Natural Resources Canada   Ressources naturelles Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8378

Stratigraphic synthesis of the Hudson Platform in Manitoba, Ontario, and Nunavut: Ordovician–Silurian

D.K. Armstrong, M.P.B. Nicolas, K.E. Hahn, and D. Lavoie

2018

Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8378

Stratigraphic synthesis of the Hudson Platform in Manitoba, Ontario, and Nunavut: Ordovician–Silurian

D.K. Armstrong[1], M.P.B. Nicolas[2], K.E. Hahn[1], and D. Lavoie[3]

[1] Ontario Geological Survey, 933 Ramsey Lake Road, Sudbury, Ontario P3E 6B5
[2] Manitoba Geological Survey, 360-1395 Ellice Avenue, Winnipeg, Manitoba R2G 3P2
[3] Geological Survey of Canada, 490 de la Couronne, Québec, Quebec G1K 9A9

2018

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018

Information contained in this publication or product may be reproduced, in part or in whole, and by any means, for personal or public non-commercial purposes, without charge or further permission, unless otherwise specified.
You are asked to:
- exercise due diligence in ensuring the accuracy of the materials reproduced;
- indicate the complete title of the materials reproduced, and the name of the author organization; and
- indicate that the reproduction is a copy of an official work that is published by Natural Resources Canada (NRCan) and that the reproduction has not been produced in affiliation with, or with the endorsement of, NRCan.

Commercial reproduction and distribution is prohibited except with written permission from NRCan. For more information, contact NRCan at nrcan.copyrightdroitdauteur.rncan@canada.ca.

Permanent link: https://doi.org/10.4095/308418

This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/).

Recommended citation
Armstrong, D.K., Nicolas, M.P.B., Hahn, K.E., and Lavoie, D., 2018. Stratigraphic synthesis of the Hudson Platform in Manitoba, Ontario, and Nunavut: Ordovician–Silurian; Geological Survey of Canada, Open File 8378, 48 p. https://doi.org/10.4095/308418

Publications in this series have not been edited; they are released as submitted by the author.

TABLE OF CONTENTS

FIGURE LIST

ABSTRACT

The Hudson Bay Basin is the largest intracratonic basin in North America. Together with its smaller satellite basins, Moose River Basin to the south and Foxe Basin to the north, it forms the Hudson Platform. Geological study of this large, marine-dominated, area goes back to the 19th century when explorers started to describe rock units along the shore on many Arctic islands. Modern era geological description, including mostly stratigraphy and paleontology, started in the mid 20th century when numbers of geologists described the rock successions, onshore and offshore, resulting in local stratigraphic nomenclatures and frameworks hardly correlatable from one area to another.

At the start of the initial Hudson Bay-Foxe Basins project and subsequent Hudson Bay-Ungava project of the Geoscience for Energy and Minerals program of the Geological Survey of Canada, one of the major research goals was to propose a unified or at least, a modern understanding of the stratigraphic succession over this large geological domain. This report presents the resulting stratigraphic framework based on 9 years (2008-2017) of new Ordovician to Silurian lithostratigraphic, biostratigraphic and chemostratigraphic, onshore and offshore research and data acquisition over the entire basin. A second report will focus on the aerially more restricted Devonian succession.

The Ordovician to Silurian succession in northeastern Manitoba and northern Ontario, present in the Hudson Bay Lowland and Moose River Basin, is for the first time integrated in a single stratigraphic framework. To the north in the Hudson Bay Basin, Foxe Basin and Hudson Strait, stratigraphic nomenclatures are integrated in one new framework that is now correlated with the successions further to the south. Biostratigraphy and chemostratigraphy were both instrumental in the correlation of distant rock successions.

PREVIOUS WORK

The Hudson Platform represents the largest Phanerozoic sedimentary basin in Canada. It covers 820,000 km^2 (about 6% of the area of Canada), of which 2/3 is covered by water. The Hudson Platform encompasses parts of northeastern Manitoba, northern Ontario and Nunavut (Fig. 1). The Platform contains the large Hudson Bay Basin and the smaller adjacent Moose River and Foxe basins to the south and north, respectively. The Hudson Bay Basin is separated from the Moose River Basin by the Cape Henrietta-Maria Arch whereas the Bell Arch separates Hudson Bay Basin from Foxe Basin; the two arches are broad positive basement-involved structural elements for which the formation mechanism(s) is poorly understood. The Hudson Platform unconformably overlies and is encircled by Precambrian rocks. The basement includes metamorphic and igneous rocks of the PaleoProterozoic Trans-Hudson Orogen, a tectonic suture zone marking the contact between the Superior and Churchill cratons that underlie the southern and northern parts of the Hudson Platform, respectively (Eaton and Darbyshire, 2009).

The Hudson Platform surface area significantly exceeds that of other intracratonic basins (e.g., Michigan, Illinois, Williston basins), but the Hudson Platform is characterized by the thinnest and the shortest-time preserved sedimentary succession of the intracratonic basins of North America (Quinlan, 1987; Pinet et al., 2013). This has been attributed to the stiff lithospheric root and high elastic thickness beneath the basin, which may have existed during its formation (Kaminski and Jaupart, 2000). The Paleozoic succession consists of Early (?) - Middle-Late Ordovician to Late Devonian rocks with a maximum preserved thickness of about 2500 m in Hudson Bay (Pinet et al., 2013). Reports of upper Paleozoic strata (Tillement et al. 1976) have not been supported by subsequent work. Mesozoic to recently documented mid-Tertiary strata (Galloway et al., 2012) locally occur at the top of the succession. The Hudson Platform is the erosional remnant of a more extensive cratonic cover that probably had episodic connection during the Paleozoic (Sanford, 1987) and possibly Mesozoic (White et al., 2000) with platformal areas to the north (Arctic Platform) and south (St. Lawrence Platform, Michigan and Williston basins).

