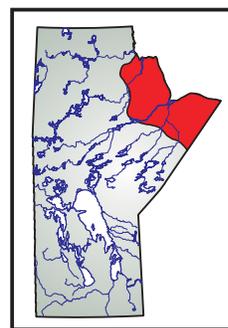


GS-16 Stratigraphy of three exploratory oil-well cores in the Hudson Bay Lowland, northeastern Manitoba (parts of NTS 54B10, F8, G1)

by M.P.B. Nicolas



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Summary

The Hudson Bay and Foxe Basins Project is in its third year of the Geo-mapping for Energy and Minerals (GEM) program. This year's work was focused on completing the logging of all available core in the Hudson Bay Lowland (HBL) of Manitoba, and conducting additional sampling for geochemical and biostratigraphic analysis. Three onshore exploratory oil wells were drilled and fully cored between 1967 and 1970. The stratigraphic interpretation of the wells is presented herein, through careful core logging, geophysical log interpretation and review of a combination of published and unpublished reports. A structural cross-section through the three wells displays the rapid northeastern dip of the formations towards the centre of the sedimentary basin. A stratigraphic cross-section through the same wells shows the increase in sedimentary thickness of the Silurian formations compared to the Ordovician formations, which is a result of increased sediment production and basin downwarping that started in the Silurian. These conditions all support the theory that the Hudson Bay Basin has undergone sufficient burial and heating for source rocks to pass through the oil window, leading to a potentially active hydrocarbon system in this basin.

Introduction

The Hudson Bay and Foxe Basins Project of the GEM program was introduced in Nicolas and Lavoie (2009) and is a Geological Survey of Canada program whose energy side aims to study the hydrocarbon potential of these Phanerozoic sedimentary basins. The Manitoba component of the project is located in the HBL of northeastern Manitoba. Project activities during the third year of the project included core logging and sampling for geochemical and biostratigraphic analysis. The core logging component was a continuation of last year's work, which is described in Nicolas and Lavoie (2010).

Two undergraduate honours theses projects at the Department of Geological Sciences at the University of Manitoba, conducted during the 2010–2011 school year, were supported by the GEM Hudson Bay and Foxe Basins Project and aimed at particular formations and topics of interest. The thesis by M. Wong, and supervised by N. Chow and the author, was done on the lithofacies and stratigraphic correlation of the Ordovician Red Head Rapids Formation in the Kaskattama No. 1 and Comeault No. 1 cores. The thesis by B. Wheadon, and supervised

