New Geoscience Data for the Hudson Platform: Opening-up the Last North American Intracratonic Basin to Oil Exploration*

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Summary

The Phanerozoic 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 Platform is the only intracratonic basin in North America completely encircled by the Precambrian craton (Figure 1), and the mechanism responsible for its formation is yet to be fully understood. As part of the 2008-2013 Geo-mapping for Energy and Minerals (GEM) program, the Geological Survey of Canada initiated a research project aimed at generating a better understanding of the geological evolution of the basin that will lead to a modern appraisal of its hydrocarbon potential. Re-evaluation of historical geoscience information is in progress, and new data are being currently gathered. The on-going integration of geoscience information will shed new light on the evolution of this basin and lead to the identification of new potential hydrocarbon plays in this oil-prone basin.

Introduction

The Hudson Platform covers 600,000 km^2 and encompasses parts of northeastern Manitoba, northern Ontario and Nunavut, with two thirds of the area covered by waters of Hudson Bay (Figure 1). The Platform contains the large Hudson Bay Basin and the smaller Moose River and Foxe satellite basins. The surface of the Hudson Platform rivals that of other intracratonic basins, although it is characterized by a thinner preserved sedimentary succession.

Geological Setting

The Hudson Bay Basin unconformably rests on the Canadian Shield. Its basement is composed of metamorphic rocks of the Superior and Churchill provinces. Superimposed on a continental-scale free air gravity low, significant regional-scale positive gravity anomalies characterize the Hudson Bay Basin.

The succession of the Hudson Platform consists of Ordovician to recently documented mid-Tertiary strata (Figure 2; Hu et al., 2011; Galloway, 2011), with a maximum preserved thickness of about 2000 m in Hudson Bay. The Paleozoic succession includes Upper Ordovician to Upper Devonian shallow marine carbonates, reefs and thin mudstones with thick Lower Devonian evaporites in structural lows. Paleozoic strata are unconformably overlain by thin, erosional remnants of Middle Jurassic and Lower Cretaceous nonmarine and marine sandstones, mudstones, and lignite seams.

An updated stratigraphic framework for the central Hudson Bay has been achieved through the reappraisal of well logs and new biostratigraphic data. A major unconformity has been identified at the Silurian – Devonian boundary (Hu et al., 2011).

A detailed knowledge of the geometry of the Hudson Bay Basin is hampered by the low quality of vintage seismic data. The main structural feature is an array of NNW-trending fault blocks in the central part of the basin, oriented perpendicular to the Superior and Churchill Precambrian suture zone. Onlapping relationships indicate that faults bounding the horst were mainly active during the Silurian – earliest Devonian. 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 and limits structural imbricated basins characterized by preserved sedimentary successions much thicker (~2 km) than those preserved on neighbouring islands (<0.6 km). The fault array 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 offshore exploration wells drilled in Hudson Bay. Most of the seismic profiles and all of the exploration wells are located 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.

Outcrops of high-quality Upper Ordovician source rocks (TOC up to 35%) have been known for many years (Macauley, 1986, 1987; Zhang, 2008), and new occurrences have been recently identified in northern Ontario, where the organic-rich interval reaches 10 -15 m (Armstrong and Lavoie, 2010). One of the long-perceived exploration risk was the assumed low thermal maturation levels of potential source rocks, although close to 40% of Tmax values in the Ordovician section indicate the oil window. An organic matter reflectance study (Bertrand and Malo, 2012) of offshore well cuttings indicates that Devonian strata are immature, but Ordovician-Silurian strata sit in the oil window (Ro vitrinite equivalent of 0.6% to 0.8%; Figure 3). New data on Ordovician units in northern Ontario also indicates the oil window.

Early results indicate many prospective petroleum reservoir and trap types occur in the basin. Upper Ordovician fault-related dolomite bodies were identified in the field and in cores (Lavoie et al., 2011). Stable isotope analyses indicate that hydrothermalism is a likely mechanism for dolomitization, and seismic features indicate the local presence of fault-bounded sags in the Paleozoic platform. Other prospective reservoirs identified in outcrop include porous Upper Ordovician microbial reefs and Lower Silurian metazoan reefs locally impregnated with bitumen. Analyses of offshore well data indicate many carbonate and clastic units within the Paleozoic succession have sufficient porosity and permeability to form good quality reservoirs.

