Hydrocarbon Generation Modelling of the Åre, Melke and Spekk Formations, Haltenbanken Area, Norway*

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Abstract

The present study involves 1D basin modelling of two wells from the Haltenbanken Area (the Midgard well 6407/4-1 and the Smørbukk well 6506/12-9S), by employing BAS software (a Basin Simulator which is developed by IFE). The core objective is to estimate the minimum critical moments (timing of oil and gas generation and expulsion) for the Åre, Melke and Spekk formations at these two locations by reconstructing the burial and thermal histories, utilizing the formation thicknesses, age of horizons, geothermal gradients and other relevant parameters. It is furthermore a target to evaluate if two common modelling tools in use provide the same or different time estimates. This study utilized two different kinetic modelling approaches, i.e. the Pepper and Corvi model (1995) and the Tissot and Espitalie (1969 and 1975) model for the kerogen transformation. These modelling approaches are based on realistic source rocks' pre-exponential factors and distribution of activation energies.

It was found that both kinetic modelling techniques yielded similar results concerning the critical moments and the remaining potentials for the source rocks, but that the two models differ quite considerably concerning results for the expelled quantities of oil and gas.

According to modelling results (Case-1, Case-2, Case-3), the Åre Formation started HC generation at the depth of 3200 m and is recently at the depth of approximately 5000 m. The time for oil generation in this formation was estimated to be ca. 92 Ma b.p. at the Midgard location and 87 Ma at the Smørbukk location, which corresponds to Turonian – Late Cretaceous. Gas from this formation is estimated to start from ca. 30 Ma b.p. (Rupelian – Early Oligocene) for the Midgard location and at ca. 50 Ma (Ypresian – Early Eocene) for the Smørbukk location.

Furthermore, modelling results for the Melke Formation suggests HC generation at the depth of ca. 3200 m. This formation is currently at the depth of ca. 4200 m and 4100 m in the Midgard and the Smørbukk regions respectively. This formation is modelled to have started oil generation at ca. 47 Ma b.p. (at Midgard) and ca. 48 Ma b.p. (at Smørbukk), which corresponds to Lutetian – Middle Eocene time. Similarly,

gas generation from this formation is estimated at ca.13 Ma b.p. (Serravallian – Middle Miocene) for the Midgard region and ca.20 Ma b.p. (Burdigalian – Early Miocene) for the Smørbukk region.

The current study suggests that the Spekk Formation started HC generation at the depth of ca. 2900 m, while at present this formation is at the depth of ca. 4200 m at the location of the Midgard and the Smørbukk fields. This formation started oil generation at ca. 40 Ma b.p., that corresponds to the Bartonian – Middle Eocene time, in the Midgard Field, while oil generation from the shales in the Smørbukk Field took place at ca. 55 Ma b.p. (Ypresian – Early Eocene). Early Gas generation from the shales of this formation is estimated to have been initiated at ca. 10 Ma b.p. (Tortonian – Late Miocene) at the Midgard field and at ca. 25 Ma b.p. (Chattian – Late Oligocene) for the Spekk Formation at the Smørbukk Field.

Another objective of the present work was to estimate the remaining source rock potential of these wells today. This study estimates 5% remaining potential for the Åre Formation, while 40% - 50% reactive kerogen is computed to be left within the Melke Formation. Similarly, the present modelling argues that Spekk Formation has 40% - 55% remaining potential in the areas under investigation.

Bearing in mind the fact that both the Midgard and Smørbukk fields have received petroleum charges from down flank regions, which are buried deeper than the investigated formations in the trap themselves, the current results provide minimum times for actual reservoir filling. Still, the relative time difference for HC generation in these three formations may still be applicable to the deeper “oil and gas kitchens”. It is outside the scope of this study, but still of interest that this residual potential may affect the cap rock properties of the structures, as continued generation of HC compounds could tentatively act to hinder the influx of petroleum products from the main reservoir.