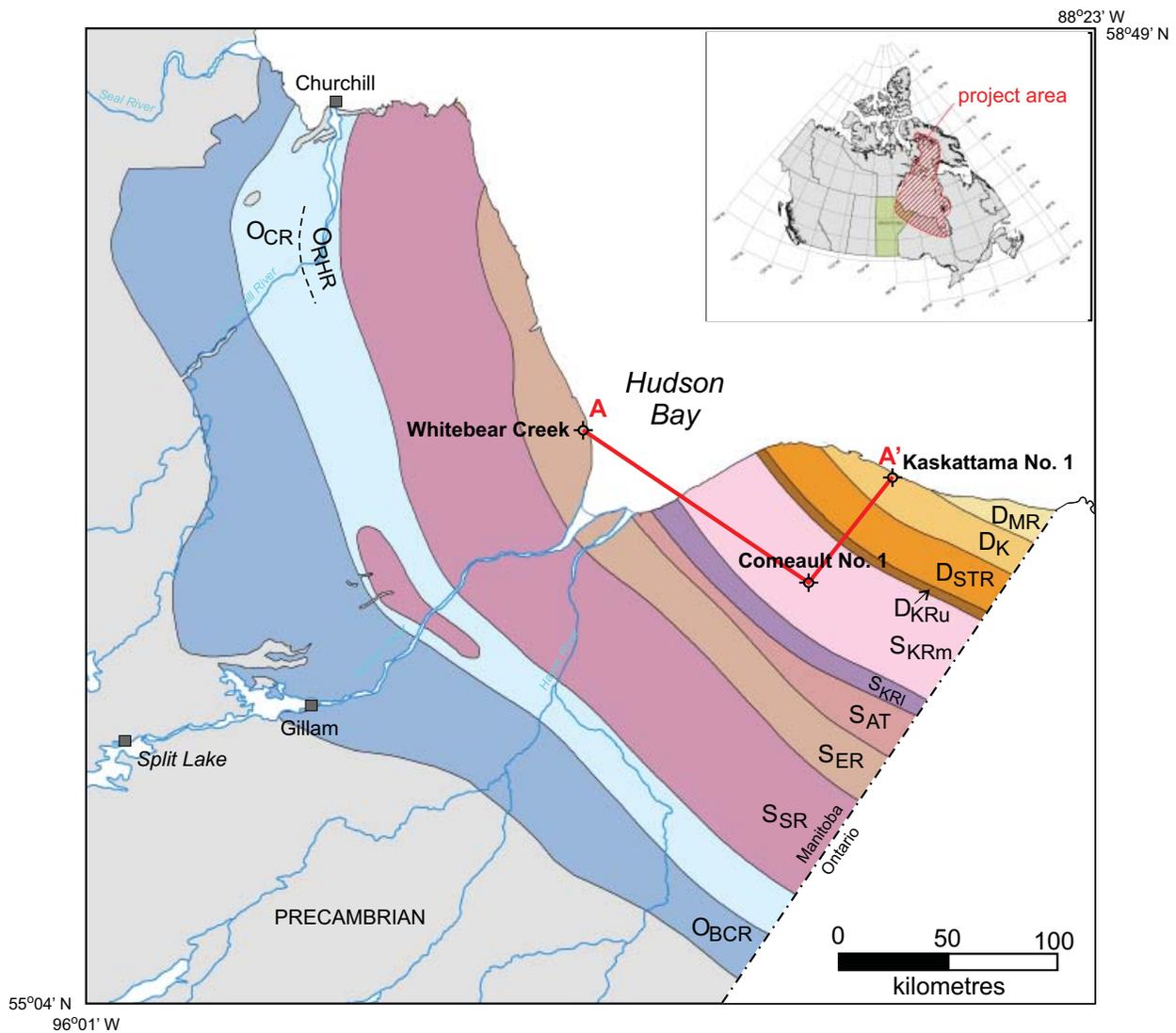
by B. Elias and G. Young, focused on the lithostratigraphy, chemostratigraphy and biostratigraphy of the Airport Cove West M-3-03 stratigraphic core drilled near the Churchill, Manitoba.

Onshore exploratory oil wells

Three exploration oil wells were drilled on the HBL in northeastern Manitoba (Figure GS-16-1): 1) Sogepet Aquit Kaskattama Prov. No. 1 in 1967, 2) Houston Oils et al. Comeault Prov. No. 1 in 1968, and 3) Merland et al. Whitebear Creek Prov. in 1970 (Nicolas and Lavoie, 2010). No oil exploration has been conducted in the HBL since 1970. All three exploration oil wells are dry, have been abandoned and were fully cored, from near surface (assumed base of glacial sediments) to their termination in the crystalline Precambrian basement rocks. Core recovery was generally good and increasing in quality downhole, but the core has been exploited significantly over the years, degrading the quality of the core remaining today. With the exception of approximately the upper 100 m, the Comeault No. 1 core is in good form and provides a good lower Silurian to Ordovician section. The Kaskattama No. 1 core was subject to oversampling in places, leaving behind core rubble that makes it hard to measure depths accurately. This is the only core of the lower Devonian formations in the HBL in Manitoba; coverage includes the lower Devonian to Ordovician section. The Whitebear Creek core has been looked at and sampled the least of the three, and is in excellent shape; however, despite full recovery, the location of the lower 121 m of this core is unknown. Available Whitebear Creek core covers the lower Silurian to Ordovician section.

