SYDNEY BASIN AND NOVA SCOTIA FORENSIC GEOCHEMISTRY

FINAL REPORT

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Executive Summary

The first part of this project was a review of available geochemical data on source rocks that could occur in the Sydney Basin. A report was prepared that summarized this evaluation and assessed the major knowledge gaps. Based on the latter, a field and core sampling program was proposed and carried out. The samples collected were analyzed geochemically. Some of the field samples were also provided to biostratigraphers working on another component of the Sydney Basin Program. A final report has been prepared that combined older with the new data collected during the present study, for an assessment of potential source rocks within the Sydney Basin and the implications that this has for petroleum systems in this area. Because only a small portion of the Sydney Basin is onshore and few deep wells have been drilled in the offshore, some of the proposed source rocks have not yet been proven to occur in the Sydney Basin. Their presence is considered likely based on their occurrence in surrounding subbasins.

The following are considered possible source rocks within the Sydney Basin:

Middle Devonian McAdams Lake Formation. This formation has moderately thick intervals with high TOC contents that possibly have oil-prone organic matter. This interval is considered high risk for a working petroleum system because of its very limited known occurrence and the uncertainty over how oil-prone its organic matter actually is.

Middle Horton Strathlorne Formation. This interval has not yet been proven to be present in the Sydney Basin but based on seismic is thought to occur in half-grabens identified in the offshore. It is the only source rock to have sourced economic quantities of hydrocarbons within the Maritimes Basin, in New Brunswick, and is known as a source of staining and as an oil shale interval in other Nova Scotia subbasins. In these other subbasins, the Strathlorne Formation can have a significant thickness of very organic-rich, highly oil-prone, lacustrine algal-derived Type I organic matter.

Windsor Group. There appears to be several intervals with source rock potential within the basal Macumber Formation and associated with the evaporites. The Macumber Formation has not yet been observed in the Sydney Basin but may occur in the offshore. Windsor Group intervals with hydrocarbon source potential are often thin and contain organic matter with limited potential to generate oil.

Mabou Group. Although the onshore lower Mabou Cape Dauphin Formation has previously been suggested as a possible source rock, this was not supported by new data collected during the present study. Age-equivalent units to the Cape Dauphin Formation in western Newfoundland and in Britain contain excellent lacustrine potential source rocks that could be present in the offshore.

Morien Group. If sufficiently mature, thick coals within the Sydney Mines Formation and other Morien coals would be a source of extremely large volumes of gas. This is most likely today manifest as a potential coal-bed methane resource because of the lack of suitable seals for conventional traps. There are thin intervals of oil shales and ‘dull coals” associated with some of the coal seams that have some potential to generate oil. Their cumulative thickness in the

on- and near-shore does not suggest they could generate economically significant volumes of oil, although they could be thicker in the offshore.

The Sydney Basin probably reached maximum depth of burial during the Permian since when there has been significant uplift of the basin. As hydrocarbons were generated and expelled in Late Carboniferous-Permian time, preservation in traps is a significant risk. This risk could be eased by salt seals.

The most likely working petroleum system in the offshore would be one with Horton lacustrine source rocks that have generated and expelled hydrocarbons now trapped in upper Horton or lower Windsor reservoirs sealed with Windsor evaporites (i.e. a 'sub-salt play'). Potentially, hydrocarbons sourced from McAdams Lake Formation and lower Windsor Group source rocks such as the Macumber could contribute to the hydrocarbon charge. This does not rule out the presence of other petroleum systems but they are considered riskier. Half–grabens that have been identified on seismic and which are thought to contain Horton and Windsor sediments may be the best locations to look for plays based on this petroleum system.

Project Introduction and Objectives

This project was instigated to provide Nova Scotia Department of Energy information to encourage oil and gas exploration in the Sydney Basin when the call for bids is made for the offshore eastern Cape Breton Island area in 2017. A major perceived risk in the Sydney Basin is the presence of working petroleum systems within the Upper Paleozoic sediments deposited in this basin. Consequently, the objective of this study was a reappraisal of the oil and gas potential of the Sydney Basin from a petroleum systems perspective, largely by looking at what potential source rocks could be effective in this area. This was achieved by reviewing historical data, attempting to fill knowledge gaps in this data by new sampling and analyses, and incorporating both old and new data into a final report that highlights the source rocks most likely to be effective in the Sydney Basin and hence what petroleum systems might be the best to consider from an exploration perspective.

Project Deliverables

The accompanying report entitled, 'Sydney Basin Petroleum Systems – Synthesis of Historical and New Geochemical Data', contains a review of the older and new data collected for this study, details on the new samples collected for this study (in Appendices) and the geochemical data obtained from geochemical analysis of this data. Previously, a PowerPoint summary presentation has been provided to Nova Scotia Department of Energy for marketing to Oil and Gas companies. An abstract was prepared for the 2017 GeoConvention to be held in Calgary in May which has been accepted for an oral presentation by Fowler.

Conclusions

Potential source rocks, ranging in age from Middle Devonian to Upper Carboniferous, have are suggested to occur in the Sydney Basin. As they are not yet known in the Sydney Basin, the presence of some of these source rocks is inferred based on their occurrence in surrounding subbasins and published interpretation of Sydney Basin seismic data. A major risk for working petroleum systems in the Sydney Basin is preservation of hydrocarbons as generation and expulsion from source rocks occurred in Late Carboniferous to Permian time which is a long time for most reservoir seals to be effective. The most likely working petroleum system in the offshore would be one with Horton lacustrine source rocks that have generated and expelled hydrocarbons now trapped in upper Horton or lower Windsor reservoirs sealed with Windsor evaporites (i.e. a 'sub-salt play'). Potentially, hydrocarbons sourced from McAdams Lake Formation and lower Windsor Group source rocks such as the Macumber could contribute to the hydrocarbon charge. This does not rule out the presence of other petroleum systems but they are considered riskier. Half–grabens that have been identified on seismic and which are thought to contain Horton and Windsor sediments may be the best locations to look for plays based on this petroleum system.

Recommendations

It is hard to recommend new geochemical work on onshore Sydney Basin samples as, to the author's knowledge, there are no unsampled outcrops or drillholes that would greatly aide an understanding of petroleum systems in the offshore. Piston coring might provide some interesting results but it is suspected that hydrocarbon seeps will be dominated by methane derived from the relatively shallow, thick coal seams. Analysis of samples from the wells drilled in the Whale Basin (e.g. Sandpiper 2J-77) that penetrated older Sydney Basin sediments might indicate if potential Horton source rocks extend into this part of the basin. However, this area is outside of Nova Scotia jurisdiction and so this may not be appropriate. Analyses of samples from a deep offshore well would provide the most useful data, if one is ever drilled as a result of the forthcoming land sale.