Limited 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 (Roger et al., 2011). Preliminary interpretations of Radarsat images indicate possible oil slicks in surface waters of Hudson Bay water (Figure 4).

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 documented pockmark-like features on the seabed may hypothetically be associated with hydrocarbon generation and migration.

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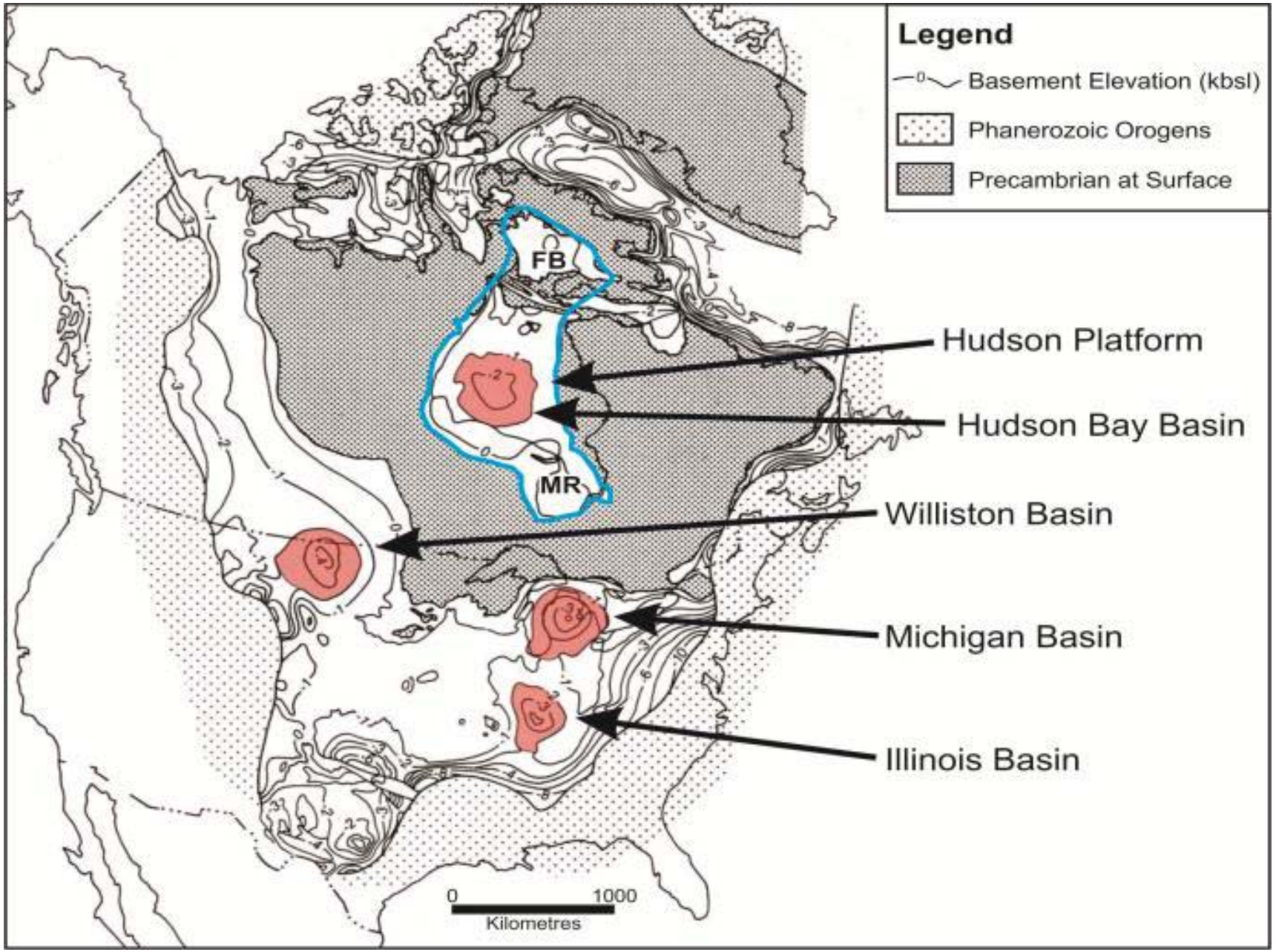

Figure 1: General setting of the Hudson Bay Basin in North America. MR is Moose River Basin and FB is Foxe Basin.