Hudson Bay was discovered by Henry Hudson in 1610 and, given its relatively remote location and lack of known resources, it remained poorly known geographically and geologically well into the 20th century. It remains geologically one of the least studied sedimentary basin in Canada. The onshore extension of the Phanerozoic succession forms the Hudson Bay Lowland and consists of relatively thin succession of nearly flat-lying sedimentary rocks exposed in northeastern Manitoba, northern Ontario and northward, on the southern part of Southampton Island as well as on Coats and Mansel islands in Nunavut. Similarly, the Foxe Basin is a largely marine sedimentary basin with preserved onshore erosional margins expressed as nearly flat-lying strata known on Melville Peninsula, in the northern part of Southampton Island and on southeast and south Baffin Island.

Early explorers in the Hudson Bay area made episodic geological observations starting in the late 1880's (Bell, 1884, 1895; Low 1887; Dowling, 1901; Wilson, 1902; Parks, 1904). The first fairly comprehensive summary of the stratigraphy was by Savage and van Tuyl (1919). Little work was done on Paleozoic strata of the Hudson Platform during the 1920s-1940s. Studies of Paleozoic strata restarted in the 1950s (e.g., Nelson, 1952, 1963; Hogg, 1953; Fritz et al 1957), but it was only in the mid to late 1960s that regional-scale mapping was conducted by GSC officers along major rivers in Manitoba and Ontario (Nelson, 1964, Nelson and Johnson, 1966, Sanford et al., 1968, Heywood and Sanford, 1976; Sanford and Norris, 1973; Cumming 1975). Rocks of Ordovician, Silurian, Devonian, Jurassic/Cretaceous and Cenozoic ages were mapped although the geology is obscured by the very low relief, swampy muskeg terrain that covers the Hudson Bay Lowland. A comprehensive bibliography of the geology of Hudson Bay was published by Verma (1978)

Conversely, the first geological observations for Foxe Basin are those of Parry (1824, 1825) who recognized carbonates and collected fossils. The first significant regional geological coverage of the onshore extension of the Foxe Basin was part of a major GSC mapping operation (Trettin, 1975) that used the Paleozoic stratigraphy defined at the northern end of Baffin Island by Lemon and Blackadar (1963) and Trettin (1969). A recent summary of the geology and paleontology of Foxe Basin was provided by McCracken and Bolton (2000).