Stratigraphy

Drilled in 1967, Kaskattama No. 1 was the first exploration oil well in Manitoba's HBL, followed by Comeault No. 1 in 1968. These two wells were drilled during a time of significant exploration in Hudson Bay and the HBL. By the time Whitebear Creek was drilled in 1970, however, there was little interest in the area. As a result, much more information is available on the first two cores compared to the third. Technical well files on the first two wells are detailed although their stratigraphic interpretations are dated. Little stratigraphic information is available for the third well, and the available information is uncertain.



LEGEND

Devonian		Silurian		Ordovician	
D_{MR}	Moose River Fm	S_{KRm}	Kenogami River Fm (middle)	O_{RHR}	Red Head Rapids Fm
D_K	Kwataboahagan Fm	S_{KRI}	Kenogami River Fm (lower)	O_{CR}	Churchill River Gp
D_{STR}	Stooping River Fm	S_{AT}	Attawapiskat Fm	O_{BCR}	Bad Cache Rapids Gp
D_{KRu}	Kenogami River Fm (upper)	S_{ER}	Ekwan River Fm		
		S_{SR}	Severn River Fm		
				 Kaskattama No. 1	Exploratory oil well, dry and abandoned
				A — A'	Cross section line

Figure GS-16-1: Stratigraphy of the Hudson Bay Lowland in northeastern Manitoba, showing the location of the three exploration oil wells; inset is the project area for the Geo-mapping for Energy and Minerals Hudson Bay and Foxe Basins Project.

The best way to date and understand the sedimentary succession in a sedimentary basin is through biostratigraphy. This method was, and still is, extensively used in the Hudson Bay region, since this frontier basin still holds many questions and few answers. It is difficult to draw a good stratigraphic framework to describe a basin as large as the Hudson Bay Basin on only nine deep exploratory wells, three of which are located in Manitoba, and the others are offshore and in Ontario. Although recent attempts at combining old outcrop information with new outcrop data and stratigraphic interpretations have resulted in a modernization of the stratigraphic column for the Hudson Bay Basin, there have been challenges. Attempting a solid stratigraphic framework for a basin of this size and with multiple geological perspectives, there are many interpretations that come forth, all with their own proper reasoning based on the geologist's choices, which strongly depend on the method used to make the correlations, such as lithostratigraphy, chemostratigraphy or biostratigraphy. Some formational names have changed, which has led to changes of contacts, further complicating the puzzle.

In an attempt to reconcile stratigraphic issues in the HBL of Manitoba, a listing of the formation tops and some of its members for the three oil wells is compiled in Table GS-16-1. These stratigraphic tops are based on the

author's logging of the core, employing lithostratigraphy as the dominant correlation method, in combination with biostratigraphic correlations from both published reports (Nelson and Johnson, 1968; Norford, 1970, 1971; Le Fèvre et al., 1976; Suchy and Stearn, 1992; Jin et al., 1993; Zhang and Barnes, 2007) and unpublished sources, such as Suchy (1992), government reports and notes, and petroleum technical well files. Since the Whitebear Creek core was missing the lower formations, geophysical log picks were used to determine stratigraphic picks for the missing horizons.

Figure GS-16-2 shows a structural cross-section through the three HBL oil wells, from west to east, illustrating the pronounced northeastern dip of the sedimentary strata towards the centre of the basin. Figure GS-16-3 shows a stratigraphic cross-section through the three wells using the top of the Red Head Rapids Formation/Ordovician-Silurian boundary as the stratigraphic datum. The stratigraphic cross-section shows the variability in thickness of the formations and its members. The Ordovician formations as a whole show little variability in thickness towards the basin's centre. In comparison, the Silurian formations, particularly the Severn River Formation, show tremendous thickening in the same direction. This is indicative of increased sediment productivity in the Silurian compared to the

Table GS-16-1: Stratigraphic tops for the three exploration oil wells in the Hudson Bay Lowland, northeastern Manitoba.

