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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Aliya Mukhametdinova

PhD Program: Petroleum Engineering

Title of Thesis: Investigation of Reservoir Properties of Unconventional Reservoirs Using Low-Field Nuclear Magnetic Resonance

Supervisor: Associate Professor Alexey N. Cheremisin

Name of the Reviewer:

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 22-02-2021**

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
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

Ms. Aliya MUKHAMETDINOVA's thesis entitled, "Investigation of Reservoir Properties of Unconventional Reservoirs Using Low-Field Nuclear Magnetic Resonance," is generally well-written and acceptable with some editorial changes throughout the text. The thesis research project is aimed at development of comprehensive methodologies for determining petrophysical properties of unconventional "tight" reservoirs using low-field Nuclear Magnetic Resonance (NMR) at realistic reservoir conditions.

Accordingly, the available workflows for defining liquid saturations using NMR were adapted and new ones were developed to address to meet the research requirements and applicability to very low permeability reservoir rocks. The newly-developed workflow was successfully implemented on the target reservoir samples from Domanik and Bazhenov shale formations. Also, a detailed comparison of the results was carried out with a number of other relevant methods to confirm the reliability of the findings using NMR technique.

A new NMR T_1-T_2 maps interpretation approach was proposed for optimum fluid interpretation of the shale rock samples. Based on the experimental data and analyses on fluid identification, T_1-T_2 mapping schemes were also developed. The newly developed techniques were implemented in the applications of the NMR in thermal and gas enhanced oil recovery (EOR) research for evaluation of the oil displacement, saturation control during high-pressure air injection (HPAI), *in situ* combustion (ISC), and CO_2 injection for shale and heavy-oil carbonate formations.

In addition, a novel methodology for the evaluation of the unfrozen water content in permafrost was developed. T_2 relaxation data was utilized for the calculation of the fluid volume in the core center at temperatures below 0°C. Novel experimental setups at formation conditions were designed and experiments were carried out in a high-pressure NMR cell. The results from the high-pressure, high-temperature (HPHT) experiments were used to analyze the process of the water and CO_2 diffusion in the oil-saturated core. Overall, the proposed concepts are of great interest in the fundamental study of the porous structure, saturation, and reservoir properties of unconventional reservoirs.

The thesis consists of the well-balanced combination of relevant background, fundamentals and application of novel approaches to quantify fluid saturations in ultra-low permeability reservoir rocks at realistic reservoir conditions using low-field NMR. The results show consistent and reasonable match with other currently available techniques. It also highlights the complexities and challenges associated with the quantification of hydrocarbons in "tight" unconventional reservoirs. The newly developed techniques for the NMR applications will be highly applicable in improving reliability of the quantification of the thight resources.

It is clear that Aliya has carried out a lot of original work which provides significant insights into the complexities and challenges associated with fluid saturation determination in "tight" reservoirs. I believe that she has made a good use of the existing literature. Her thesis, with minor editorial corrections, will be an excellent reference resource for future studies and applications.

Ms. Aliya Mukhmetdinova's thesis certainly satisfies the thesis requirements of her PhD program. Ms. Mukhmetdinova has clearly demonstrated her capabilities of performing research work of high caliber. Presented PhD Thesis may be considered as complete qualification for a PhD candidate.

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*