

## Geological Setting and Petroleum Potential of the Paleozoic Hudson Platform, Northern Canada – Current Knowledge

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### Summary

The Paleozoic-Mesozoic Hudson Platform is the least studied sedimentary basin in Canada despite the fact that it is one of the largest sedimentary accumulations in North America. Of all these basins, the Hudson Bay Basin is the only basin completely encircled by the old Precambrian craton (Fig. 1) and the mechanism(s?) responsible for its formation are yet to be fully understood. As part of the 2008-2013 Geomapping for Energy and Minerals (GEM) program, the Geological Survey of Canada initiated (2009) a new research project aimed at developing a better understanding of the geological evolution of the basin that will lead to a modern appraisal of its hydrocarbon potential. Reevaluation of historical geoscience information is in progress, and new data are being currently gathered. The on-going integration of the geoscience information sheds new light on the evolution of this basin and led to the proposal of new potential hydrocarbon plays in this oil-prone basin.

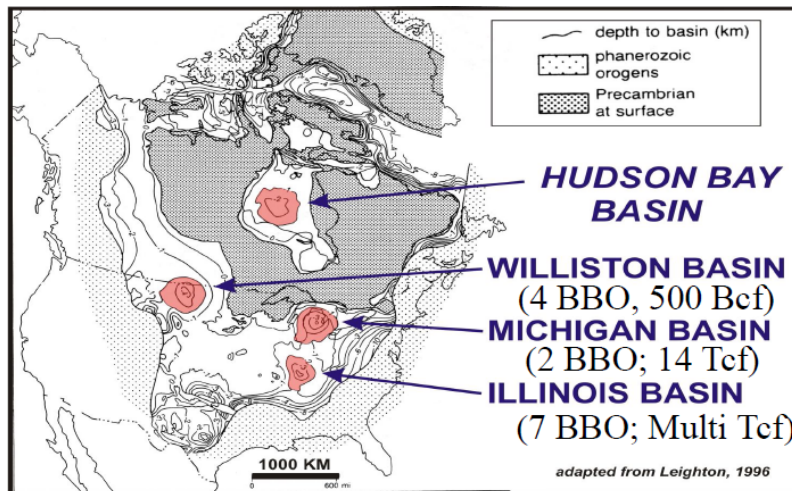


Figure 1: General setting of the Hudson Bay Basin in North America.

### Introduction

The Hudson Platform covers 600,000 km<sup>2</sup> and represents the largest Phanerozoic sedimentary basin in Canada. The Hudson Platform encompasses parts of northeastern Manitoba, northern Ontario and Nunavut, with two thirds of the area covered by waters of Hudson Bay (Fig. 1). The Platform contains the large

Hudson Bay Basin and smaller satellite Moose River and Foxe basins. The Hudson Platform is the least studied intracratonic basin in North America; its surface area rivals that of other intracratonic basins although it is characterized by a thinner preserved sedimentary succession.

## Geological Setting

The Phanerozoic Hudson Bay basin unconformably rests over the Canadian Shield. Its basement is composed of metamorphic rocks of the Superior and Churchill provinces (respectively to the south and north of the basin) that amalgamated at circa 1.9-1.8 Ga. Superimposed on a continental-scale gravity low, significant regional-scale positive gravity anomalies characterize the Hudson Bay.

The succession of the Hudson Platform consists of Ordovician to Cretaceous strata (Fig. 2; Sanford and Grant, 1990), with a maximum preserved thickness of about 2500 m in Hudson Bay. The Paleozoic succession includes Upper Ordovician to Upper Devonian shallow marine carbonates, reefs and thin mudstones with thick Upper Silurian evaporites. Paleozoic strata are unconformably overlain by thin, erosional remnants of Middle Jurassic and Lower Cretaceous non-marine and marine sandstones, mudstones and lignite seams.