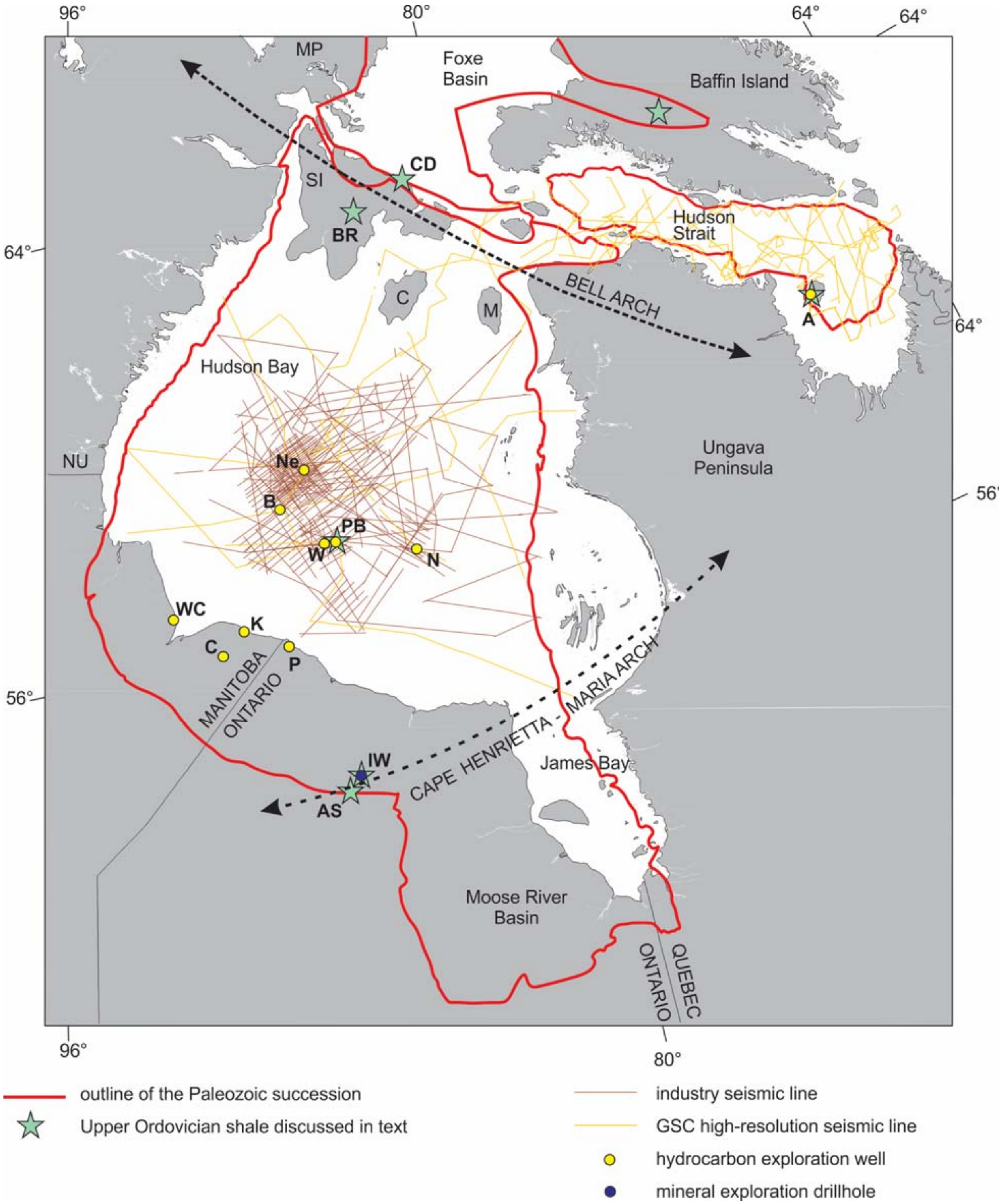

Figure 1. Map of the Hudson Platform showing the extent of the Hudson Bay Basin and adjacent basins. Multichannel industry seismic lines and Geological Survey of Canada (GSC) high-resolution seismic lines are depicted. Hydrocarbon exploration wells: A = Premium Homestead L-26 Akpatok; B = Trillium et al. O-23 Beluga; C = Houston et al. No. 1 Comeault; K = Sogepet Aquitaine No. 1 Kaskattama; N = Aquitaine et al. O-58 Narwhal South; Ne = ICG et al. N-01 Netsiq; P = Aquitaine No. 1 Pen Island; PB = Aquitaine et al. C-11 Polar Bear; W = Aquitaine et al. A-71 Walrus; WC = Merland Exploration No. 1 Whitebear Creek. Base metal exploration well: IW = Inco-Winisk. AR = Asheweig River section; CD = Cape Donovan section; BR = Boas River section; SI = Southampton Island; C = Coats Island; M = Melville

Island.

Industry onshore drilling in the Hudson Bay Basin started in 1966 with the drilling of Kaskattama No. 1 well (Norford, 1970), followed by offshore drilling in Hudson Bay in 1969 shortly after a first marine seismic acquisition program showed that the sedimentary succession preserved in the central part of Hudson Bay is much thicker than its onshore counterpart. From late 1960s to 1990, the energy industry and the Geological Survey of Canada acquired over 46,000 and 40,000 linear-km of deep and shallow seismic, respectively (Fig. 1). Industry seismic acquisition was largely concentrated in the central part of Hudson Bay and resulted in generally low quality seismic lines due to acquisition problems. Based on the seismic information, industry drilled 5 offshore wells from 1969 to 1985 (Fig. 1). For all these offshore wells, local stratigraphic nomenclatures were defined largely based on well cuttings. Industry data (paper copies of seismic lines, digital well logs, cuttings and few cores) were deposited at the National Energy Board for future use. Between 1966 and 1970, industry had drilled 4 onshore wells, three of which were in Manitoba and one in Ontario.

There has been no industry seismic reflection acquisition in the Foxe Basin, some limited GSC high resolution seismic was acquired in the adjacent Hudson Strait. Nonetheless, one exploration well (Rowley M-04 well) was drilled in 1971 on Rowley Island near the northern reach of the Foxe Basin (Trettin, 1975).

RECENT WORK AND DATA USED FOR CORRELATIONS

The synthesis presented in this report (Fig. 2) is based on recent re-evaluation of vintage stratigraphic and well log data and acquisition of new stratigraphic (litho-, bio- and chemostratigraphic) information at strategic locations.

Hudson Bay Lowland - northeastern Manitoba

The Manitoba Geological Survey re-logged all 3 hydrocarbon exploration well cores in the Hudson Bay Lowland as well as 8 mineral exploration, 5 stratigraphic and 17 geotechnical cores (Nicolas and Lavoie, 2010; Nicolas and Armstrong, 2017). In addition, 70 core descriptions from Manitoba's mineral assessment files, in combination with core photos (if available) were reviewed to estimate stratigraphic unit distribution and unit thicknesses. The carbonate units of 3 hydrocarbon and 2 mineral exploration wells, as well as some outcrops, were sampled for carbon stable isotope chemostratigraphy (1225 analyses) and more argillaceous and shaly units were sampled for organic geochemical analysis (36 samples; Nicolas and Lavoie, 2012). Hahn et al. (2016, 2017) conducted infill chemostratigraphic sampling to supplement the previous studies, in addition to new sampling from mineral exploration drill cores and outcrops (including type sections) on the Churchill River. In total Hahn et al. (2016) logged (in some cases re-logged) 14 cores; 3 from Manitoba and 11 from Ontario. In total, over 450 additional samples from cores and outcrops were analyzed for stable

