REPORT

of the Scientific Advisor for the dissertation thesis submitted on the Requirements for the Degree of Doctor of Philosophy (Ph.D.) in Petroleum Engineering (6D070800) Satbayev University by Akasheva Zhibek Kairatovna entitled

"Study of the fluid flow in a porous medium based on the pore-scale modelling"

This report is presented to certify that the doctoral student, Ms. Akasheva, has successfully fulfilled all the requirements needed for the Ph.D. degree conferment.

The relevance of the work

Understanding immiscible two-phase flow through porous media at the pore- scale is central to a number of industrial applications such as enhanced oil recovery, carbon dioxide storage and etc. As it was noted in the dissertation, pore-scale modelling of fluid flow in a porous medium can determine the parameters of fluid flow and porous media without conducting complex laboratory experiments. Ms. Akasheva provided insight into the advantages of pore-scale modelling of fluid flow in a porous medium such as the ability to perform numerous numerical experiments on the same digital model of the core sample, faster time to determine the parameters of a porous medium and fluid flow and fewer financial resources.

The research results, their scientific novelty, and practical value

The Ph.D. student has shown the potentials of three different methodologies, namely (1) direct finite-volume based simulations for investigating two-phase flow patterns at the scale of few pores and capillaries, (2) experimental approach for studying the effect of acidizing (rock dissolution) on the pore structure at the scale of core samples, for several core samples of various heterogeneity, and (3) digital core analysis and pore-network modelling for studying single- and two-phase flow properties of the samples before and after acidizing. Her work shows the potential of each of the three approaches and where they can be used to study pore-scale phenomena at different scales. Also, she has presented a rigorous analysis of various parameters affecting each type of the modelling and experimental study in her work.

The scientific novelty of the dissertation lies in obtaining digital images of carbonate core samples and pore-scale modeling of the microstructure of a real porous medium in order to predict the properties of a porous medium and fluid flow.

The practical value of the dissertation lies in the description of the method for calculating the geometric characteristics of a porous medium (absolute permeability,

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porosity, tortuosity, specific surface area, pore radius, and pore throat) and the method for calculating the characteristics of a fluid flow in a porous medium (relative phase permeabilities, capillary pressure) using pore-network modelling.

The Ph.D. student also presented the results of studying the dependence of permeability on other parameters of the porous medium for carbonate rocks, which will facilitate the modeling process for other fields, since the existing dependencies were mainly obtained for ideal porous media.

Finally, I can note that the manuscript presented by Ms Akasheva is well written. Overall, the results and the scientific approach are presented clearly.

The experimental study of multiphase flows in porous media and numerical modelling of this process with the objective of the evaluation of dynamic parameters of the flow requires advanced skills, such as knowledge of experimental methods and also of solid knowledge of multiphase flows, so Ms Akasheva successfully demonstrated these two aspects.

In conclusion, the Ph.D. student has provided a high level of scientific research that is of high interest and contributes to the collective knowledge of the community of petroleum engineers. This work corresponds to the requirements for the Ph.D. thesis. Therefore, I recommend that the author, Zhibek Akasheva, be allowed to defend her thesis because she deserves the Doctor of Philosophy (Ph.D.) in the specialty 6D070800 — Petroleum Engineering.

Nancy, 7.09.2023

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