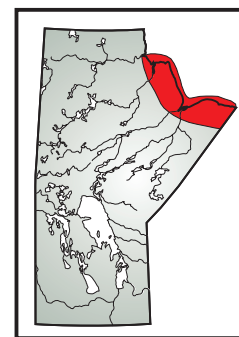


GS-16 Hudson Bay and Foxe Basins Project: introduction to the Geo-mapping for Energy and Minerals, GEM–Energy initiative, northeastern Manitoba (parts of NTS 54)
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Summary

The Hudson Bay and Foxe Basins Project is part of the new Geological Survey of Canada Geo-mapping for Energy and Minerals (GEM) program, which aims to study the hydrocarbon potential of these basins. In Manitoba, the Hudson Bay Basin is represented by the Paleozoic carbonate succession of the Hudson Bay Lowland (HBL) in the northeastern corner of the province. Re-evaluation of existing geoscientific data through the lens of modern ideas and theories and application of new scientific technologies are currently underway. In addition, new data will be acquired in areas currently presenting knowledge gaps.

Preliminary results obtained in 2009 from core descriptions of drillholes from Manitoba suggest that hydrothermal dolomitization processes may have occurred. If proven true, through microscopic examination and geochemistry, this discovery can provide key information on the evolution of the Hudson Bay Basin and its hydrocarbon resource potential.

Introduction

As part of the new Geological Survey of Canada Geo-mapping for Energy and Minerals (GEM) program, a new project on the hydrocarbon potential of the Hudson Bay and Foxe basins has been initiated. Partners in this project include National Energy Board, Northern and Indian Affairs Canada, the Manitoba, Ontario, Quebec and Nunavut governments, and Canadian universities.

Hudson Bay Basin and Foxe Basin are intracratonic basins that cover a large area of Nunavut and significant onshore segments of Manitoba, Ontario and Quebec (Figure GS-16-1). These basins, which form close to 25% of Canada's landmass, constitute today's frontier in the areas of both geoscience and hydrocarbon systems knowledge. Very little hydrocarbon exploration has been done in these basins, and the latest round of exploration dates back more than 25 years.

The project aims to document the characteristics of potential hydrocarbon systems in the successions of the Hudson Bay and Foxe basins by reassessing available geoscience data and acquiring new data in areas or domains that currently present knowledge gaps. As part of this new

project, a re-examination and eventual re-interpretation of well data from northeastern Manitoba is underway. Similar studies will be carried out on material from onshore wells in northern Ontario and offshore wells under National Energy Board jurisdiction.

The Hudson Bay Basin consists primarily of shallow marine to peritidal Upper Ordovician to Upper Devonian carbonate sequences with locally abundant evaporite (Upper Silurian) and nearshore clastic rocks (Lower Devonian); poorly constrained Mesozoic sediments are interpreted as locally overlying the Paleozoic succession (Norris, 2003). In the past, industry has claimed that the Hudson Bay Basin was never buried deeply enough for the generation of hydrocarbons out of known source rocks. This claim of supposed lack of significant burial was based on the presence of non-mature oil shale that crops out on Southampton Island and of a 2.5 km thick succession deduced from the low quality seismic data available for the central part of Hudson Bay. However, new thermochronological dating (apatite fission track and (U-Th)/He) results from northern Ontario and southwestern Manitoba suggest that erosion of up to 3.4 km of Paleozoic strata occurred in that southern reach of the basin (Feinstein et al., 2009; K.G. Osadetz, pers. comm., 2009), as well as unexpected high geothermal gradients (>46°C/km) throughout the burial history. The 2.5 km of burial might therefore represent a minimum preserved depth estimate, whereas the amount of burial and thermal conditions of the succession might actually have been significantly greater, at least locally. The recent documentation of possible pockmarks (fluid escape features) in the northern reach of Hudson Bay could indicate that active hydrocarbon venting out of the basin occurred (Dietrich et al., 2009).

It is also critical to consider that current understanding of the maturation history of the Paleozoic succession in these basins is based almost entirely on maximum temperature (T_{\max}) values generated by the Rock Eval™ analysis of samples (Zhang, 2008). However, in the Paleozoic successions of eastern Canada, T_{\max} has proven to be an unreliable indicator of the burial history. Instead, reflectance of organic material or bitumen has been shown to provide more precise maturation data (Roy, 2008).