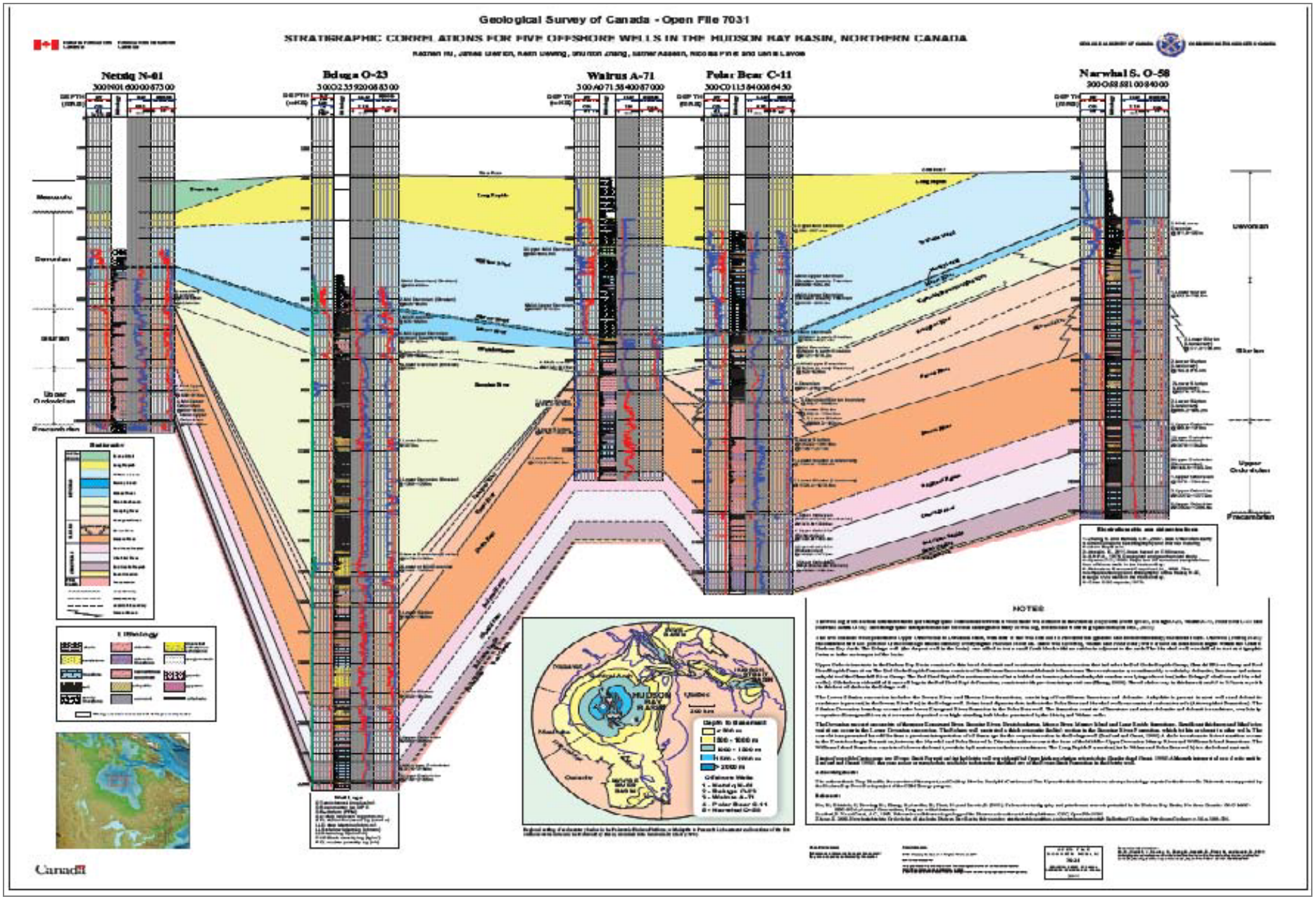

Figure 2: Stratigraphic framework based on new biostratigraphic data and correlation of offshore well logs (Hu et al., 2011).