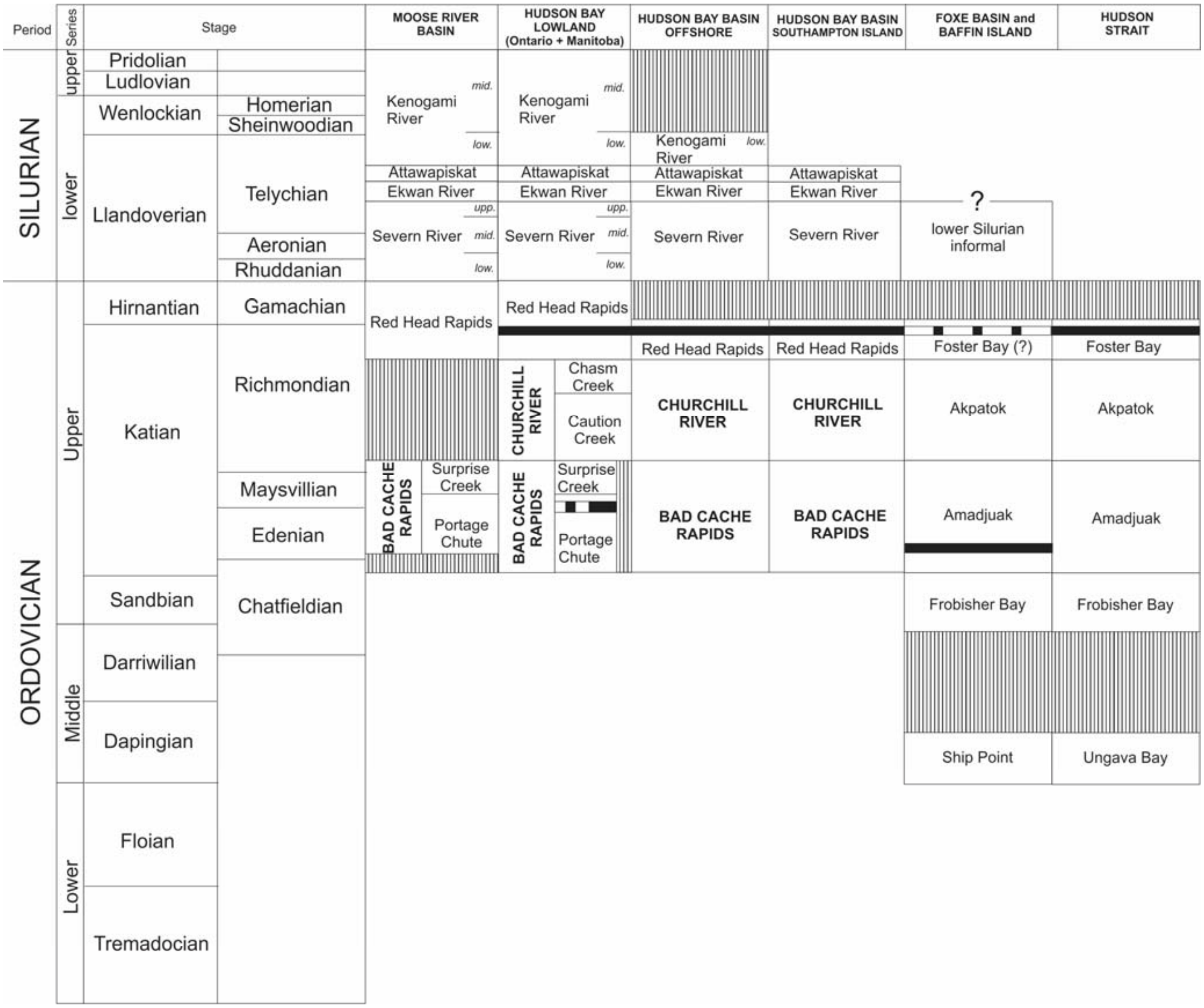

Figure 2: Correlation of the Ordovician – Silurian stratigraphy for 6 main areas in the Hudson Platform. Stratigraphic summary of main units is presented in Annexes 1 to 6. Vertical hatched patterns is for non-deposition or erosion. Solid black boxes indicate stratigraphic position of organic black limy mudstone previously all assigned to the Boas River Formation, see text for details. Horizontal dotted black line indicate stratigraphic position of some Upper Ordovician organic-rich units for which the presence or extension is equivocal. Stratigraphic assignment: **GROUP**, Formation, *member*.

carbon and oxygen isotopes by Hahn et al. (2016).

The type sections of the available stratigraphic units and other outcrops, along the Churchill River and Churchill coastal area were revisited for stratigraphic correlation (Nicolas and Young, 2014; Hahn et al. 2017) with stratigraphic test cores and new biostratigraphic study (16 conodont samples, 31 chitinozoan samples, and 9 palynology samples). As part of this project, research grants were allocated to the University of Manitoba leading to a large number undergraduate theses covering diverse stratigraphic, sedimentological and chemostratigraphic themes. The new works include Wheadon (2011); Wong (2011); Duncan (2012); Lapenskie (2012); Ramdoyal (2012); Pietrus (2013);

Eggie et al. (2014); Demski et al. (2015).

Hudson Bay Lowland and Moose River Basin - northern Ontario

The Ontario Geological Survey carried out a detailed re-evaluation and sampling for carbon isotope chemostratigraphy (477 samples) and biostratigraphy (26 conodont samples and 54 chitinozoan samples) of the sole hydrocarbon exploration well in northwestern Ontario, Aquitaine Sogepet et al. Pen No. 1 (Armstrong et al. 2013). In addition, 68 mineral exploration and stratigraphic test cores were logged in whole or in part from 2010 to 2017, in support of the GSC GEM1 and GEM2 programs (Armstrong and Lavoie 2010; Ratcliffe and Armstrong 2013; Chow and Armstrong 2015; Braun et al. 2016); 13 of these cores were sampled for conodont analysis (42 samples); 11 for chitinozoan analysis (78 samples); 35 for carbon isotope stratigraphy (1646 samples); 18 (including Pen No. 1) for organic geochemical analysis (80 samples); and 20 cores (including Pen No. 1) for major and trace element analysis (646 samples).

Helicopter-supported field work along most of the major rivers in the James and Hudson Bay lowlands led to lithostratigraphic descriptions of previously established type sections of geological units, as well as a large number of additional outcrops (Armstrong 2011, 2014, 2015; Ratcliffe and Armstrong 2013). A total of 139 outcrops were examined in detail during field seasons from 2011 to 2015; 41 outcrops were sampled for conodont analysis (52 samples); 1 for chitinozoan analysis (6 samples); 107 for carbon isotope stratigraphy (354 samples); 10 for organic geochemical analysis (29 samples); and 15 outcrops for major and trace element analysis (49 samples). As part of this project, research grant agreements were defined and allocated to universities of Ottawa, Laurentian and Manitoba for undergraduate (B.Sc.) and post-doctoral research (St. Jean 2012; Bibby 2013; Braun 2016; Braun et al. 2016; Hahn et al. 2016). The list of new contributions is found in the reference list.