Era/Epoch	Formation/Member	Whitebear Creek depth (m)	Comeault No. 1 depth (m)	Kaskattama No. 1 depth (m)
Pleistocene	Glacial drift (till and gravel)	0.00	0.00	0.00
	Base of glacial drift	?	?	?
Devonian	Stooping River Formation			20.42
	upper Kenogami River Formation			125.27
Silurian	middle Kenogami River Formation			128.93
	lower Kenogami River Formation		60.96	314.56
Ordovician	Attawapiskat Formation	30.48	96.62	327.97
	Ekwana River Formation	60.17	133.50	393.50
	Severn River Formation	85.85	182.88	435.87
	Red Head Rapids Formation	220.83	423.52	667.52
	Churchill River Group	269.36	465.62	699.52
	Chasm Creek Formation	269.36	465.62	699.52
	Caution Creek Formation	299.80	529.60	739.64
Ordovician	Bad Cache Rapids Group	328.57	549.77	791.58
	Surprise Creek Formation	328.57	549.77	791.58
	Portage Chute Formation	380.09	564.24	818.40
	Member 2	380.09	564.24	818.40
	Member 1 (basal clastics)	390.14	614.33	884.85
Precambrian	Precambrian (weathered)	396.54	616.01	887.68
	Precambrian (fresh)	402.34		889.36
	<i>Total Depth (m)</i>	<i>427.02</i>	<i>647.70</i>	<i>896.42</i>

