[PS]What are the Consequences of the Cenozoic Glaciation Events on the Petroleum Systems in the Norwegian Barents Sea?*

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Search and Discovery Article #30306 (2013)**
Posted December 16, 2013

*Adapted from poster presentation given at AAPG 3P Arctic Polar Petroleum Potential Conference & Exhibition, Stavanger, Norway, October 15-18, 2013

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Abstract

Widespread glaciations during the late Pliocene-Pleistocene resulted in extensive erosion from the continental shelf areas of the Norwegian Barents Sea. It also led to synchronous deposition of thick sedimentary wedges on the continental slopes (Laberg et al. 2010, 2012). This large-mass redistribution resulted in uplift and tilting of underlying traps, and most likely affected the entire hydrocarbon systems. Some of the potential consequences are changes in hydrocarbon generation, secondary migration, fluid composition and location of pools (Doré et al. 2000, 2002). In the Norwegian Barents Sea, many of the uplift consequences have not been fully understood yet. The most important questions are Have the Cenozoic uplift and erosion events of the western Barents Sea caused gas expansion and leakage? What is a magnitude of gas expansion and leakage caused by these events? How much petroleum has leaked and how much is left?

In order to address these questions SINTEF Petroleum Research introduced the project 'Impact of Cenozoic structural development and glacial erosion on gas expansion, hydraulic fracturing and leakage' using basin modeling approaches. A key part of this project is my Ph.D. work. I am going to present the Ph.D. work setup that includes building a complete basin model of a selected area in the Norwegian Barents Sea. The basin model input I am going to use includes a new source-rock model, new pressure and secondary migration model. Physical parameters of sedimentary rocks dependent on uplift will be refined by lab tests. Cenozoic burial history will be reconstructed, considering new erosion and glaciation concepts (Knies et al. 2012, Laberg et al. 2012). An impact of various ice-load scenarios on the pressure and migration modeling will be evaluated by using probabilistic Monte-Carlo modeling techniques.

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"Impact of Cenozoic structural development and glacial erosion on gas expansion, hydraulic fracturing and leakage" SINTEF Petroleum Research – ENI Norge project 2013 - 2016.

Background & Main Questions

Glaciations over sedimentary basins can have a number of serious consequences for petroleum systems (Lerche et al. 1997). The most important are: changes in hydrocarbon generation rates, migration directions, accumulations and also in rock physical properties. Moreover, glaciations may lead to severe erosion and to uplift of glaciated terrains. These cycles of loading and unloading can also cause fracture development within cap rocks leading to hydrocarbon leakage from traps.

It is thought that these consequences, in combination with pre-glacial Cenozoic uplift and erosion, might be a reason why hydrocarbon exploration in the Barents Sea has not met previous expectations. However, it is not very well known which of these consequences were the most severe for the Barents Sea's petroleum systems and what were the magnitudes of these consequences. We would therefore like to answer the following questions:

- How much oil and gas is left and how much has been leaked due to glaciations and pre-glacial uplift and erosion?
- Were either Cenozoic glaciations or pre-glacial mechanisms the most catastrophic for petroleum systems?
- How did rock mechanics and PVT properties in traps change due to multiple uplift events?

Approach

We will build a complete basin model and carry out petroleum systems modelling. The basin model will include the newest findings from literature, and include methodology for capturing the evolution of the sediment properties, reflecting the specific Cenozoic burial history of this area.

We will employ probabilistic Monte Carlo - secondary migration approach (Sylta & Krokstad 2003) to test how sensitive the petroleum system is to various glacially-related scenarios and parameters. The same approach will be used to construct *a posteriori* parameter distributions and therefore improve knowledge about Cenozoic burial history. We tentatively propose to test the following parameters: average ice-sheet thickness, duration of the glacial periods and different amounts and scenarios of erosion.

Results

The outcome constitutes a well constrained basin model which includes:

- a new Cenozoic burial history model which incorporate new glaciation history concepts (Helmke et al. 2003; Knies et al. 2007, 2009) and new erosion concepts (Laberg et al. 2012, Larsen et al. 2010),
- a new calculation scheme for permeability and mechanical strength accounting for changes in mechanical properties due to multiple periods of uplift-deposition,
- qualitative and quantitative evaluation of the effects of gas expansion due to uplift events

Due to the nature of the probabilistic basin modelling approach we will constrain glacially-related parameters and therefore expand knowledge about Cenozoic burial history in the Barents Sea. The final results from basin modelling will consist of probability maps of hydrocarbon accumulations.