Central offshore Hudson Bay

The Geological Survey of Canada (GSC) and the Canada-Nunavut Geoscience Office (C-NGO) carried out a detailed re-evaluation of the material available from the 5 historical hydrocarbon exploration wells. Access to the data was made possible through the National Energy Board. Well logs and cutting descriptions were used to reconstruct the stratigraphy in each well using the framework proposed by Zhang and Barnes (2007) following Norris (1993). A re-evaluation of the conodont data was made as well as extensive sampling for chitinozoans (75 samples) that led to a refined biostratigraphic framework. The summary of the stratigraphic framework is found in Hu et al (2011). Given the almost total lack of significant cores, no attempt was made to define the carbon isotope chemostratigraphy as cuttings were sampled over too wide intervals in order to hope for any rigorous resolution.

Northern Hudson Bay – Southampton Island

The C-NGO carried out detailed field stratigraphic survey on the Ordovician succession from 2007 to 2011. Detailed outcrop description as well as extensive sampling for conodont biostratigraphy (269 samples; Zhang 2008, 2011) have resulted in the refinement of the previous stratigraphy of Norris

(1993). 69 samples from the island were submitted for Rock Eval analysis. No detailed new observation and work was carried out on the Silurian succession on Southampton Island, and the stratigraphy used is that of Norris (1993). The list of these new contributions is found in the reference list.

Foxe Basin – Baffin Island, Rowley Island and Melville Peninsula

As part of the GEM program, the C-NGO carried out field work on Melville Peninsula and on south Baffin Island. The work consisted in detailed lithostratigraphic description and sampling for conodont biostratigraphy of the outcropping Ordovician succession (123 and 130 samples from Melville Peninsula and Baffin Island, respectively; Zhang 2012, 2013). 46 new samples for Rock Eval analyses were collected from Baffin Island. Partial re-logging of the Rowley M-04 well was made in order to evaluate the potential stratigraphic assignment of the Silurian interval in the well only designed as the "lower Silurian interval" in Trettin (1975). The list of the new Ordovician contributions is found in the reference list.

Hudson Strait – Akpatok Island

A detailed field campaign on Akpatok Island was carried out jointly by the GSC and the C-NGO, the work was directed at the Ordovician carbonate succession on the island through a description of the lithologic succession and sampling for conodont biostratigraphy (90 samples; Zhang and Mate 2015; Zhang 2018). Samples for Rock Eval analyses were collected from field (5 samples) and the Homestead L-26 Akpatok well (41 samples). The latter well drilled on the island was not studied in any more detail and the stratigraphic description of the basal two formations (Frobisher Bay and Ungava Bay) are taken from Workum et al (1976) and Sanford and Grant (2000). The list of the new Ordovician contributions is found in the reference list.

STRATIGRAPHIC FRAMEWORK

Figure 2 presents the current stratigraphic framework for the Ordovician to Silurian over the entire study area. Cambrian sediments are present in the northern part of the Foxe Basin (Trettin, 1975) but were not studied during the GEM program and are not discussed herein. Devonian and younger sediments will be the focus of a separate report. Annexes 1 to 6 present the summary of the stratigraphic units for 6 distinct geographic areas. These annexes include, for each stratigraphic unit, a brief description of the dominant lithologies as well as important secondary lithologies and some diagnostic elements. All this information as well as the proposed age range of the units are derived from the main references indicated in the annexes. Some contentious correlations or characterization of units are described below.

The Ordovician black shales – the issue with the original Boas River Formation

The term "Boas River" was introduced by Heywood and Sanford (1976) for an Upper Ordovician organic matter rich, carbonate-rich mudstone unit on Southampton Island. A 2–2.5 m thick succession is found along the Boas River and despite the lack of underlying and overlying units at that specific locality, the unit was assumed to be present between the Bad Cache Rapids and Churchill River groups. This informal unit was later given formation status and its presence reported on Baffin Island, Akpatok Island and in northern Ontario (Sanford and Grant, 1990, 1998, 2000). Nelson and Johnson (1966) reported the presence of thin and platy petroliferous interbeds within the lower carbonate beds of the Red Head Rapids Formation along Sixteen Mile Brook on Southampton Island. Although not observed by Heywood and Sanford (1976), the Sixteen Mile Brook organic-rich beds were sampled and reported on by McCracken and Nowlan (1989), Dewing and Copper (1990) and Zhang (2011).

Based on extensive field observations and conodont studies at the above-cited localities and at Cape Donovan, a new locality on the north shore of Southampton Island exposing three intervals of thin fissile, black shaly lime mudstone beds in the Red Head Rapids Formation, Zhang (2008) reassigned all organic rich intervals on Southampton Island to the Richmondian Red Head Rapids Formation (Fig. 2). The Richmondian organic-rich beds are proposed to be present on Akpatok Island in the Foster Bay Formation (Zhang 2018), however, organic rich limy mudstones on southern Baffin Island assigned to the Boas River Formation by Sanford and Grant (2000) are characterized by Edenian conodonts (McCracken 2000) and included in the lower part of the Amadjuak Formation by Zhang (2012), a stratigraphic equivalent to the Portage Chute Formation (Bad Cache Rapids Group) (Fig. 2). The presence of two black organic-rich limy mudstone intervals (a lower Edenian-Maysvillian and an upper Richmondian) in the Hudson Platform has recently been confirmed by new graptolite data (Zhang and Riva, 2018).

