Basin Analysis and Sequence Stratigraphy Technical Division

Burial History and Petroleum Generation of the Doig Formation

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ABSTRACT

The Doig Formation is a Lower to Middle Triassic fine-grained interval of the Western Canada Sedimentary Basin that extends continuously across northeast British Columbia and central western Alberta. The findings of a petroleum systems model study of the basin are presented here. The model is focused on the Doig with the aim of reconstructing the basin burial history, constraining the timing of generation and migration of hydrocarbons, and estimating the volume and phases of hydrocarbons generated and retained in the source-rock. It incorporates regional basin fill, geometry and geochronological data, detailed mapping of the lithology, total organic content, kerogen properties and reaction kinetics. The model is constrained by published boundary conditions and calibrated to vitrine reflectance and Rock-Eval pyrolysis thermal maturity data, present-day temperature measurements and porosity. The basin subsidence history is divisible into seven phases based on subsidence rates (Figure 1). During the Paleozoic passive margin stage net subsidence rates were low (between 3 and 6 m/Ma) and deposition was mostly restricted to the northern part of the basin. In the Triassic, after the collapse of the Peace River Arch, the Peace River Embayment becomes the depocenter of the basin, and subsidence rates reach up to 15 m/Ma. In the third phase, through the Jurassic and most of Early Cretaceous, subsidence rates were low, with significant erosion of Triassic strata. Towards the end of the Early Cretaceous, average subsidence rate accelerated initially to 90 m/Ma, then up to a maximum of 390 m/Ma by the end of the Late Cretaceous. Then throughout the Cenozoic, several kilometers of Upper Cretaceous and Paleogene strata were removed at average rates of 80 m/Ma. Thermal maturity of all source rocks increases from east to west towards the fold and thrust belt (Figure 2). Paleo depth of burial is the main control on source rock maturity, while regional variations in heat flow have a secondary control. The Doig Formation is mature with respect to hydrocarbon generation across its entire extension; however, along the eastern edge, transformation ratios are very low and no significant amounts of hydrocarbons could have been thermally generated. The dry gas hosted in the Doig in this region is either biogenic or migrated from deeper portions of the basin. The onset of hydrocarbon generation in the study area was in the Pennsylvanian, when the Duvernay and Exshaw source rocks reached the oil window; however, slow subsidence rates from the Permian through Jurassic prevented these source rocks from generating significant quantities of petroleum until the end of the Early Cretaceous. Paleozoic source rocks reached peak oil during the Albian, followed by the Doig, which entered the oil window later in the Albian. Due to the drastic increase in subsidence rates towards the end of the Early Cretaceous, Jurassic and Cretaceous source rocks all entered the oil window during the Late Cretaceous. The basin critical moment of hydrocarbon generation occurred at 71 Ma. Petroleum generation rate declined

sharply in the beginning of the Cenozoic, with the erosion of Upper Cretaceous and Paleogene strata, and by the Eocene, 99% of the total hydrocarbons had been generated.

