Complex Tectonic Development of the Barents Sea - Geohistory, Erosion, Glaciations*

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Abstract

Basin modeling aims at reconstructing the time evolution of a sedimentary basin in order to make quantitative predictions of hydrocarbons accumulations. With increasing geological complexity of relevant sedimentary basins, there is a growing need for basin modeling tools that can handle more of the complex controlling geological processes that lead to the generation and migration of hydrocarbons. The Barents Sea is a good example; it has gone through a complex tectonic development.

The western Barents Sea is characterized by broad platform areas cut by fairly narrow rifts. In contrast, the eastern Barents Sea is a very broad and deep sag basin with little internal structuring. Glacial climate changes over the last million years have influenced the distribution of oil and gas reserves in the Barents Sea. Hydrocarbon exploration in the Norwegian part of the Barents Sea has been rather unsuccessful so far; numerous glaciations during the last 3 million years are regarded to be a major cause for this.

Discussion

The western Barents Sea is characterized by broad platform areas cut by fairly narrow rifts. In contrast, the eastern Barents Sea is a very broad and deep sag basin with little internal structuring. Currently, the nature and origin of these differences are not well documented and understood. The deep basins in the eastern Barents Sea are probably not developed by lithospheric extension. An alternative process, suggested here, is compressional stress-induced subsidence. The application of an in-plane force to lithosphere containing a pre-existing deflection would alter the distribution of bending stresses, which in turn would induce an additional subsidence of the lithosphere (Figure 1).

Glacial climate changes over the last million years have influenced the distribution of oil and gas reserves in the Barents Sea. Hydrocarbon exploration in the Norwegian part of the Barents Sea has been rather unsuccessful so far; numerous glaciations during the last 3 million years (Figure 2) are regarded to be a major cause for this.

Rapid erosion and subsequent differential uplift and tilting is commonly envisioned to have led to spillage of hydrocarbons, phase transition from oil to gas, expansion of gas, seal failure, and cooling of source rocks. In addition to glacial erosion, repeated ice and sediment loading had great influence on and the temperature history, i.e. hydrocarbon maturation hydrocarbon and migration routes. Glaciers, sediments, and erosion act as loads on the Earth's surface – positive or negative. Both glaciers and glacial erosion will lead to significant isostatic tilting of the reservoirs. Glacial erosion leads to significantly lower sub-surface temperatures, and will thus deactivate source rock hydrocarbon generation.

Detailed control on the glacial history, glacial erosion, and sediment deposition is therefore an important factor for identification of the remaining hydrocarbon resources in the Barents Sea.