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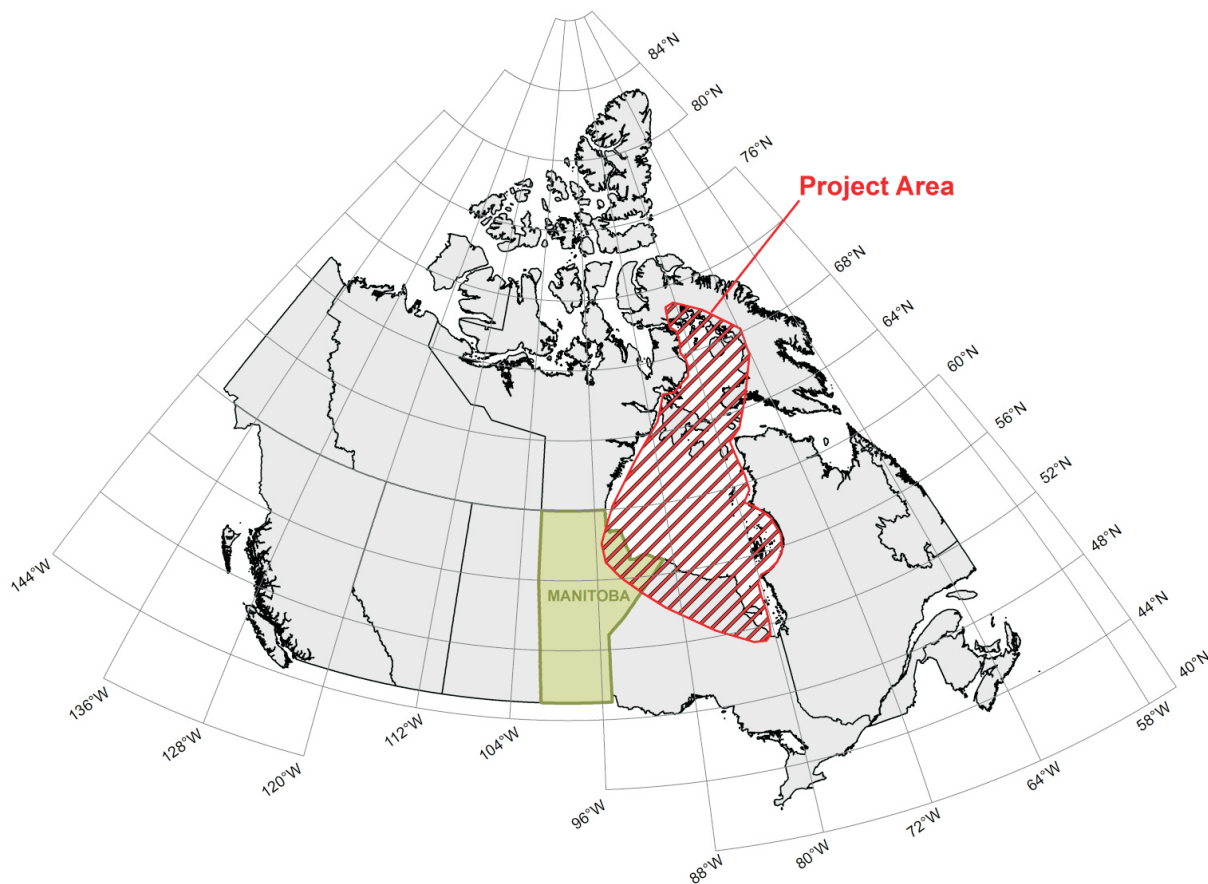


Figure GS-16-1: Location of the Hudson Bay and Foxe Basins Project area.

During the course of this project, new samples of archived core will be taken and petrographically analyzed. Moreover, new knowledge about hydrocarbon reservoirs and plays needs to be tested for the Hudson Bay Basin; for example, the concept of hydrothermal dolomite units (Davies and Smith, 2006) was not available at the time of the last round of exploration. Hydrothermal dolomite units are highly brecciated and their seismic expression (e.g., the seismic 'sags'; Davies and Smith, 2006) has been tentatively identified on available industry seismic images (Dietrich et al., 2009).