In northern Ontario, a 10 m interval of shaly lime mudstone assigned to the Boas River Formation (Sanford and Grant, 1990) was described from two mineral exploration cores (INCO-Winisk #49212 and #49204). The conodont fauna suggests a dominant middle Maysvillian age with potential extension down into the mid-Edenian and up to lower Richmondian (McCracken, 1990). The Boas River Formation was then assumed to be, like on Southampton Island (Heywood and Sanford 1976), present between the Bad Cache Rapids and the Churchill River groups. A recent re-examination of the encasing lithologies suggests that the black lime mudstone interval is instead near the stratigraphic top of the Portage Chute Formation (Fig. 2; Hahn et al. 2016).

An outcrop section of fissile organic-rich lime mudstone was also recently described on the Asheweig River by Armstrong (2011) and was the subject of a B.Sc. thesis (St-Jean, 2012). The 4 m succession is located about 50 km south of the INCO-Winisk wells. The outcrop appears lithologically similar to the upper few meters of the Boas River Formation in the core intervals and includes an immediately overlying crinoidal packstone to grainstone that had, by analogy to the core (Armstrong and Lavoie 2010), previously been interpreted as basal Churchill River Group (Armstrong 2011). Hahn et al. (2016), however, noted lithologic similarities of this overlying strata in both core and outcrop, to the Portage Chute Formation, and suggested that strata assigned to the Boas River Formation in Ontario are part of the upper Portage Chute Formation. However, conodonts reported from the Asheweig River exposure (McCracken, pers. comm. 2018) suggest that it is Richmondian. Furthermore, the occurrence of the conodont *Rhipidognathus symmetricus* in this outcrop (McCracken, pers. comm. 2018) suggests it is Late Ordovician and should be assigned to the Red Head Rapids Formation (Zhang 2011).

Thus there appear to be two organic-rich shaly lime mudstones in northern Ontario: one (in INCO-Winisk cores) of mid-Maysvillian to early Richmondian age and another (in the Asheweig River outcrop) that, based on occurrence of *R. symmetricus*, is late Richmondian in age and assignable to the Red Head Rapids Formation (see Fig. 2).

Zhang and Riva (2018), proposed to designate all the Upper Ordovician organic-rich shaly mudstones in the Hudson Platform as specific informal facies, either within the Richmondian interval (Red Head Rapids and Foster Bay formations) or within the Edenian-Maysvillian-Richmondian? interval (Portage Chute and Amadjuak formations) (Fig. 2).

Ordovician units of the Churchill coastal area

Nicolas and Young (2014) noted that the Upper Ordovician and Lower Silurian units in the Churchill coastal region differ from those anywhere else in the Hudson Bay Lowland. This is interpreted to be caused by paleotopography that dominated and controlled deposition in this area where depositional environments were distinctly nearshore (see also Johnson and Baarli, 1987; Johnson et al., 1988). Sitting directly on the Proterozoic Churchill quartzite, the succession begins with the Upper Ordovician Churchill River Group, up through the Red Head Rapids Formation to the Lower Silurian Severn River Formation. The Bad Cache Rapids Group is not present in this area due to a broad embayment in a ridge of Proterozoic Churchill quartzite, where this ridge formed a string of islands during the Ordovician (Nelson and Johnson, 2002). This resulted in distinct microenvironments to form around the paleoarchipelago and paleotopography, therefore delaying the start of marine deposition up to facies correlative with Churchill River Group. Differences in lithology include the presence of sandstone-rich beds at the base of the Churchill River Group where in other parts of the basin sandstones have been restricted to the base of the older Bad Cache Rapids Group (e.g. Airport cove in Nicolas and Young, 2014); paleoshorelines with cephalopod-rich, thick quartz sandstone beds (e.g. Seahorse Gully in Nicolas and Young, 2014); and a rocky shoreline of Paleoproterozoic quartzite boulders with Churchill River Group dolostones deposited over, against and infilling between boulders (Nicolas and Young, 2014). Such differences suggest that definition of local stratigraphic members in the Churchill area may help to differentiate and understand them. Alternatively, it just may be worth noting that the occurrence of these local lithological differences and missing stratigraphic units can occur locally anywhere in the basin where significant paleotopography is present.

Correlating Ordovician stratigraphy from Manitoba to Ontario

Researchers (Nicolas and Lavoie, 2010, 2012; Nicolas and Young, 2014; Nicolas and Armstrong, 2017; Hahn et al. 2017) have successfully correlated the Ordovician units (Fig 2; Annex 1) from their type sections in the Churchill area into the subsurface of northeastern Manitoba, utilizing petroleum exploration well logs and cores and mineral exploration cores. This lithostratigraphy correlates well with the Ordovician stratigraphy of the deep well, Pen No. 1 in the extreme northwest corner of Ontario (Nicolas and Armstrong 2017; Hahn et al. 2017; Armstrong et. al. 2013). Sparse data sources (few cores or wells and lack of outcrop) and thinning of the Paleozoic succession complicates correlation of stratigraphy to the east and south in Ontario, towards the Cape Henriette-Maria Arch and into the Moose River Basin. Despite this, the lithostratigraphic succession of units remains relatively consistent to at least the INCO-Winisk cores near the Cape Henrietta-Maria Arch (Hahn et al. 2016; Fig. 1).