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Acknowledgements

I would like to thank ENI Norge for providing financial means and data. I am also obliged to SINTEF Petroleum Research for support and guidance.

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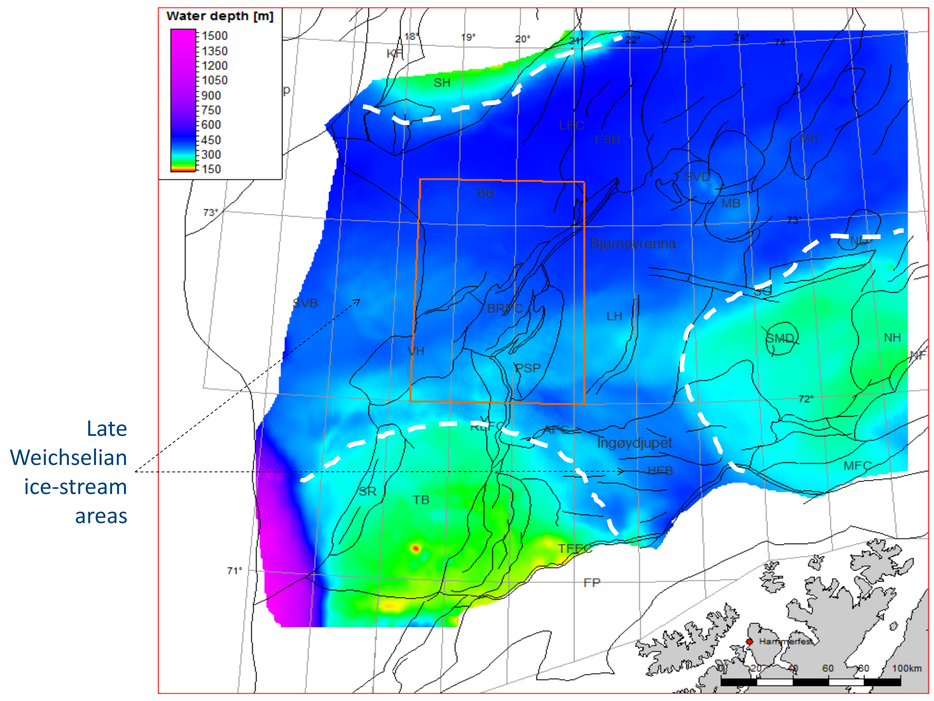
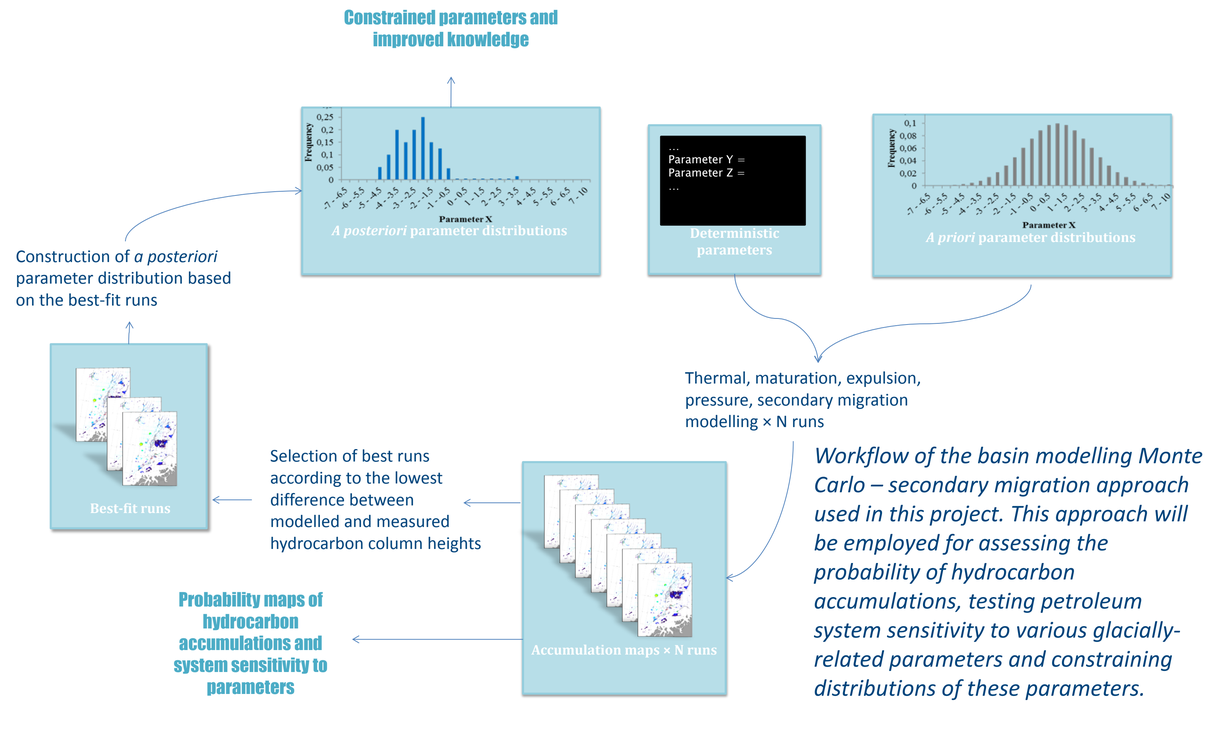
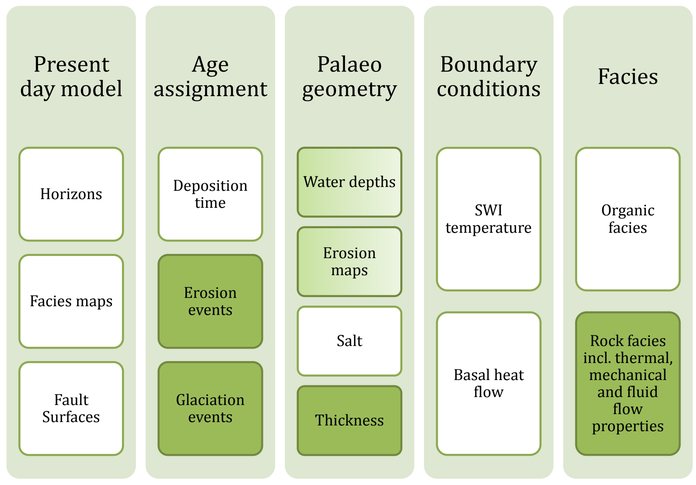