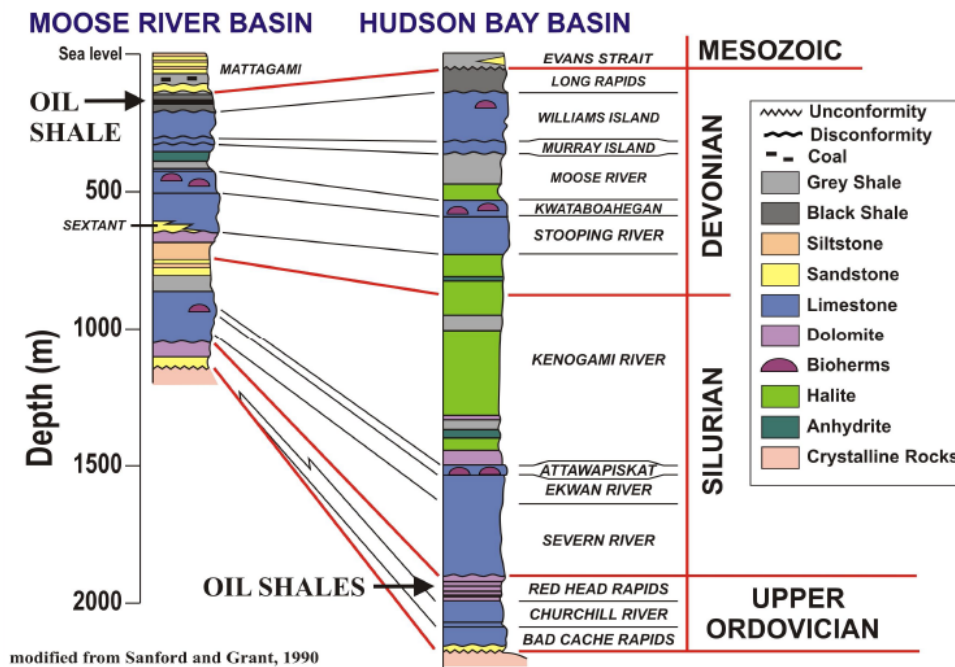


Figure 2: Stratigraphy of the Hudson Bay and Moose River basins with location of hydrocarbon source rocks

In recent years, there has been some significant stratigraphic and sedimentological research on the Upper Ordovician to Lower Silurian carbonates (Suchy and Stearn, 1993; Zhang and Barnes, 2007; Zhang, 2008, 2010; amongst others). The Upper Silurian to Devonian succession has been ignored in recent works.

A detailed knowledge of the geometry of the basin is hampered by the low quality of vintage seismic data. The main structural feature is a NNW trending basin-central horst, perpendicular to the Precambrian basement suture zone. Onlapping relationships indicate that faults bounding the horst were mainly active during the Silurian. Another major structural feature is a WNW-trending fault array that forms the northern boundary of the basin. This fault array parallels the Hudson Strait that connects the Hudson Bay to the Atlantic Ocean, which may have been tectonically active during the Cretaceous or even later.

## Hydrocarbon systems

The hydrocarbon potential of the Hudson Platform is poorly constrained and the area is currently viewed as a frontier prospect. During the first phase of exploration (1970-1980), over 46 000 line-km of seismic reflection data were acquired and 5 exploration wells drilled. Most of the seismic profiles and all of the exploration wells are located in a relatively small area in the central part of the bay. A limited number of onshore wells have also been drilled. Although bitumen has been reported in some wells, all were dry and exploration companies abandoned the area in the 1980s. The Geological Survey of Canada and its partners are carrying out a re-evaluation of the petroleum systems and hydrocarbon resource potential of the Hudson Platform.

Outcrops of high quality Upper Ordovician source rocks (TOC up to 35%) have been known for many years (Macauley, 1986, 1987; Hamblin, 2008; Zhang, 2008) and new occurrences have been recently identified in northern Ontario (Armstrong and Lavoie, 2010) (Fig. 3). Over the years, industry was concerned with the assumed low thermal maturation as Tmax values suggested largely immature successions. On-going acquisition of reflectance data from Hudson Bay well cuttings suggest that the Ordovician source rock interval is within the oil window ( $R_{o_{vit-equiv.}}$  of 0.6% to 1%). The new thermal maturation data will be combined with new Apatite Fission Track (AFT) and U-Th/He geothermochronology data to define the burial and exhumation history of the Hudson Bay Basin.