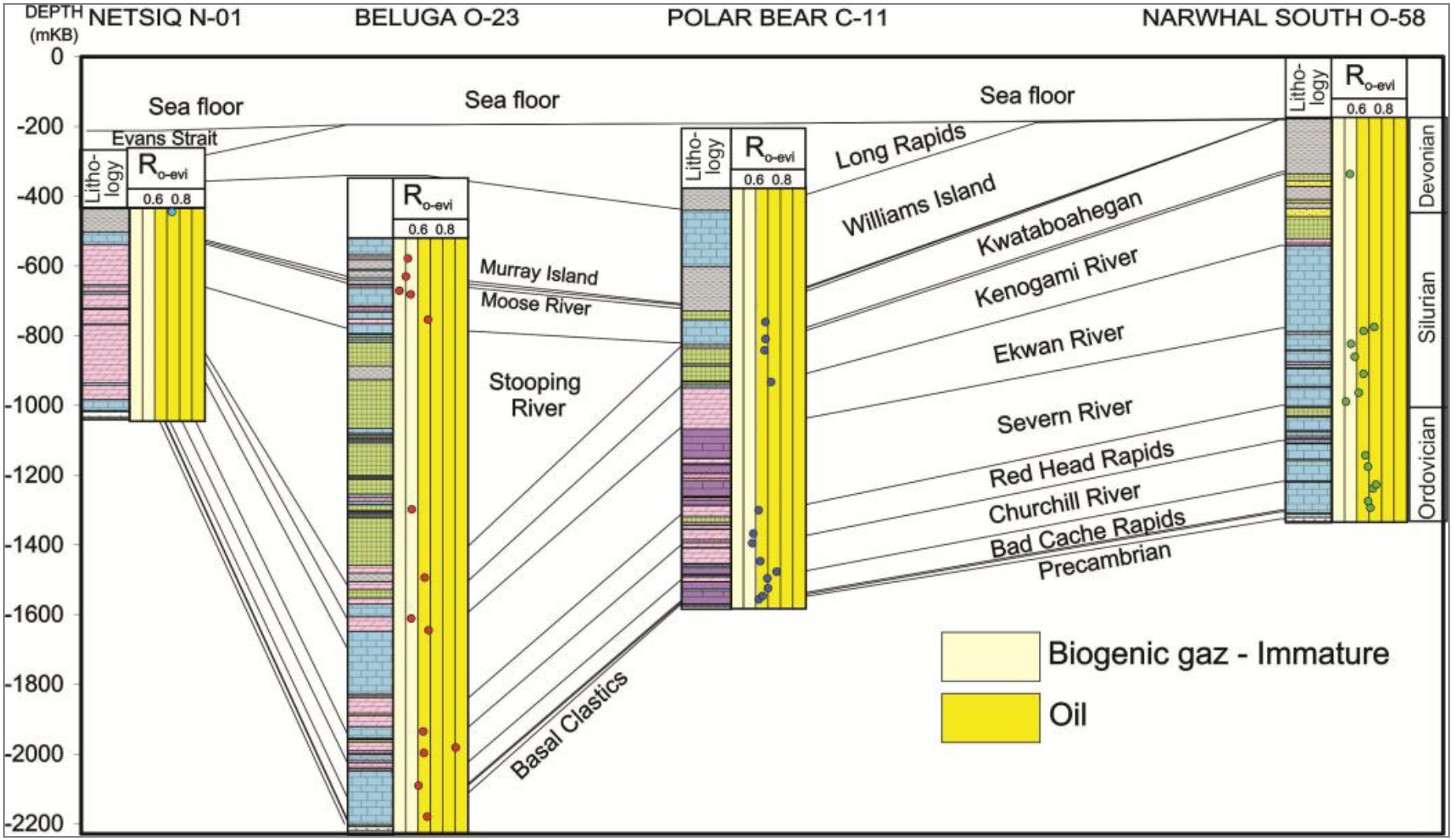

Figure 3: Reflectance of dispersed organic matter from Hudson Bay offshore wells (from Bertrand and Malo, 2012).