In the Moose River Basin, the Ordovician succession consists of, in ascending order, the Portage Chute and Surprise Creek formations of the Bad Cache Rapids Group and the Red Head Rapids Formation (Hahn et al. 2016). The lithological association of these units is similar to homonym units in the Hudson Bay Basin (Annexes 3 and 4). There does not appear to be any strata in the Moose River Basin with lithologic characteristics of the Caution Creek and Chasm Creek formations of the Churchill River Group. This is contrary to previous mapping (e.g., Sanford and Grant 1998) which shows the Churchill River Group extending well into the Moose River Basin. Also, Jin et al. (1997) reported Churchill River Group brachiopod fauna from outcrops mapped as Bad Cache Rapids Group in this project. Conodonts are equivocal, as all sub-Red Head Rapids Formation samples in the Moose River Basin analyzed for this project indicate age ranges from mid-Edenian to Richmondian (McCracken pers. comm. 2014, 2018; McCracken 2017a-d). Chitinozoan analyses for the same stratigraphy indicate age ranges from Edenian to Maysvillian for these strata (Asselin pers. comm. 2013).

Carbon isotope chemostratigraphic correlation was applied to the Ordovician in the Hudson Platform in Ontario to help resolve the apparent lack of Churchill River Group strata in the Moose River Basin (Turner and Armstrong 2015). Isotopic profiles of representative cores from the Hudson Bay Basin (Pen No. 1) and Moose River Basin (KWG-Spider DR-94-19) were compared to the Ordovician global composite curve (Saltzman and Thomas 2012). Most elements (e.g., excursions) of the global curve were identified in both profiles, although the profile segment that corresponds to the Churchill River Group in Pen No. 1 is absent in the Moose River Basin profile. Turner and Armstrong (2015) proposed that this strata was for the most part not deposited in the Moose River Basin due to differential subsidence possibly related to far-field tectonic effects of the Taconic Orogeny. They suggest that the Cape Henrietta Maria Arch may have represented a structural buttress that limited the effects of far-field tectonics to the Moose River Basin.

Chemostratigraphic correlations were also extended into northern Manitoba (Hahn et. al. 2017). While east-west correlations (among basinward cores with thicker more preserved stratigraphy) appeared valid, north-south correlations towards the basin margin locations and into the Moose River Basin (via mineral exploration cores) appeared more tenuous. Hahn et al. (2017) identified carbon isotopic excursions, defined in the North American composite curve (Bergstrom et al. 2015), in basinward wells such as Pen No. 1, and tentatively correlated most of them to similar excursions in isotopic profiles from Moose River Basin wells. These appear to support preliminary conclusions of Turner and Armstrong (2015), however further work is required to resolve chemostratigraphic profile and lithostratigraphic correlations within the available biostratigraphic framework, and within the constraints of reasonable depositional environment relationships.

The Ordovician–Silurian boundary

There is no known or unequivocal lithologic evidence of a significant unconformity associated with the Ordovician-Silurian boundary in the core intervals from Manitoba and Ontario. On Southampton

Island, a thick succession of unsorted coarse conglomerate is seen at one locality (Cape Donovan area; Fig. 1) deeply cutting through planar lime mudstones of the Red Head Rapids Formation; the conglomerate is overlain by the typical limestones of the Severn River Formation (Zhang, 2010). In a detailed conodont study of wells in Hudson Bay, Zhang and Barnes (2007) concluded to the absence of the Gamachian (Hirnantian), inferring a significant disconformity is present at the Ordovician–Silurian boundary.

The Late Ordovician Hirnantian Isotope Carbon Excursion (HICE) is recognized in wells and cores from the Hudson Bay Basin of northern Manitoba (Demski et al. 2015; Nicolas, 2016) and Ontario (Armstrong et al. 2013) and into the Moose River Basin in Ontario (Turner and Armstrong 2015; Hahn et al. 2016). The Ordovician–Silurian boundary is commonly assumed to be at the $\delta^{13}C$ negative spike above the HICE, possibly related to a disconformity (e.g., Demski et al. 2015). Within the upper part of the Red Head Rapids Formation in the Moose River Basin, Silurian or Silurian "aspect" conodonts are found beneath this negative spike and above or within HICE (McCracken 2017a, 2017c; McCracken et al. 2013). This supports the Hirnantian age determination, as mixed Ordovician-Silurian conodont faunas have been reported from this time-slice (Melchin et al. 1991; Demski et al. 2015).

The Silurian Severn River Formation

The Lower Silurian Severn River Formation is the thickest formation in the southern Hudson Platform; it is 236 m thick in Pen No. 1 (Nicolas and Armstrong, 2017). The dominant lithologic characteristic of this formation is *Thalassinoides*-like burrow-mottling, similar to the Upper Ordovician Portage Chute Formation, Bad Cache Rapids Group. Based on lithologic and faunal characteristics this formation has been divided into 3 informal members, lower, middle and upper (LeFèvre et al., 1976; Norris, 1993; Armstrong et al. 2013; Nicolas and Armstrong 2017). The lower member is characterized by locally abundant large *Virgiana decussata* brachiopods in coral and stromatoporoid bearing packstones and grainstones, indicating an energetic shallow subtidal environment. The middle member is characterized by cyclic deposition of dolomitic, burrow-mottled wackestone, intraclastic packstone, dolomudstone, anhydrite, and green, argillaceous dolomudstone to siltstone, indicating very shallow subtidal to intertidal environments. The upper member is dominated by burrow-mottled, bio-wackestones, with thin bio- to intraclastic packstones and grainstones, indicating a return to energetic shallow subtidal conditions. Cyclic sedimentation continues in the upper member, with cycles sometimes capped with greenish, argillaceous dolosiltite, and only rarely containing evaporites.

