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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: Associate Professor Dmitry Dylov

I confirm the absence of any conflict of interest	**Date: 31-08-2021**

Reviewer's Report

Mr. Ebadi presents an AI-driven paradigm to studying and quantifying fluid transport in tight and porous media. This is concurrent with the state of art in the field of Oil and Gas, with both fundamental and immediate applied prospects in petroleum engineering and related disciplines. The main outcome is the easy to use framework that can help assess fluid dynamics in unconventional porous media with model-agnostic methods, meaning that the deep-learning toolset could be employed without having to model high-order non-trivial theoretical effects of fluid's motion.

Writing improvements include stylistic proof-reading with a general recommendation to avoid excessive epithets and semantically redundant adjectives: the drier the scientific text, the better.

Figures (and text in Figures, in particular) are often pixelated and rasterized. It is recommended to spend some time on improving the quality of the Figures.

A Notation subsection is missing. It is recommended to include consistent notation section and to reference to it throughout the rest of the text. All parameters and variables have to be defined before they are used in the equations. See Equations (3), (4), and (5), where the numerical values immediately appear in the equations. Consider introducing them first, and then, consider switching to the derivations with variables instead of numbers.

As a thesis about fluid dynamics, the section about conventional Solvers could be significantly expanded to have a more consistent introduction and to show the state-of-art in the field without deep learning

(e.g., classical go-to approaches). Is Newton's method with some variable change (Jacobian) the best that the classical methods have to offer? (Hard to believe if so) What about non-iterative blind/non-blind methods to perform numerical optimization? (such as PSO). Instead of writing "slightly faster", it is better to provide a precise table that compares computational efficiency of the methods. Otherwise, Figure 2 indicates similar performance, making the statement about efficiency confusing (al methods seem to be identical and almost coincide with the analytical curves). Please elaborate or improve the description for clarity.

With regard to deep learning methods, one immediately notices that the apparatus is used as a tool, which could be improved by having an extra introductory section about the DL approaches, where it would be described that the layers perform nothing but an approximation of a transfer function between the input and the output. Same applies to computed tomography material which appears too suddenly. A proper intro to the imaging modality is missing. It is required given that a big portion of the author's contribution related to image denoising.

The second half of the work is a bit strange to me personally. Ultimately, the inclusion of PDFs is, perhaps, a convention in the field; but it ruins the thesis, making it less self-sufficient as a text to refer in the future. The lack of structure in the second half is a little confusing, with the outlook into the future work being washed out, with somewhat unclear perspectives into the new research directions that this thesis should help open. Or, perhaps, this is just a perception caused by the writing style. Anyway, I recommend to add a solidifying conclusions section that would unite the material and that would outline the future work. A collection of pre-print do not do this job properly.

Mr. Ebadi has published 5 journal papers in the field-specific journals, where he is the first author in 2 papers. He is also a corresponding author in 2 other papers, where he is neither the first nor the senior author (perhaps, that is also a convention in the field, or in Prof. Koroteev's group). Lastly, there were 3 proceeding papers published at conferences (the author order has not been disclosed and I did not look). Overall, the quantity and the quality in the publication record meet the requirements for the Ph.D. degree.

Provisional Recommendation

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

☐ *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*