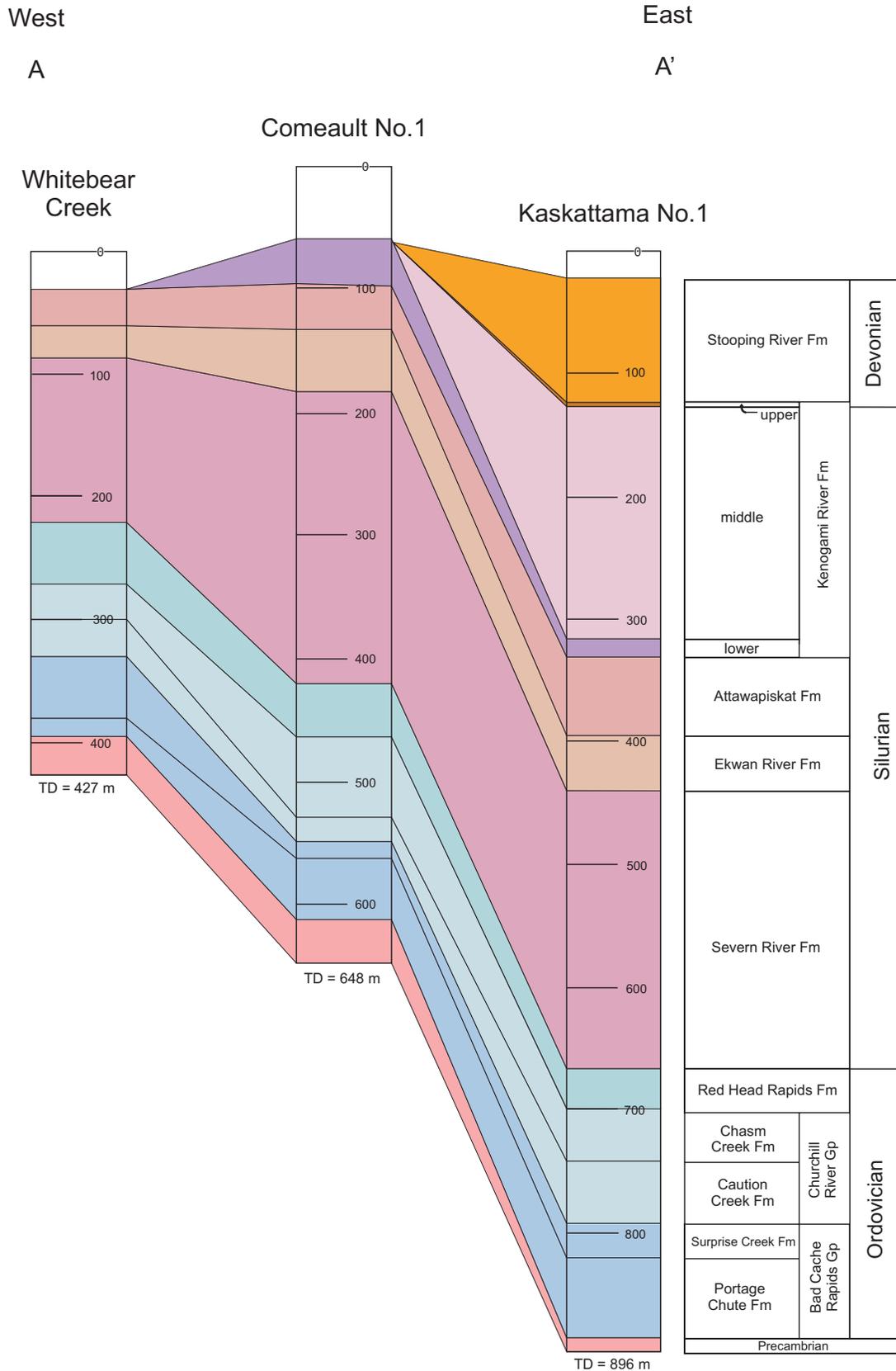


Figure GS-16-2: Structural cross-section AA' through the Whitebear Creek, Comeault No. 1 and Kaskattama No. 1 oil wells (datum at sea level), Hudson Bay Lowland, northeastern Manitoba. Vertical depths are shown in metres below kelly bushing. Abbreviation: TD, total depth.