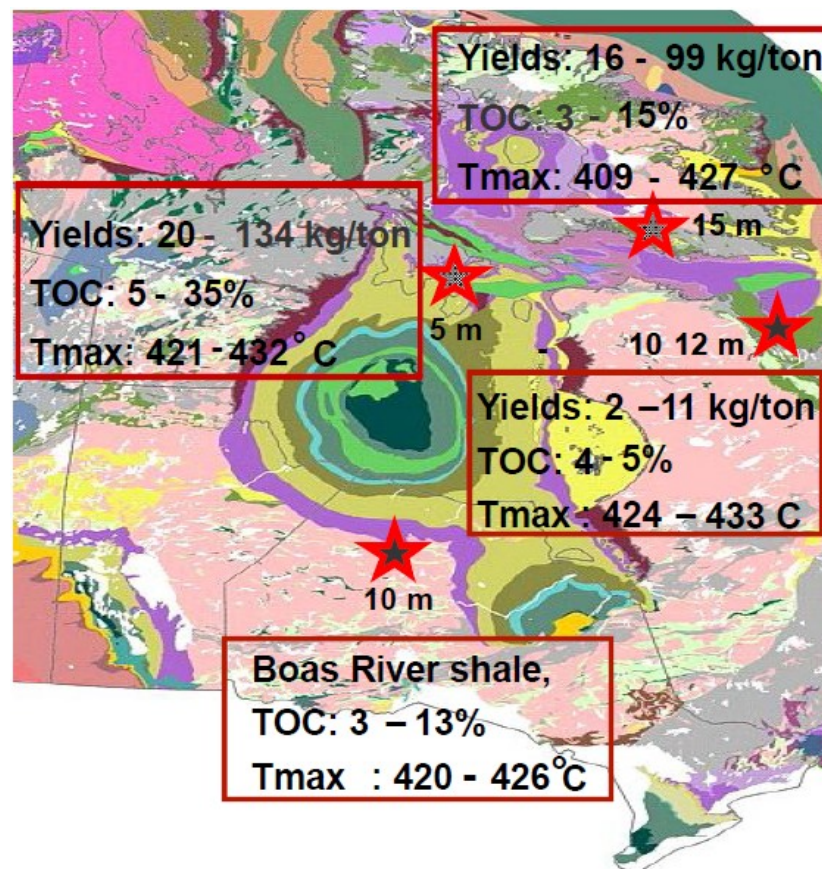


Figure 3: Outcrops of Upper Ordovician source rocks with thickness and geochemical data

Early results point toward several prospective petroleum reservoir and trap types. Upper Ordovician fault-related dolomite bodies were identified in the field and in cores. Preliminary stable isotope analyses indicate that hydrothermalism is a likely mechanism for dolomitization and some seismic features are suggestive of



fault-bounded sags in the Paleozoic platform. Large-scale outcrops of Upper Ordovician porous microbial and cement reefs are exposed whereas smaller-scale Lower Silurian metazoan reefs are locally bitumen impregnated.

Limited new high-resolution bathymetric surveys in northern and central Hudson Bay have led to the recognition of a significant number of circular sea-floor depressions similar to fluid or gas-escape pockmarks (Fig. 4; Roger et al., 2011). Radarsat images have recently been gathered over the entire area in an attempt to identify potential oil slicks.

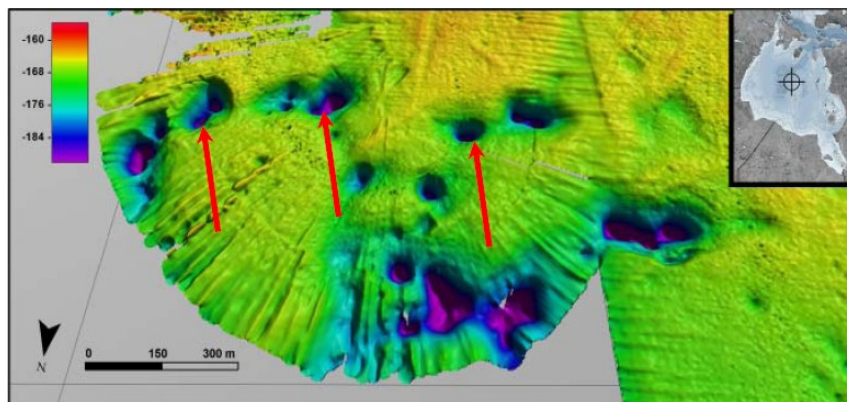


Figure 4: High resolution sea-floor map in central Hudson Bay showing pockmark depressions (red arrows)

## Conclusions

The Hudson Bay Platform is a major frontier sedimentary basin with coeval basins to the south (Michigan, Illinois) being world-class hydrocarbon producers. The previous round of hydrocarbon exploration resulted in drilling of a limited number of dry wells. The Geological Survey of Canada is reassessing historical data and acquiring new hydrocarbon-related information. Outcrops of high-quality Ordovician source rocks are identified on all sides of the basin. New thermal maturation data suggest that the source rocks are within the oil-generating window and locally abundant pockmarks may hypothetically be associated with hydrocarbon generation and migration. Porous and locally bitumen-impregnated hydrothermal dolomites and reefs are present.

## References

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