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Skolkovo Institute of Science and Technology

# Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Tatiana Bondarenko

**PhD Program:** Petroleum Engineering

**Title of Thesis:** Evaluation of high-pressure air injection potential for in-situ synthetic oil generation from oil shale: Bazhenov Formation

**Supervisor:** Prof. Alexey Cheremisin

**Chair of PhD defense Jury:** Prof. Alexei Buchachenko ***Email:*** *a.buchachenko@skoltech.ru*

**Date of Thesis Defense:** December 03, 2018

**Name of the Reviewer:** Yuri Popov

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| I confirm the absence of any conflict of interest<br><br>(Alternatively, Reviewer can formulate a possible conflict) | **Signature:**<br><br>**Date: 25-11-2018** |

*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 thesis quality can be estimated as quite good accounting for significant scientific results obtained and described by Tatiana Bondarenko. The research covers several important topics – evaluation of potential effect from thermal enhanced oil recovery, such as in-situ pyrolysis, hot water/supercritical water extraction, and air injection, for the hydrocarbons production from source rocks enriched by kerogen. Results inferred from geochemical analysis of Bazhenov Formation rock samples after pyrolysis, hydropyrolysis and oxidation exposure have an essential importance for evaluation of high-pressure air injection potential for in-situ synthetic oil generation. An original approach to 2D pyrolysis data analysis was suggested and applied to evaluate the homogeneity of kerogen conversion in low-permeable consolidated rock samples. Parameter $S_4CO_2$ was used as identification of fuel laydown in oil shales during the oxidation process. Sophisticated thermal property measurements before and after combustion tube test allowed to enhance understanding of thermal processes that occur *in-situ* during the air injection. Unfortunately, statistical processing the experimental data can not be estimated as comprehensive in some cases that influenced on reliability of few conclusions.

The structure of the thesis is logical and contains five chapters. A detailed literature review of the previous laboratory investigations including oil shale pyrolysis, oxidation, and hydropyrolysis mechanisms of kerogen conversion is presented in Chapter 2. As the result, Tatiana proposed a methodology of laboratory experiments for evaluation of HPAI effectiveness in oil shale formations, followed by description of the results obtained (Chapter 3). Chapter 4 contains the combustion tube test results, which summarize the effects observed during a separate investigation of coexisting processes. The thesis content is relevant to the thesis topic.

The methods used in the dissertation can be estimated as relevant. After each set of experiments, core analysis was performed, including pyrolysis investigation and elemental analysis. The experimental methods and approaches used in this research are relevant and allowed to obtain significant scientific results for the problem solution. The unique equipment of the Skoltech CHR laboratory was used for experimental modeling of thermal EOR processes. Such experiments as high-pressure ramped temperature oxidation and pyrolysis were conducted using Bazhenov shale samples for the first time. These tests gave a relevant estimation of air injection potential for oil generation from kerogen. Proposed laboratory work-flow is logical and unique due to thorough core analysis after exposure.

Results presented in the thesis are significant for Russia and the international scientific world. They comply with the current state of the art. Obtained results are relevant to industry application. The research results were included in the Skoltech reports on commercial projects with industrial partners. Oil companies can use the experimental results, presented in the thesis, for monitoring field operations in terms of gas composition, oil characterization and kerogen conversion while coring. Industry can use the experimental results obtained in this work for numerical simulation. The data helped to evaluate the effectiveness of the HPAI method and estimate the oil recovery at selected Bazhenov Formation fields of interest. The research results described in the thesis can be considered as original in the oil&gas science. The obtained results can be considered as relevant to applications.

Results obtained in this research were published in *"Journal of Petroleum Science and Engineering"*, that belongs to prestigious international journals (Q1) in petroleum engineering area, and Russian oil and gas industry reputable journal *"Oil Industry"*. The scientific results described in the published papers relate to the thesis research.

**Provisional Recommendation**

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| ☒ *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* |