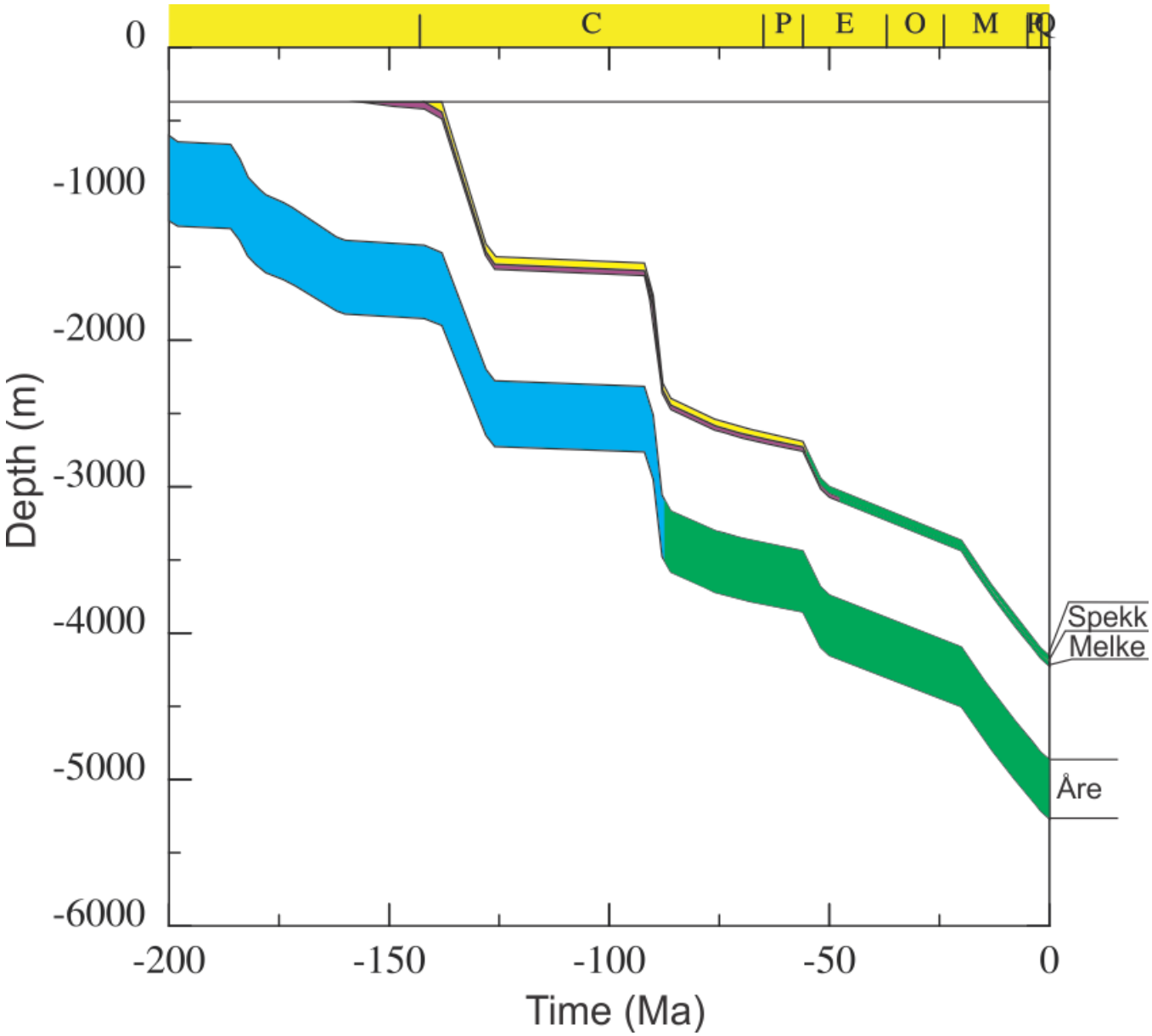

Figure 1. Time-depth cross plot for the Åre, Melke and Spekk formations for the Smørbukk (6506/12-9S) well. Green colour represents mature part of the source rocks, the information on maturity is derived from the VR (%)-time cross plots for the respective formations (other figures).