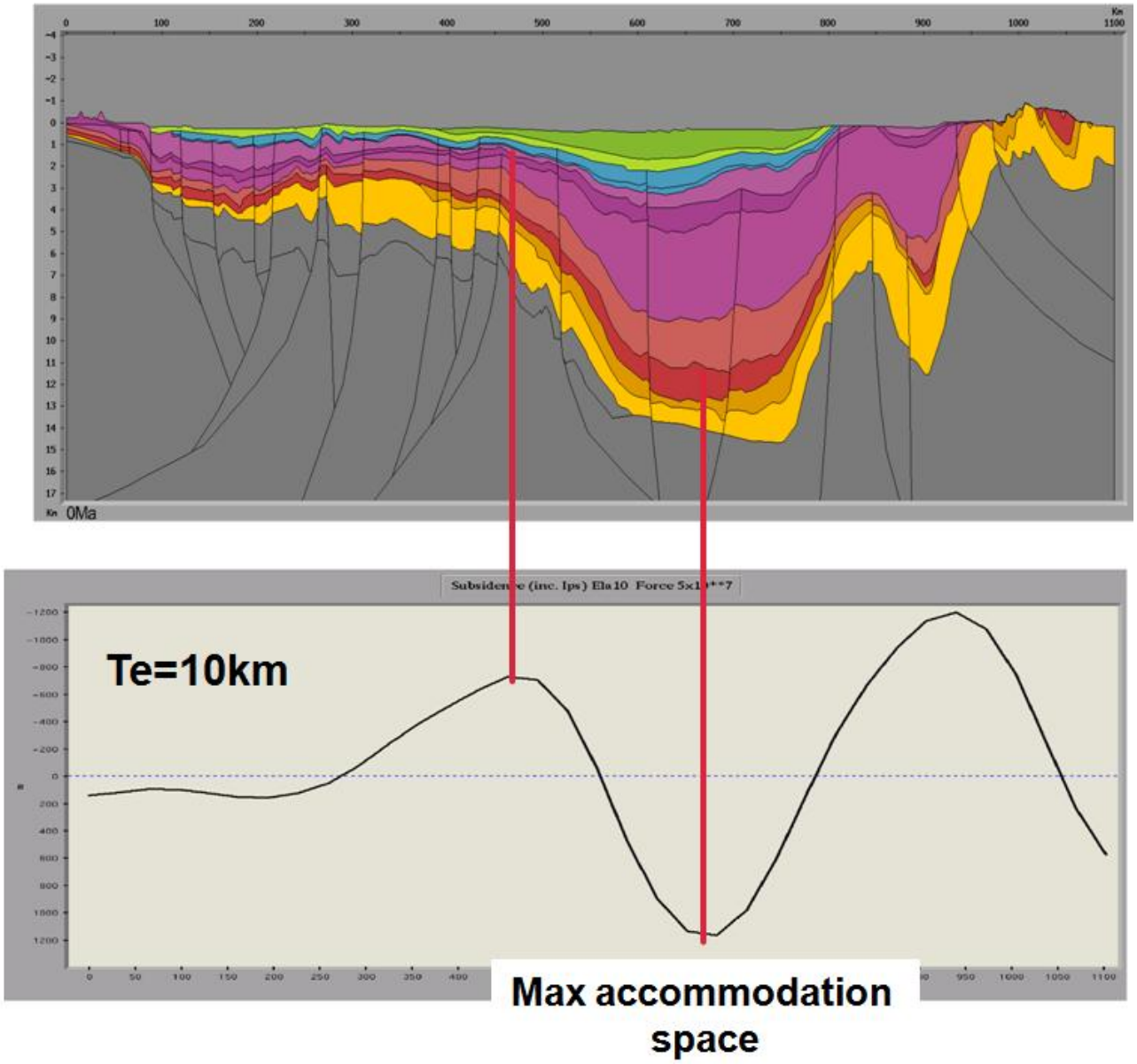

Figure 1. The effect of an in-plane post Devonian compressional force applied on a regional profile over the Barents Sea from Novaya Zemlya to Svalbard.

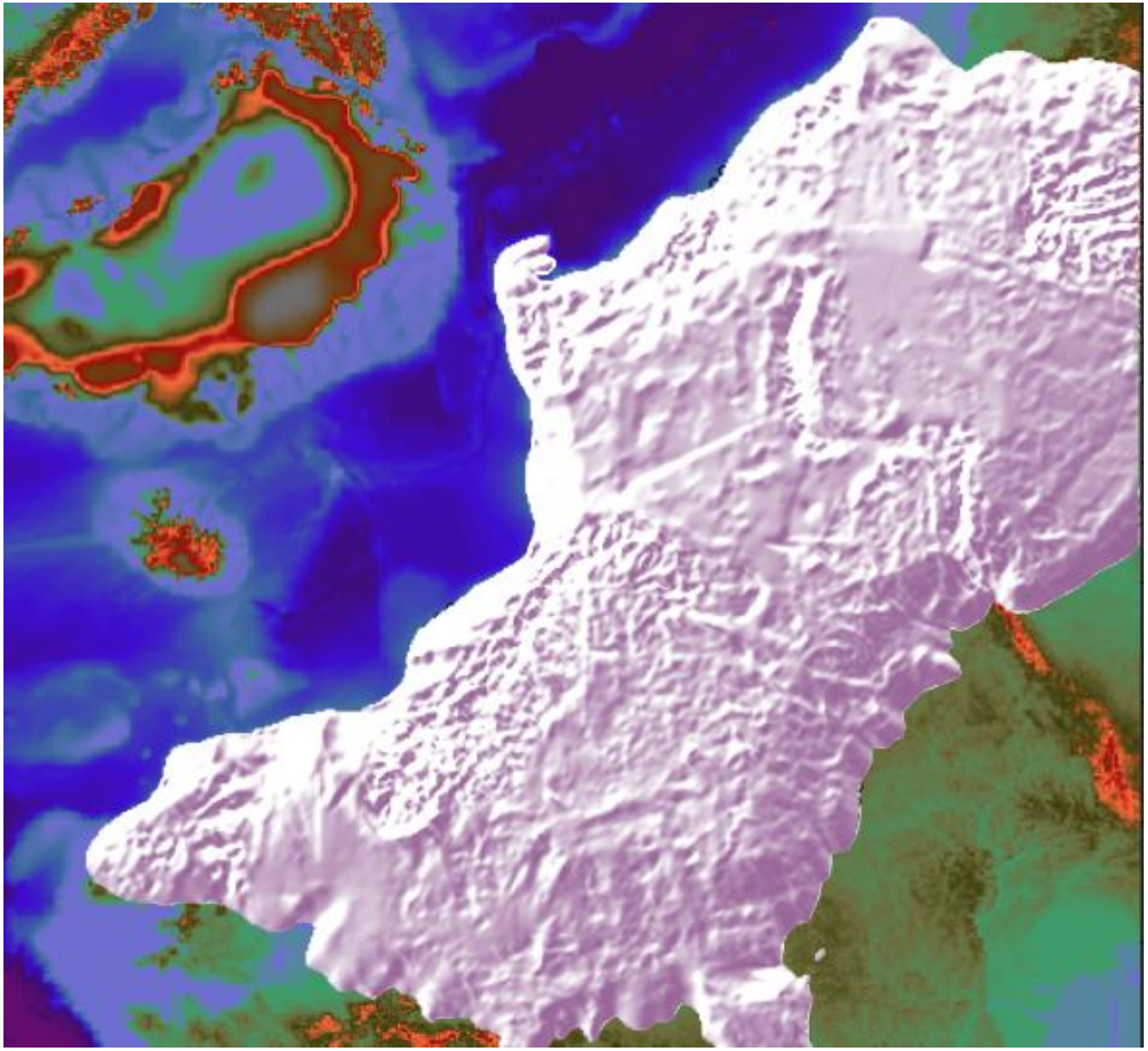

Figure 2. Typical glaciations over the last million years in Northern Europe.