In Manitoba, the Hudson Bay Basin is represented by the Paleozoic carbonate succession of the Hudson Bay Lowland (HBL) in the northeastern corner of the province. The HBL consist of a progressive erosional truncation of the Devonian, Silurian and Ordovician formations, from youngest in the northeast to oldest in the southwest, towards the basin margin (Figure GS-16-2).

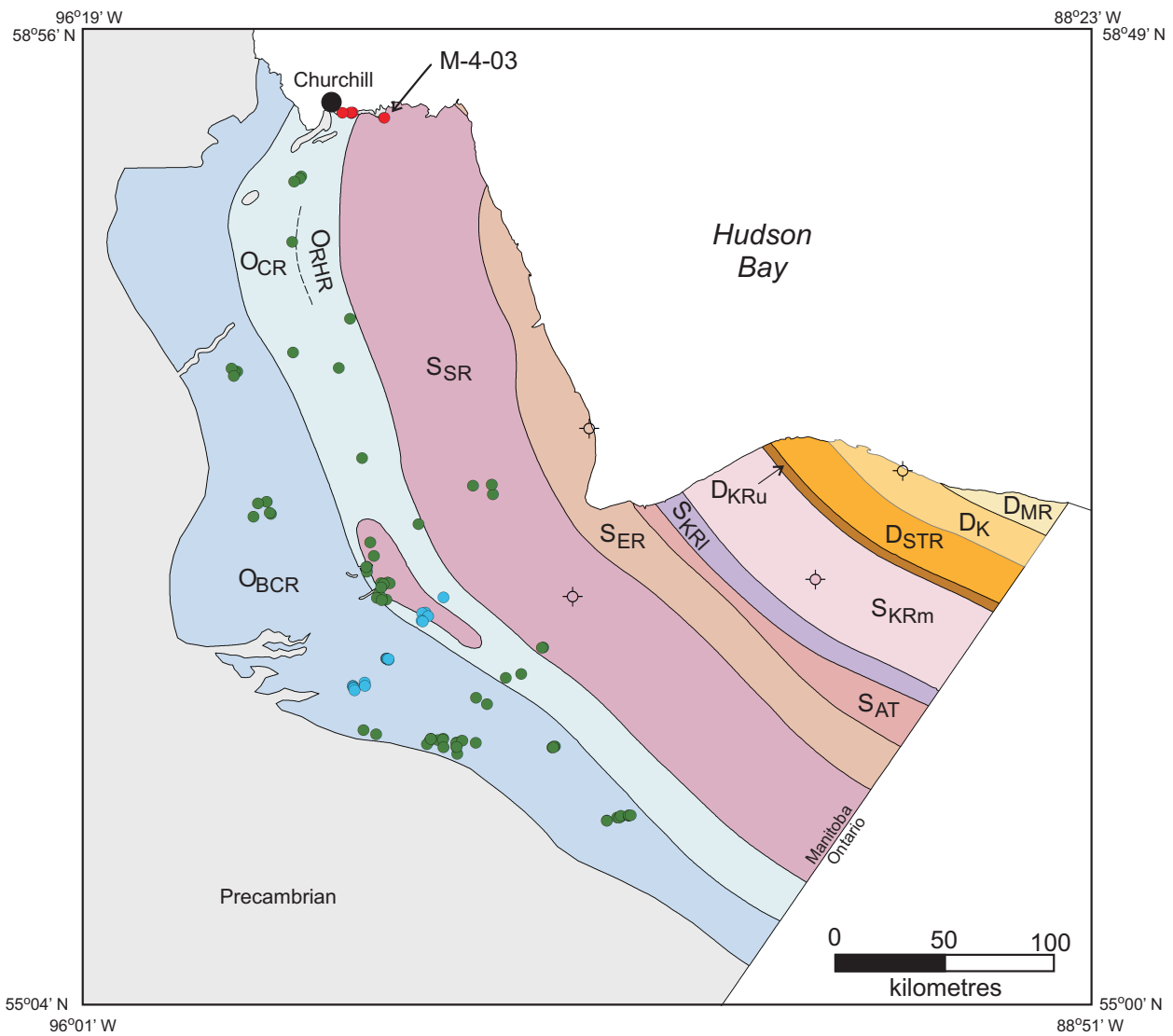
Purpose and analytical procedure

Over the last few decades, a number of exploration (hydrocarbons, base metal) and geotechnical (Manitoba Hydro) wells have been drilled in the Manitoba onshore extension of the Hudson Bay basin. Re-evaluation of these drillholes and cores is necessary because a significant number of exploration targets in nearby intracratonic