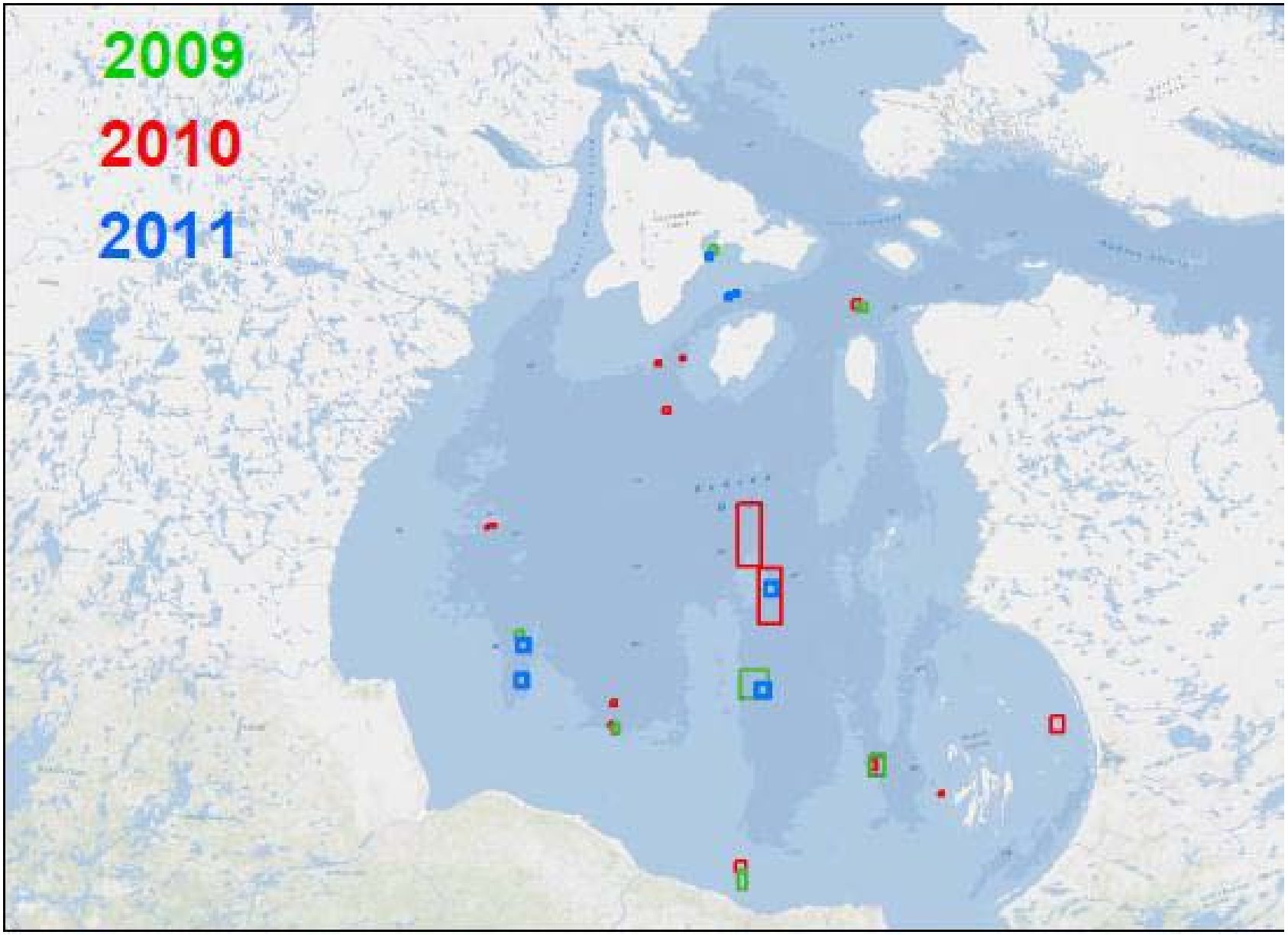

Figure 4: Interpretation of Radarsat multi-year data over Hudson Bay with the presence of potential oil slicks