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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Georgy Peshkov

PhD Program: Petroleum Engineering

Title of Thesis: Improving the accuracy of thermal history in basin modelling: reduction of uncertainties in petroleum system analysis

Supervisor: Professor Dimitri Pissarenko
Co-supervisor: Dr. Evgeny Chekhonin

Name of the Reviewer: Prof. Stefan Markus Schmalholz

I confirm the absence of any conflict of interest	**Date: 18-11-2021**

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

The quality of the PhD thesis of Georgy Peshkov is very high. The thesis is well structured and written, the objectives are very well explained, and the model approaches, assumptions and results are clearly explained. The PhD thesis consists of 6 chapters. Chapter 1 presents an overview of current challenges in thermal modelling of basins. Chapter 2 focuses on the joint use of thermal properties and measured heat flow data to construct 1D thermal models. Chapter 3 describes thermal and structural modelling challenges and proposes a workflow for integrating thermal and structural models. Chapter 4 focuses on the use of gravity data analysis in basin history reconstruction. Chapter 5 presents a workflow for thermal history reconstructions with 3D basin models. Chapter 6 summarises the performed work and presents the main conclusions and recommendations for future work.

The topic of the thesis and the applied methods are very relevant. The topic is hydrocarbon potential assessment, and the main methods are quantitative basin and heat flow modelling combined with the calibration of the models by, for example, bore hole temperature measurements, gravity data, stratigraphic data and vitrinite reflectance data.

The research presented in the thesis is of high scientific relevance due to the application to real-world cases studies and the comparison of results obtained with different models and methods. The comparison of results from so-called backstripping models with results from so-called thermo-tectono-stratigraphic models is very important, because it shows that ignoring certain processes, such as sediment layer stretching, thermal blanketing or basement heterogeneity, can provide different assessments for hydrocarbon potential. Georgy Peshkov could show that such different results can occur even if both models are equally calibrated by bore hole temperatures and vitrinite reflectance data. Such comparison of results from two different modelling approaches is presented in the publication of Peshkov et al., Marine and Petroleum Geology, 2021.

The results presented in the thesis have important implications for practical applications of hydrocarbon potential assessment because the thesis demonstrates several reasons for the uncertainty of hydrocarbon maturity models and proposes several approaches to mitigate these uncertainties. Particularly, the applications to many real-world case studies is important and relevant. The thesis also provides several important recommendations for future hydrocarbon assessment, based on three workflows: (1) combination of thermo-tectono-stratigraphic models with petroleum system models; (2) extension of the first workflow to 3D and (3) considering basement heterogeneity using gravity data, since this heterogeneity impacts the thermal properties and hence heat flow assessments.

Furthermore, the quality of the publications with Gregory Peshkov as first author or co-author is very high. Particularly, the publication of Peshkov et al., Energies, 2021, presents very original, innovative and relevant results, because in this paper for the first time, to the best of my knowledge, two types of models are combined: basin modelling, simulating the formation of a sedimentary basin by lithosphere rifting, and hydro-mechanical modelling, simulating the formation of gas chimneys by so-called porosity waves. In this study, the initial model configuration for the hydro-mechanical model is generated with the basin model. The presented approach of combining several types of models to better understand sedimentary basin formation and basin-scale fluid/gas flow dynamics has a great potential for further improving hydrocarbon reservoir exploitation and potential assessment.

In the PhD manuscript, there are only a few typos and in one place the same figure is displayed accidentally more than once. These are minor issues that can be corrected within an hour. I can send to Georgy Peshkov a PDF of his PhD manuscript in which I have highlighted these very minor issues so that he can correct them.

Provisional Recommendation
X *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*