Predictive Modeling of Sandstone Reservoir Distribution in the SW Scotian Basin

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The SW Scotian Basin is considered an under-explored passive margin sedimentary basin, however, it is also the most probable location to find oil on the Scotian Margin. The basin is complicated by tectonics, salt diapirism, and uncertainty with the interactions between carbonate and clastic sediments in deep-water, all of which make seismic interpretation difficult. The SW Scotian Basin is of specific interest because of the possibility of deep-water clastic reservoirs in the lesser-known Middle–Late Jurassic successions, with the main risks in deep-water being the distribution, size, and reservoir quality of sands. The goal of this project is to understand the stratigraphic evolution of the SW Scotian Basin from the Callovian–Tithonian as well as the delivery of clastic sediment from the Shelburne Delta into deep-water. One way to do this is to develop a forward stratigraphic model of sediment distribution for the Middle–Late Jurassic successions, between the J163 (near top Callivian) and J150 (mid Tithonian) seismic markers.

Modeling of SW Scotian Basin has been performed with DionisosFlow™ and CougarFlow™ software. DionisosFlow™ is able to simulate sediment distribution over basin scales and geological time spans with the main goal of simulating the average geometry and facies of the sedimentary unit. CougarFlow™ is a statistical analysis software that is able to perform sensitivity analysis on the DionisosFlow™ model in order to understand the uncertainty within the various parameters. Simulations are calibrated to available geological data such as regional thickness maps, seismic interpretation, lithofacies interpreted from well logs, river-derived sediment supply, carbonate production, eustasy and sea floor bathymetry.

The reference case model has been calibrated to match calibration criteria to a minimum of 80 %. This model utilizes an initial carbonate ramp bathymetry (as indicated at Monterey Jack E-43) for the beginning of the model (J163), and a shelf edge reef and deep basin bathymetry for the end of the model (J150). Modeling results indicate three important phases of sedimentation in the SW Scotian Basin: (1) carbonate drowning (163-161 Ma), (2) clastic sedimentation (161-153.1 Ma), and (3) return to a carbonate environment (153.1-150 Ma). For the first phase of sedimentation, sand is mostly deposited on the shelf behind a carbonate reef front, which is decreasing in extent. A small amount of sand progrades from the Shelburne Delta at this time into deep-water. For the second phase of sedimentation, an increase of sediment supply to the basin is noted. Clastic sediments cover the shelf, significantly reducing the extent of carbonate sediments, and a large amount of clastic sediment progrades from the Shelburne Delta into deep-water. For the final phase of sedimentation, sediment supply becomes reduced, and carbonate sediments re-establish along the shelf edge. CougarFlow™ results of 350 simulations of the reference case model indicate that the main parameters controlling the extent of basin floor sandy fans in the basin are the water discharge values of the Bay of Fundy river source, the location of the Maine river source, and the diffusion coefficients for sand.

Two additional models as well as respective CougarFlow™ models were made to test different initial and final bathymetries, one with a persistent reef at J163, and the other with a persistent reef and deep basin for J163 and J150. Both of these models indicate that sand is still transported from the Shelburne Delta into deep-water, similar to the three stages of sedimentation in the reference case model, however, more sand occurs closer to the basin edge, immediately down-dip of the Shelburne Delta.

Additional simulations were performed in order to understand how lesser amounts of geological data affect the modeling of sedimentation of clastic and carbonate sediments in the SW Scotian Basin, and which geological parameters are the most important to define in frontier basins. Five models with hypothetically less geological data are compared to the reference case model: wrong seismic pick (reduced sediment thickness), no information on river sources, no information from the COST G-2 well, different bathymetry, and carbonate extent. All models show a similar trend in sedimentation as the reference case model and are well calibrated (above 80 %) except for the reduced sediment thickness model. All models show sand down-dip of the Shelburne Delta. The most important geological information needed in frontier basins is the seismic surfaces (regional thickness map) and paleobathymetry.

In summary, forward stratigraphic modeling results indicate that a shallow ramp paleobathymetry was possible for the J163 seismic marker. Simulation results indicate that the best place to find sand in deep-water is immediately down-dip of the Shelburne Delta close to the basin edge. This result is further supported by the additional bathymetry models that were ran as well as the five less constrained models. Although this result is promising, further work needs to be preformed on understanding the complex salt tectonics as well as the influence of climate on sediment delivery to the basin. Refinement of the model by a reduction of the cell size and an increase in the amount of sediment classes may lead to additional insights on sediment distributions, facies refinement, and may resolve some limitations and assumptions that were made with the model.