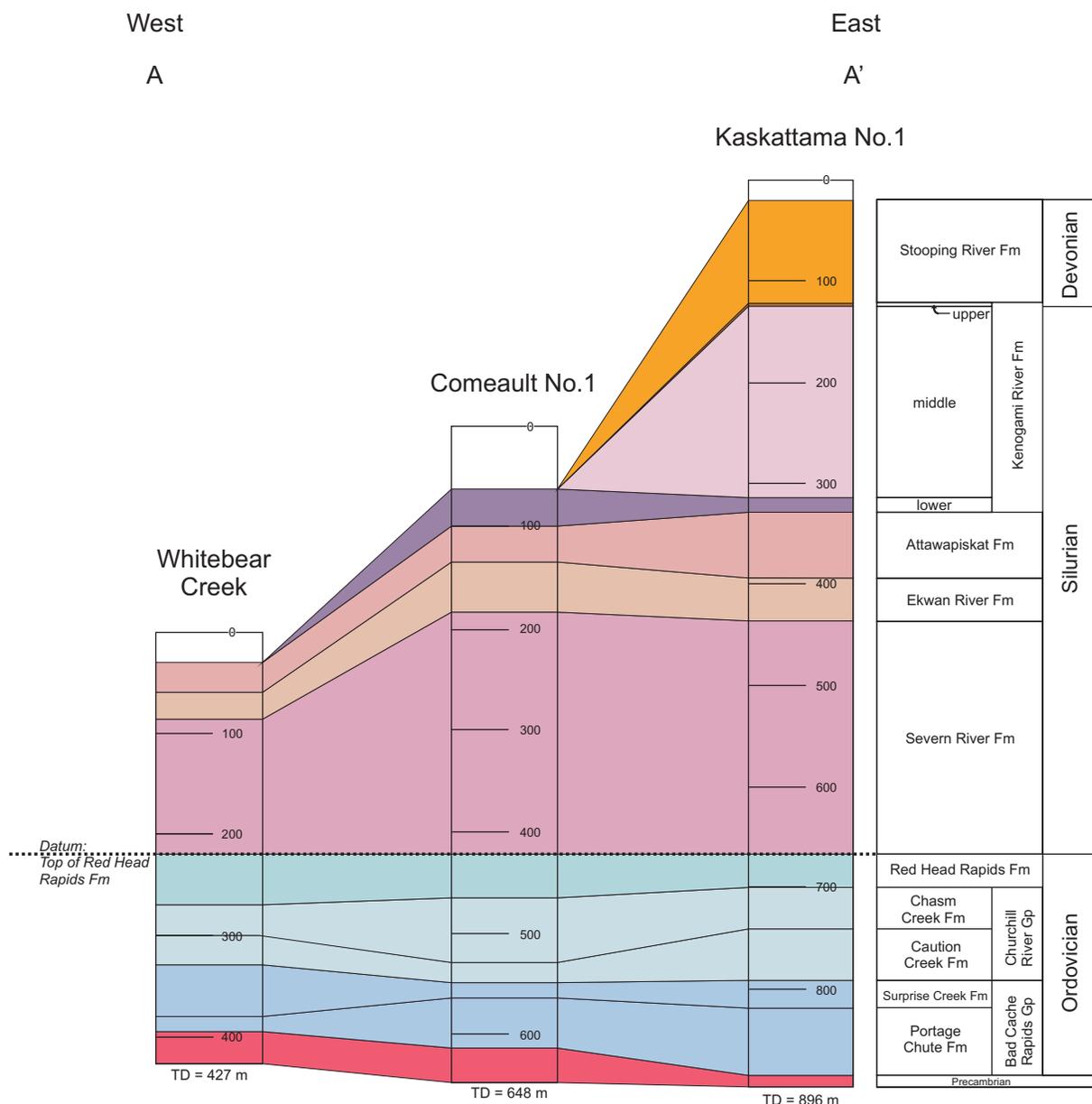


Figure GS-16-3: Stratigraphic cross-section AA' through the Whitebear Creek, Comeault No. 1 and Kaskattama No. 1 oil wells (datum at top of Red Head Rapids Formation), Hudson Bay Lowland, northeastern Manitoba. Vertical depths are shown in metres below kelly bushing. Abbreviation: TD, total depth.

Ordovician, which translates to an increase in sediment load and downward of the basin during the Silurian. These conditions are favourable for the basin to have undergone enough burial and heating for source rocks to pass through the oil window. Hydrocarbon migration evidence in the onshore core, such as the bituminous residue along open fractures (Nicolas and Lavoie, 2010), has been seen in multiple cores logged throughout the HBL for this project.

Future work

New samples were collected from the three oil-well cores, in addition to diamond-drill exploration core, for

geochemical analysis and biostratigraphic interpretation. Results from these samples are pending.

In the Department of Geological Sciences at the University of Manitoba, additional GEM-supported undergraduate theses projects in the HBL are planned for this year:

- a detailed study of the Ordovician–Silurian strata and systemic boundary in the Churchill Northern Studies Centre Quarry M-4-03 core, done by K. Lapenski and supervised by B. Elias and G. Young,
- a detailed study of the Red Head Rapids Formation and Ordovician-Silurian boundary interval in the

Whitebear Creek core, done by B. Duncan and supervised by B. Elias and the author, and

- the sedimentology and petroleum reservoir potential of the Attawapiskat Formation, northeastern Manitoba in the Whitebear Creek, Kaskattama No. 1 and Comeault No. 1 cores, done by A. Ramdoyal and supervised by N. Chow.

Economic considerations

A good comprehension of the stratigraphy of the HBL is important in understanding the sedimentological framework in this part of the Hudson Bay Basin. Understanding the rocks and how they change over distances is critical in hydrocarbon exploration, as hydrocarbon sources and traps are formed as a result of these variations. This compilation and synthesis of stratigraphic tops information will assist geoscientists in their research and exploration activities, and can help promote hydrocarbon exploration in the northern region. Hydrocarbon exploration activities in Manitoba's north and offshore areas would, in turn, provide a source for significant economic growth and stimulus for this region.

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