



Seismic and Lithological Characterization and Source Rock Potential of the Aptian Naskapi Shale Member, Logan Canyon Formation, Offshore Nova Scotia

Anne C. Hargreaves, Grant D. Wach

Department of Earth and Environmental Sciences – Dalhousie University

Summary

Identifying organic-rich intervals that contribute to viable source rocks helps in understanding petroleum systems and reducing risk in hydrocarbon exploration. The distal Cretaceous and Jurassic shale section offshore Nova Scotia has been viewed as a lean source rock. However, it is uncertain if there are sufficient concentrations of strata with elevated total organic carbon (TOC) values to form the continuous fluid phase necessary for effective primary hydrocarbon generation and migration. In many parts of the world, Cretaceous Oceanic Anoxic Events (OAE's) are associated with significant amounts of organic-rich matter which, with sufficient thermal maturity, have generated prolific volumes of petroleum.

The fluvial-deltaic successions of the Cretaceous Logan Canyon and Cretaceous-Upper Jurassic Missisauga formations in the Sable Subbasin, offshore Nova Scotia, have been the main sources of hydrocarbon production since the early 1990s. The distal and laterally equivalent stratas of the Jurassic-Cretaceous Verrill Canyon Formation (Bajocian – Barremian) and the Logan Canyon Formation (Aptian – Albian) are transgressive shale sequences within the two sand-rich successions. These appear to correspond to global oceanic anoxic events (OAEs). The Aptian Naskapi Member of the Logan Canyon formation is a significant one and is the focus of this study.

When comparing existing levels of total organic carbon from the Scotian Basin with those from OAE's found elsewhere in the world, the Cretaceous Naskapi Member exhibits lower levels of organic matter. The results of this investigation demonstrate:

- a) A high delta-derived sediment load focused in the Sable Subbasin during the Cretaceous that resulted in high dilution rates of organic matter.
- b) The direction and strength of the ocean current regime during the Aptian was not conducive to sufficient preservation of organic matter.

Comparison of the Scotian Margin with time equivalent Cretaceous deposits from elsewhere on the circum-Atlantic margin, indicates that volumetrically insignificant amounts of organic-rich intervals with high TOC values are found, resulting in ineffective Cretaceous source rock. This is a result of paleo-ocean current patterns and the high volume of sediments shed from the adjacent Appalachian Mountains, which served to dilute the concentration of and impede the preservations of organic-rich intervals.

Method

Datasets from 95 wells on the Scotian Shelf were examined, incorporating temperature, total organic carbon, x-ray fluorescence, gamma ray, sonic, density and neutron wireline logs, lithological descriptions from cuttings and cores, data on sedimentation rates, paleo-ocean currents and seismic interpretations of the Naskapi Member. This analysis resulted in the creation of an extensive suite of isochore maps and 3-D models. The ensuing maps portray the stratigraphy, sedimentology, and diagenesis of the Naskapi depositional interval.

Conclusions

The Cretaceous Period reflects a time of a global greenhouse climate, with low sea levels in the Early Cretaceous, rising and peaking in the late mid-Cretaceous. These warmer temperatures increased the potential for oceanic anoxic events. However, the Scotian Basin did not accumulate or preserve significant amounts of organic-rich shale necessary to create an effective regional source rock during the Cretaceous (Aptian) global oceanic anoxic events. This was due in part to a high delta-derived sediment load focused in the Sable Subbasin during the Cretaceous that resulted in dilution of organic matter by siliciclastic material. A drier climate in the Aptian contributed to a largely terrestrial Type III kerogen being deposited via distributaries, and this did not result in creating effective source rock in the Scotian Basin as was seen further south. The very effective source rock, the La Luna in the eastern Venezuelan Basin, was deposited when prevailing ocean currents and upwelling of nutrient-rich water created a nutrient trap, resulting in rich undiluted beds of organic matter with significantly greater TOC than was found in the Cretaceous Aptian in the Scotian Basin.

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