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Petroleum Systems of the Sydney Basin, onshore and offshore Nova Scotia

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Summary

This presentation reviews old and new geochemical data in order to identify possible source rocks in the Sydney Basin, as well as attribute the origin of oil shows sampled in this and other adjacent Maritimes subbasins. Based on this evidence, as well as thermal maturity and burial history data, possible petroleum systems will be proposed that might encourage renewed exploration in the Sydney Basin when the call for bids is made for the offshore area in 2017.

Introduction

In 2017 there is scheduled to be a call for bids for much of the offshore Nova Scotian portion of the Sydney Basin, offshore eastern Cape Breton Island. There has been no significant exploration for petroleum in over thirty years in this area. The Sydney Basin is the eastern part of the regional Maritimes Basin. Only about 2,000 km^2 out of a total area of possibly greater than 150,000 km^2 is onshore with the basin extending northwards and eastwards to Newfoundland (Boehner and Giles, 2008). Onshore it contains up to 3500 m of Middle Devonian to Late Carboniferous continental and marine sediments. Historically, it has been best known for the exploitation of its Upper Carboniferous coal resources. Some oil and gas exploration has taken place in the nearshore with three unsuccessful wells drilled between 1974 and 1983.

Method

This presentation is a reappraisal of the oil and gas potential of the Sydney Basin from a petroleum systems perspective. It uses publicly available geochemical data as well new data collected on outcrop and core samples that have been obtained as part of an on-going study. Rock-Eval/TOC analyses are used to distinguish potential source rock intervals. The origins of oil shows are identified using gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS).

Data Review

A problem with investigating the petroleum potential of the Sydney Basin is the lack of data over most of the basin. Much of the evidence for source rocks in the Sydney Basin is based on onshore data, from their limited outcrops occurrence within the basin or elsewhere in the Maritimes Basin.

The oldest potential source rock is the latest Early-Middle Devonian McAdams Lake Formation that occurs in a small area in the south of the basin. This a lacustrine unit that has TOC contents up to 18.5% and was once considered a possible oil shale resource (Smith and Naylor, 1990). Although the McAdams Lake Formation only has a very limited known occurrence, it has been suggested that it could occur in the offshore (White and Barr, 1998).

The Middle Horton Group (Strathlorne Formation) has lacustrine black shales with very good hydrocarbon potential in many parts of the Maritimes Basin. It is the source rock of the Stoney Creek oil field in New Brunswick. However, in the onshore portion of the Sydney Basin, the Horton Group is only represented by the limited occurrence of the Grantmire Formation. This appears to be equivalent to the Upper Horton Group which does not have hydrocarbon source rock potential. As the oil-prone Middle Horton is widespread within the Maritimes Basin and occurs in basins surrounding the Sydney Basin, it is reasonable to assume that it is present. Its possible occurrence in the Sandpiper 2J-77 well drilled in the eastern part of the Sydney Basin on the Grand Banks supports this.

The Visean age Windsor Group is the first mostly marine succession in the Sydney Basin. The basal Macumber Formation that has been suggested to be organic-rich elsewhere in Nova Scotia does not occur onshore Sydney Basin, although it may occur offshore. Black shales and limestones with hydrocarbon potential occur within the extensive Windsor Group evaporitic sequence but are usually thin. Staining is commonly noted in Windsor Group rocks in the Bras D'Or subbasin, central Nova Scotia, including a small amount of produced oil from a well in the Malagawatch area. Geochemical evidence supports a Horton Group source for many of these stains. Some do show evidence of having at least an input from an evaporitic source suggesting a Windsor Group contribution. There have also been reports of staining in drillholes that penetrated the Windsor Group within the Sydney Basin but these have not been confirmed by the present study.

The Cape Dauphin Formation of the overlying Mabou Group contains many grey to dark grey-black shales that have previously been suggested to be potential source rocks. There is no data publicly available to support this and it is being verified as part of the current study.

The Sydney Mines Formation of the Late Westphalian to Early Stephanian age Morien Group contains the principle economic coal seams that have historically been exploited in the Sydney Basin. Petroliferous limestones, that have been termed in the past 'oil shales', are associated with these coals. Additionally some of the coals, such as those within the Harbour and Hub seams, may also have oil potential. These contain several thin, dull, lipitinite-rich bands that have significantly higher HI values than other coals. The presence of these shales and coals with oil potential is a likely explanation of the hydrocarbon staining that has been commonly reported associated with Sydney Mines Formation coals. These coals also have significant gas potential.

Most potential source rocks are mature with regard to hydrocarbon generation in the offshore. The burial history of the area and basin modelling (e.g. Rehill, 1996) suggests that hydrocarbon generation occurred in Upper Carboniferous to Permian time after which the basin was uplifted. Hence preservation of hydrocarbons in traps maybe a significant petroleum system risk in the Sydney Basin. The best chance for finding large oil and gas accumulations today is probably Middle Horton Group sourced hydrocarbons in traps sealed by Windsor Group evaporites.

Conclusions

The Sydney Basin is a poorly explored Carboniferous basin that almost certainly contains oil-prone source rocks. A major exploration risk is the timing of hydrocarbon generation which occurred relatively early during the Late Paleozoic. It is suggested that, based on current knowledge, a petroleum system with hydrocarbons sourced from a Horton lacustrine source rock in a trap sealed by Windsor Group evaporites represents the best chance of finding economic accumulations of petroleum.

Acknowledgements

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