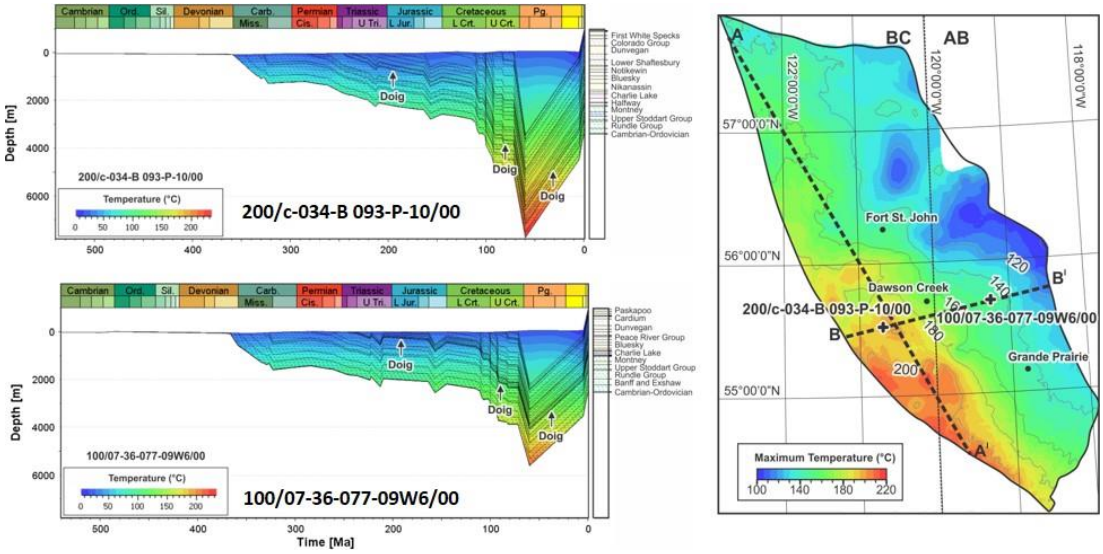

Figure 1: Left - Basin subsidence history of the WCSB at the two locations shown on the map; right - Maximum temperature map of the Doig Formation, with locations of subsidence history diagrams and cross-sections in Figure 2.

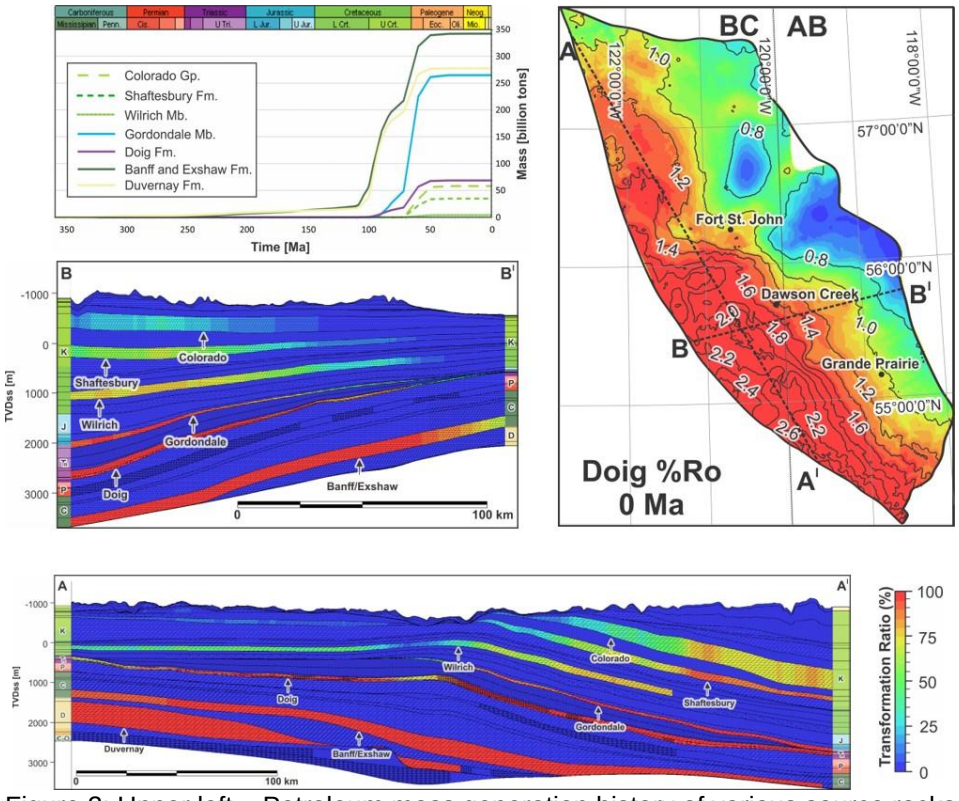

Figure 2: Upper left – Petroleum mass generation history of various source rocks in the study area; Centre left and bottom – Structural cross-sections with transformation ratio of source rocks; Right - Doig source rock present-day maturity map.

BIOGRAPHY

Dr. Pablo Lacerda Silva is a postdoctoral fellow at the University of British Columbia and a petrophysics consultant. He obtained his Ph.D. in geological sciences from the University of British Columbia in unconventional reservoirs, and his experience includes deep-water asset development, operations, and well log analysis.

Co-Author

Dr. Marc Bustin is Professor of petroleum and coal geology at the University of British Columbia and president of RMB Earth Science Consultants. He received his Ph.D. in geology in from the University of British Columbia and he has broad experience in the realm of unconventional gas exploration and exploitation both in research and in his consultancy practice.