

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Valentina Ekimova

**PhD Program:** Petroleum Engineering

**Title of Thesis:** Experimental modeling of gas hydrates interaction with a salt solution in permafrost

**Supervisor:** Dr. Evgeny Chuvilin

**Name of the Reviewer:** Irina Streletskaya

I confirm the absence of any conflict of interest  (Alternatively, Reviewer can formulate a possible conflict)	  <b>Date: 11-09-2022</b>
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*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

This work is devoted to experimental modeling of the interaction of frozen hydrate-saturated sandy sediments with salt solutions, the study of the influence of various factors (pressure, temperature, concentration and composition of the salt solution, particle size distribution of sediments) on the process of dissociation of pore gas hydrates, as well as the study of temperature effects during this interaction. The emission of methane from the permafrost zone is an urgent problem, both in the general climatic aspect and in the development of deposits due to the technical difficulties associated with drilling and operating wells. The work consists of 8 chapters, including Introduction and conclusion. The list of references is 339 titles. The work contains 76 figures and 14 tables, which illustrate well and help substantiate the main conclusions of the work. The general structure from theoretical questions to specific ones is logical and reasonable. The introduction substantiates the relevance of the problem, formulates the purpose and objectives of the work. The novelty of the work is beyond doubt: for the first time, the effect of salt migration on the dissociation of hydrates has been experimentally shown, and the dynamics of changes in the temperature field during salt transfer in frozen hydrate-containing sediments has been studied. A conceptual scheme-model of the destabilization of intrapermafrost gas hydrates in areas of permafrost distribution in continental conditions and on the Arctic shelf is proposed. All this allows us to conclude that the quality of scientific work is high.

The topic of the dissertation work corresponds to its actual content. The paper presents an exhaustive review of the literature on the current state of knowledge related to gas hydrates as a component of the permafrost, including an emphasis on the study of the effect of salts on the dissociation of hydrates. The methods used in the dissertation are relevant and for the most part unique.

The use of equipment and a complex of original new methods makes the results obtained reliable, scientifically significant and corresponding to the modern international level of technology.

The quality of publications corresponds to the modern international level. 6 co-authored articles published in high-ranking journals. The content of the articles and conclusions, affixed to the publications, correspond to the topic of the dissertation. The results of the dissertation were also presented at 4 International conferences, the materials were published.

A few comments on the dissertation text:

1. Clarification of the term permafrost is required. In foreign literature, it combines both sediments containing ice and cooled ones. It is better to clarify what the author means in each case (cooled or containing ice?) Table 1.
2. I recommend clarifying the possibility of linking gas manifestations from a depth of up to 120 m with the dissociation of gas hydrates (which, as indicated, exist at a depth of 200-400 m), as well as explaining the role of ice in this process.
3. It is necessary to add a clarification of the concept of water potential (activity), give a description of the method for its determination, and also note the applicability of this method for clay sediments.
4. P. 94, second paragraph: typo - "allows" is written twice
5. Probably, the method of determining the salt content is not representative for field studies, for masses of ice and sand, where the ratio of salts varies greatly from place to place. Apparently, it should be clarified that the method works only in laboratory conditions for artificially prepared sand samples with low humidity.
6. Clarify the limitation of the method in terms of concentration in terms of units. Does 5% mean

sediment salinity? For sands of 5%, this is a very high degree of salinity - this is 5 g per 100 g of dry soil. With this degree of salinity, cryopeg is formed at natural rock temperatures and even low water content. And if this is the concentration of the pore solution, then it should be expressed in ‰ and a corresponding clarification in the text is necessary. Do you mean calculated concentration through water content?

7. It should be noted in the text that the flow of intrapermafrost saline waters (cryopegs) down the frozen section has not been established in nature. All lenses of cryopegs in the permafrost are isolated and have no connection with each other, but this is possible under technogenic impact.

8. It is necessary to add clarification in some parts of chapter 5.4. Does the migration of salts occur in the direction of lowering the temperature? Together with water to the freezing front? This is not clear from the text.

#### 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*