basins that are now recognized as world class reservoirs (e.g., hydrothermal dolomite in the Michigan basin; Hurley and Budros, 1990) were previously unknown and their characteristic lithology (sucrosic or saddle dolomite) not described. New samples from Southampton Island (Dietrich et al., 2009), tentative re-examination of core descriptions and new core data suggest that this type of potential reservoir is likely present in the Ordovician and Silurian rocks of the northern part of the Hudson Bay Basin.

Archived core from the HBL is currently being re-examined, and samples will be analyzed by the following methods:

- Polished thin sections will be cut for dolomite petrography to assess the origin and burial evolution of reservoir forming dolomite; these samples will also be analyzed for stable isotopes and fluid inclusions.
- Samples from cuttings and cores of Paleozoic sandstone and Precambrian metamorphic basement rocks will be sent for apatite fission track and (U-Th)/He analysis to reconstruct the burial and exhumation history; the apatites used here will be chemically characterized to better constrain the thermal models.
- Samples from cuttings and cores will be analyzed for vitrinite reflectance to reconstruct the maximum burial temperature and the evolution of geothermal



LEGEND

Devonian		Silurian		Ordovician	
DMR	Moose River Fm	SKRm	Kenogami River Fm (middle)	ORHR	Red Head Rapids Fm
DK	Kwataboahegan Fm	SKRI	Kenogami River Fm (lower)	OCR	Churchill River Gp
DSTR	Stooping River Fm	SAT	Attawapiskat Fm	OBCR	Bad Cache Rapids Gp
DKRu	Kenogami River Fm (upper)	SER	Ekwon River Fm		
		SSR	Severn River Fm		
					petroleum exploration well
				●	stratigraphic test hole
				●	geotechnical borehole
				●	mineral exploration borehole

Figure GS-16-2: Geology of the Hudson Bay Lowland in northeastern Manitoba, showing drillhole sites located on, or near, those areas where Hudson Bay Basin carbonate strata are present.

gradients through time; thin sections of organic matter will be examined under the microscope for reflectance; in addition, any palynomorphs present will provide precise age constraints.

- Samples from cuttings and cores will be sent for Rock-Eval™ analysis to determine their potential for indicating the presence of organic-rich, hydrocarbon source-rock intervals.

Preliminary results from core descriptions

Cores from eight wells were re-logged this summer with particular emphasis on features that would have been

overlooked or not been given much attention during the last round of exploration. Core M-4-03, drilled by the Manitoba Geological Survey in 2003 and preliminarily described in Young et al. (2003), showed interesting features that suggest the presence of hydrothermal dolomite. Megascopic examination of the M-4-03 core showed intervals with dissolution vugs in limestone characterized by the presence of sucrosic dolomite coating walls and late calcite cement (Figure GS-16-3a). Other dissolution vugs in limestone in this same core showed fine sucrosic dolomite filling pore spaces (Figure GS-16-3b), forced replacement of limestone by dolomite (which gives the illusion of the dolomite 'intruding' the limestone; Figure

