Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Markovic Strahinja

PhD Program: Petroleum Engineering

Title of Thesis: Application of LF-NMR measurements for characterization of unconventional hydrocarbons using machine learning

Supervisor: Professor Alexey Cheremisin

Name of the Reviewer:

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 09-08-2022**

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

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

Mr. Markovic Strahinja's thesis entitled, "Application of LF-NMR measurements for characterization of unconventional hydrocarbons using machine learning " is generally well-written and its contents is logically consistently structured. There are minor editorial imperfections in the text those do not reduce the overall impression from the research.

The thesis research project is aimed at development of new workflows and models for predicting oil viscosity and water saturations from LF-NMR data.

The manuscript is comprised of five chapters, including Introduction and Conclusion.

In the Introduction the author formulates the objectives of the research and justifies their relevance. The 1st chapter provides a comprehensive overview on heavy oil and bitumen resources distribution worldwide and the state-of –the art enhanced oil recovery methods applied for their development. Further the author explains theory of the NMR method, considers in details its application for oil viscosity measurements and determination of water saturation in unconventional reservoirs.

Chapter 2 describes theory of laboratory techniques applied in the research, procedures used for samples preparations and during NMR measurement. The chapter is concluded with presentation of the experimental results and their discussion.

Chapter 3 is devoted to determination of oil viscosity by means of low-field NMR using feature engineering and supervised learning algorithms. Its provides theory of machine learning techniques and presents the results of their application to NMR data for oil viscosity characterization.

Chapter 4 discusses application of XGBoost model for in-situ water saturation determination in Canadian oil-sands by LF-NMR and density data. The chapter starts from explanation of theory and methodology of the applied research approaches. Than the author presents the results of applying different techniques for in-situ water saturation distribution.

The actual content of the work corresponds to the topic of the dissertation that is of high relevance for unconventional reservoirs properties evaluation.

The scientific significance of the results as well as their compliance with the international level and current state of the art are supported by their publication in internationally recognized top-ranking scientific magazines. In total, the author has participated in 4 publications in peer-reviewed international journals, and 2 international conferences. These numbers fully satisfy formal Skoltech's requirements to PhD candidates with respect to publications.

The applied relevance of the obtained results is proved by two patents.

It is recommended to consider the following editorial comments:

- There is a disruption in automatic numbering of subtitles of chapter 3 in the table of contents (between subtitles 3.2.3 and 3.2.4).
- In the abstract, the author states that "Finally, water saturation determination is among the most challenging tasks in petrophysical well-logging, which directly

impacts the decision-making process in hydrocarbon exploration and production." This statement seems to be too straight forward as saturation determination is a classical task of well logging. It is recommended either rephrase this statement or put it better in the context.

In conclusion, I would like to highlight that Mr. Markovic Strahinja's research confidently satisfies PhD thesis requirement and the candidate is qualified for a PhD 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*

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