics problems in the context of low permeability porous rocks. In the second part of the Introduction, the microscopic approach is considered, and problems related to imaging of the pore space and constructing the corresponding pore-scale simulators are treated. In particular, the issue of the unresolved pores is considered and ways of accounting for it during simulations are suggested.

The five published journal papers that represent the core of the thesis manuscript cover a broad range of topics related to efficient numerical solution of flow equations in porous media and to applications of the digital rock techniques to characterization of rock and modeling different aspects of rock physics.

The methodology of the research performed during the thesis project is adequate and rigorous. The theoretical frameworks and the results of modeling are presented in the publications in a clear and well documented style. Overall, the thesis manuscript gives an account of the work that is up to the modern international research standards. At the same time, conceptual connections and logical transitions between the topics of distinct publications could be more elaborate: the reader is left with the exercise of building the big picture dash-lined by the articles. I would recommend to the candidate to complement the sections that preface each publication with more material that helps the transition from one topic to another and facilitates the unification of the whole manuscript. To the same end, a Conclusion section deserves its place at the end of the main body of the manuscript: a summary of the presented results and author's conclusions are an integral part of the logical structure of a thesis.

The candidate has published five articles in high-ranking international scientific journals, and has contributed to three extended abstracts at international scientific and industrial conferences. The candidate is thus fully compliant with the formal requirements of Skoltech with regard to the publications.

I am satisfied with the volume and quality of the work performed by the candidate in the course of the thesis project. At the same time, I would like to recommend some improvements of the manuscript (see above) that may be incorporated by the candidate in the time remaining before the thesis defense.

I recommend the present thesis for the defense, after minor revisions of the manuscript.


Kind regards,

Dimitri Pissarenko

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| **Provisional Recommendation** |

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| ☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense* |

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| **X** *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report* |

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| ☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense* |