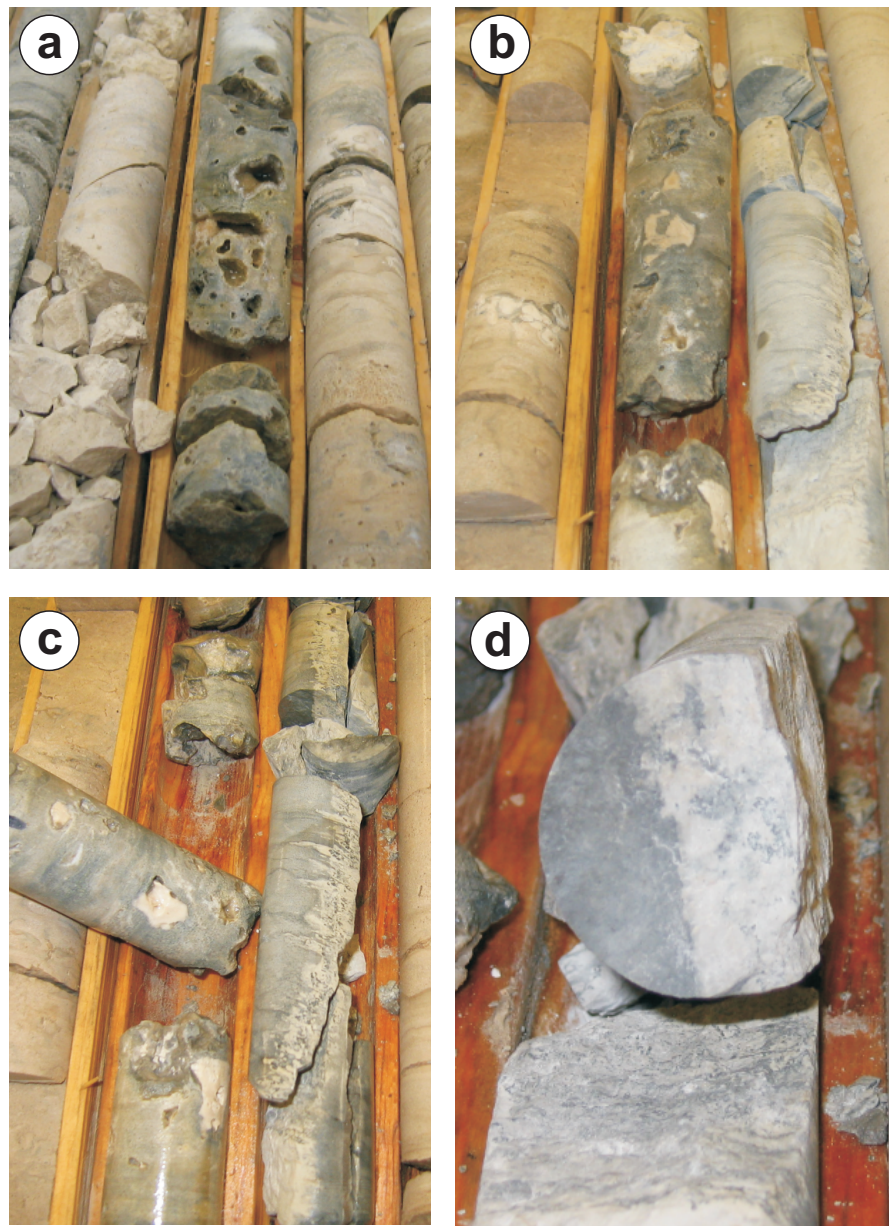


Figure GS-16-3: Photos of core M-4-03: **a)** dissolution vugs in limestone with dolomite coating walls and late calcite cement; **b)** dissolution vugs in limestone with fine sucrosic dolomite filling pore spaces; **c)** forced replacement of limestone by dolomite (dark specks are bitumen droplets in dolomite) and 30 cm long open vertical fracture which controlled dolomitization; **d)** cross-section of controlled dolomitization along fracture wall. Core diameter is 5 cm.

GS-16-3c), dark bitumen droplets (possibly due to forced maturation of local organic matter; Figure GS-16-3c), and extensive vertical fractures (which controlled dolomitization pathways; Figure GS-16-3c and Figure GS-16-3d). All these features have been sampled and will be studied at the microscopic level to determine if they represent hydrothermal dolomite or are the product of some other diagenetic mechanism.

Economic considerations

A better understanding and a modern synthesis of the geoscience and hydrocarbon systems of the Hudson Bay and Foxe basins aims to encourage industry to consider this region for future hydrocarbon exploration. Manitoba's primary advantage lies in the fact that it manages at Churchill the only deepwater port in northern waters; therefore, any exploration activities, resulting hydrocarbon production, development and related infrastructure would provide significant economic growth and stimulus to northern Manitoba.

There has been little modern exploration done in the Hudson Bay Basin and resource estimates are difficult given what little information there is available for such a large area. Although discovery of large hydrocarbon reserves is possible, but not certain (Hamblin, 2008), preliminary resource assessments have been attempted. The most recent estimate by Procter et al. (1984) put undiscovered oil potential at $130 \times 10^6 \text{ m}^3$, and undiscovered gas potential at $90 \times 10^9 \text{ m}^3$ for the area including the Hudson Bay Basin and other small surrounding adjacent basins.

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