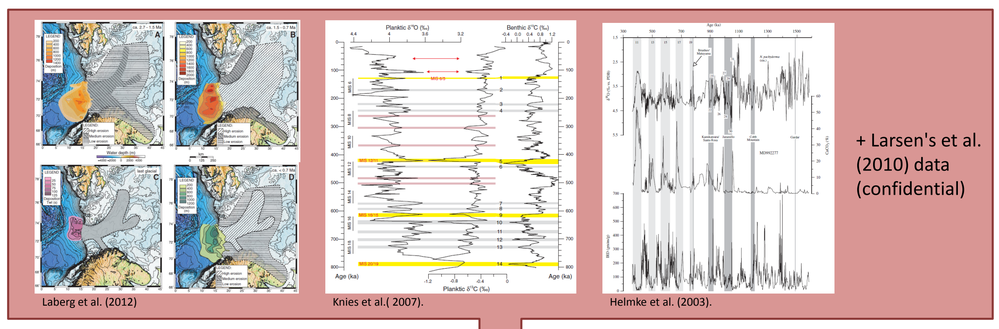
Geographical location of the basin model (orange box) over the main structural elements, bathymetrical features and water depth. Please note that the project area is localized in former ice-stream areas, where higher erosion and ice thickness are indicated.



Workflow of the basin modelling Monte Carlo – secondary migration approach used in this project. This approach will be employed for assessing the probability of hydrocarbon accumulations, testing petroleum system sensitivity to various glacially-related parameters and constraining distributions of these parameters.



The basin model input. Green boxes show input which will be determined as a part of this project, white boxes – input data provided by ENI Norge, mixed green-white boxes – cooperative effort. Elements of the basin model modified after Hantschel & Kauerauf (2009)



The key data used for a new burial history model construction.