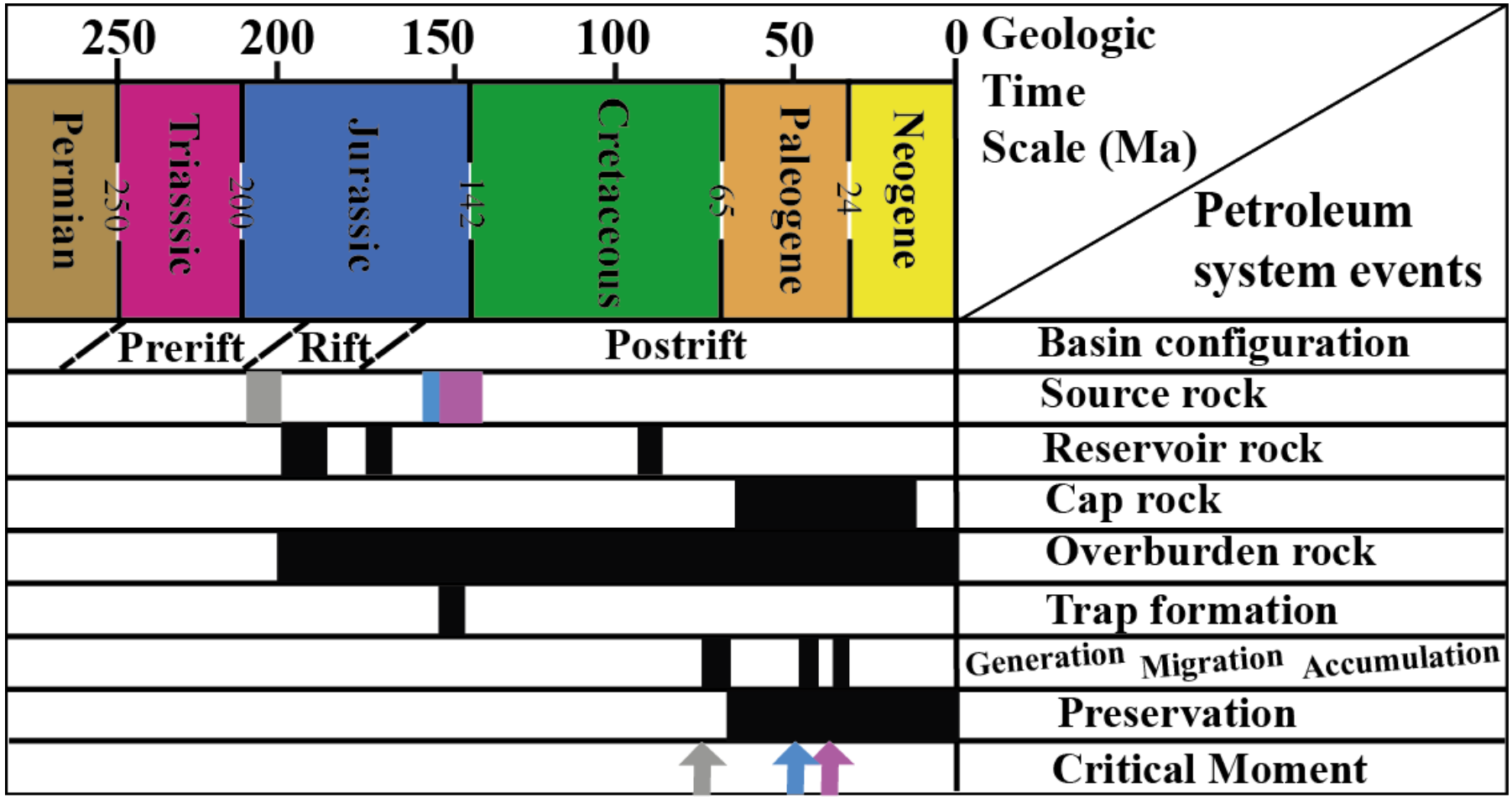

Figure 2. Petroleum system event chart for the Smørbukk well 6506/12-9S showing the relationship between the essential elements and processes as well as the preservation time and critical moment. The colours grey, blue and pink (boxes and arrows) represent the Åre, Melke and Spekk formations respectively.