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Forward stratigraphic modelling of an Early Cretaceous pelagic mixed carbonate–siliciclastic system in the Danish Central Graben

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We document for the first time a forward stratigraphic model of a pelagic–hemipelagic system from the Lower Cretaceous (Hautervian to Aptian) of the Danish Central Graben that at present host hydrocarbon accumulations. The reservoir and baffle zone thicknesses of these low-permeable chalk and marl successions (Tuxen and Sola formations) are variable and below seismic resolution, resulting in large uncertainties when constructing static reservoir models. Palynofacies have shown that marlier lithofacies contain a larger fraction of terrestrial species and chalkier lithofacies more marine species, indicating a potential sea-level control on clay content. This indicates that sequence stratigraphic principles may be valid in this basinal succession and that forward stratigraphic modelling could be applied to simulate deposition of the succession. A best-fit model was constructed that considered temporal changes in palaeo-bathymetry, eustatic sea-level fluctuations, subsidence and uplift, siliciclastic input, carbonate and organic matter production, and sediment transport mechanisms. It was calibrated to 3D seismic data, well log data, core descriptions, organic matter measurements, and biostratigraphy. The predicted thicknesses and facies matched over 90% with the calibration data. The 4D multi-lithology cellular grid shows that chalk facies occur preferentially away from landmasses and deepest parts of the basin, and the largest thicknesses are found on the shelf and slope region. To account for the non-uniqueness of the best-fit model, a sensitivity and risk analysis using response surface modelling was performed. The uncertainty ranges of the parameters were sampled using Latin hypercube sampling resulting in 100 calibrated models. The response surface was used to generate sensitivity, percentile (P10, P50, P90), and probability maps of reservoir and baffle thicknesses or net to gross. This was used to quantify risks based on defined thresholds. The results are thus of interest to better understanding sedimentary processes of a mixed pelagic carbonate–siliciclastic system and to provide architectural information for static model construction.