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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: Professor Bertrand MAILLOT, CY Cergy Paris Université, France.

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 21-11-2021**

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

- **Brief evaluation of the thesis quality and overall structure of the dissertation.**

  This report concludes that the work presented by M. Georgy Peshkov in his thesis manuscript is of a sufficient quality to be defended formally in front of a Jury.

  The 132 pages thesis manuscript presented by Georgy Peshkov along with three original research articles in major journals (two of which as a first author) and three conference abstracts demonstrate the large amount of work produced and more importantly, the large culture and practical experience acquired by M. Peshkov on petroleum basin modelling. His methodological improvements are convincingly validated in five case

studies.

The organisation of the manuscript is clear and reflects a coherent and focused set of case studies. Chapter 1 and appendix A constitute an impressive litterature review on the characterisation of the thermal state of basins adressing apparently all issues from the data on rock thermal properties to lithosphere extension models. It points to the need for better data on rock thermal properties and to the usefulness of gravity data. Fundamentally, it calls for the need of -- and that is the background inspiration of the whole thesis -- a better use of physical principles through physics based forward modelling. The next three chapters apply this general strategy respectively on 1D, 2D, 2D plus gravity data, and 3D case studies, every time practically demonstrating the improvement on final estimations of hydrocarbon ressources. Each of these chapters starts with a section on methodology and workflows. Finally, Chapter 6 recalls the issues adressed and the improvements made on the case studies and concludes the manuscript with methodological recommendations, some of which could have been developed further in prospective research projects.

The presentation of the scientific strategy and of the results closely follows the structure of the manuscript. Chapter 2 advocates the direct measurements with modern improved lab techniques (that are not part of the thesis) of rock thermal conductivity and demonstrates the improvement, compared to the use of data bases and rock mixing models, on the one-dimensional case study of the Tyumen SG6- super deep well. This is published in Chekonin et al (2020). This demonstration is obviously also valid in 2D and 3D, but the feasibility is subject to the availability of core samples. Chapter 3 advocates the coupling of thermal and structural modelling and demonstrates its advantages on the case studies of the West Siberian Basin and the Barents sea where the thermal blanketing effect by sedimentation is important. There is however no attempt at evaluating the absolute performance of the coupled approach (which I would not know how to do !). This is presented in two publications (Peshkov et al. 2021a, b). The latter also presents a very nice numerical hydro-mechanical modelling of natural chimney formations by porosity waves, although the transition from liquid to gas, and thermal effects are not included. Chapter 4, unpublished, continues with 2D cases, accounting for lateral variations in the basal heat flux that are characterised by a combination of geological data and an inversion procedure of gravity data. In the absence of direct measurement on core samples, rock thermal properties are classicaly evaluated from a data base and mixing models, thus introducing uncertainties, as analysed in Chapter 1. A very welcome sensitivity study is developed to account for these uncertainties. Chapter 5 is an application of the integration of gravity data on a 3D case in the South Kara basin, furthermore using geostatistical methods to evaluate the poorly known properties of this region. However, this part is not presented in this short chapter, apparently for confidentiality reasons.

There are very little typographical errors, showing a careful proofreading. The major weakness of the manuscript is the poor quality of the english langage, and second, the writing style. The style is often exhausting to read, with unnecessarily long phrases that do not go to the point. There are also many grammatical errors and a rather awkward english langage, with a few incomprehensible phrases (this is not the case for the publications). This makes the reading cumbersome and the understanding of the work more difficult. The methods and workflows presented at the beginning of each chapters are difficult to grasp and the figures (1, 8, 18) do not help much. See below a few examples that certainly do not form an exhaustive list.

- **The relevance of the topic of dissertation work to its actual content**

This relevance is demonstrated by my report above.

- **The relevance of the methods used in the dissertation**

The thesis being mainly a work on improving the methodology, this relevance is assured. Three workflows are proposed to reduce the uncertainties based on the present-day technical software capabilities.

- **The scientific significance of the results obtained and their compliance with the international level and current state of the art**

  I appreciate the effort to include more fundamental physical concepts in very practical workflows, and to push this effort to the point of actually demonstrating the improvement on final hydrocarbon estimations in real case studies. The publications in "Marine and Petroleum Geology" and in "Basin Research" certainly confirm the international level of the research.

- **The relevance of the obtained results to applications (if applicable)**

The results are precisely improvements of methods proven by applications through case studies.

- **The quality of publications**

Publication of three original research articles in major journals, first author in Marine and Petroleum Geology (2020) and in Energies (2021) and in two conference abstract (EGU (2020), EAEG (2019) : this is a very good publication record. The papers are generally well written and of a very good quality.

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

This is only a few examples that illustrate the main weakness of the thesis : writing style and english langage.

p. 108 top : incomprehensible phrase : "Since modelled stratigraphy,this approach is a function of a multi-coupled solution, it should be fitted with present-day input."

p. 5 top : "Chapter 1 analyses the impact of different methods of entering thermal conductivity and its thermobaric corrections on petroleum systems modelling. Besides, this is determined to be the most reliable method for the geothermic characterisation of the model. ..." The 2nd phrase makes no sense after the first one.

p. 5, top : "Chapter 1..." you mean Chapter 2 !

p. 5 first parag. of sec. 1.1.2 : could be shortened by half !

p. 25 bottom : "If the basement has the heterogeneity in its geological structure, ..." : you mean "if the basement is heterogeneous" ?

p. 30-32 : Fig 12 is reproduced three times : remove those in p. 30 and 31.

p. 33 : incomprehensible phrase : "The digging of the best solution is raised with pursuing software developers' different goals for creating their BPSM software."

p. 56 : legend of Fig. 25 : "Fig. 5" to be replaced by "Fig. 22"

p. 79, F. 35 : lines in box are too pale and in fact, invisible.

p. 80, Sec. 4.3.2 : very awkward english expression :"The bulk rock density calibration interchanges the calibration of porosity because of porosity data lack".

p. 101 Sec. 6.2 : Second and third mentioned workflows are unnecessarily inverted with respect to the order of presentation in the manuscript.

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*

Ce document a été signé par

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