The three-fold subdivision of the Severn River Formation is readily identified in both core and outcrop in both the southern Hudson Bay Basin (Armstrong et al. 2013; Nicolas and Armstrong 2017) and Moose River Basin (Ratcliffe and Armstrong 2013). Conodont biostratigraphy of Pen No. 1 core indicates the lower, middle and upper members are respectively, approximately Rhuddanian, Aeronian and early Telychian in age (Armstrong et al. 2013). This is consistent with conodont biostratigraphy and carbon isotope stratigraphy of a core in the Moose River Basin studied by Bancroft et al. (2015), after applying the correct lithostratigraphy (*as per* Ratcliffe and Armstrong 2013).

The upper contact of the Severn River Formation with the overlying Ekwan River Formation appears disconformable in outcrop (e.g., Armstrong 2011, 2015), although it is sometimes difficult to identify in cores (Armstrong et al. 2013; Ratcliffe and Armstrong 2013). The contact is marked by a slight negative shift in $\delta^{13}C$ baseline from the Ekwan into Severn River formations, and a distinct negative excursion, up to 6 per mil, below the contact (Nicolas and Armstrong 2017).

The Silurian Ekwan–Attawapiskat pair

The distinction between the lower Silurian (Telychian) Ekwan and Attawapiskat formations is equivocal, as both units have bioclastic packstone and grainstone as a major facies (Armstrong, 2015; Nicolas and Armstrong, 2017). In fact, the assignation of a succession to the Attawapiskat Formation is primarily based on the presence of meter- to decameter-sized stromatoporoid-coral-algal boundstone (Savage and van Tuyl, 1919; Nelson and Johnson, 1966). These structures are flanked by the detrital bioclastic packstone and grainstone, the dominant facies of the Ekwan River Formation. Moreover, locally, metazoan biostromes are developed in the upper Ekwan River Formation. In both Hudson Bay and Moose River basin successions of Ontario, a green shale interval has been mapped or found in cores and electric logs (gamma ray spike) within the Ekwan River Formation (Armstrong et al. 2013; Ratcliffe and Armstrong 2013; Armstrong 2015). This interval is roughly coincident with a broad negative peak in the $\delta^{13}C$ profile (Nicolas and Armstrong 2017) and, where identified, is used to assign that specific interval to the Ekwan River Formation. This green shaly interval has not yet been identified in Manitoba, possibly due to poor core recovery through this stratigraphy; an elevated gamma ray response in the Kaskattama well at this approximate stratigraphic level is coincident with an interval of missing core (Nicolas and Armstrong 2017). In the absence of metazoan boundstones, the distinction between the Ekwan River and the Attawapiskat formations should always be questioned as both units could be laterally and time equivalent.

The Kenogami River Formation

In northern Ontario and northeastern Manitoba, the Kenogami River Formation has been divided in three informal members, i) a lower member that includes evaporites and dolomudstones indicating deposition in a highly restricted environment, ii) a middle member characterized by red and green siliciclastic mudstones, siltstones and sandstones that may be have deposited in a terrestrial environment, and iii) an upper member characterized by dolomudstones (Sanford et al. 1968). Laminated dolostones overlying bioherm-like mounds on the Severn River (Armstrong 2011), may represent the lower Kenogami River Formation. In the Moose River Basin, argillaceous, evaporitic dolomudstones of the lower member are exposed in outcrops on the Albany, Drowning, and Kenogami rivers (Armstrong 2014). Near the southern margin of the Moose River Basin, on the Nagagami and Kabinakagami rivers, the lower member is characterized by laminated dolomudstones (Ratcliffe and Armstrong 2013).

Conodont data from the lower member in the Moose River Basin suggest a lower Silurian (Telychian) age (McCracken 2017a, 2017d), while no conodonts or chitinozoa have been recovered from the middle and upper members. The upper member yielded Lower Devonian (Lochkovian to Pragian) spores (McGregor et al. 1970; McGregor and Camfield 1976) suggesting that the Silurian–Devonian boundary might equivocally lie in the middle member. This last interpretation is supported by stable isotopic profiles through Devonian intervals in a number of cores in the southern Moose Basin (Chow and Armstrong 2015; Braun et al. 2016); those results suggest that the Lower Devonian (Lochkovian to Pragian) Klonk isotopic ($\delta^{13}C$) event is preserved in the upper member of the Kenogami River Formation. In central Hudson Bay, the Kenogami River Formation consists of 2 lithological assemblages separated by an interpreted local significant unconformity (Hu et al., 2011). The lower assemblage consists of limestone and minor dolomite and dolomitic sandstone. Zhang and Barnes (2007) only found Llandoverian conodonts in the lower assemblage of the Kenogami River Formation. Based on chitinozoan data, the Silurian – Devonian boundary has been placed in that lower unit (Hu et al., 2011). The upper assemblage, for which a Middle Devonian age has been suggested (Robertson Research Canadian ltd. 1986; Uyeno, 1989) is primarily made up of evaporites with minor shales and dolomudstone.

ACKNOWLEDGEMENTS

All the authors acknowledge the major involvement of Dr. Shunxin Zhang of the Canada-Nunavut Geoscience Office in Iqaluit for her tireless work and scientific contributions for our understanding of the stratigraphy of the Hudson Bay platform. This synthesis relies heavily on her multiple contributions. Thanks are also expressed to all technical staff from our respective organizations that diligently and professionally prepared and analysed the very diversified samples of that project. Thanks to the many students that were efficient field assistants and those that successfully completed B.Sc. honors and M.Sc. theses on specific themes of the project. Finally, our deep gratitude to Dr. Keith Dewing who kindly accepted to take time to review this contribution resulting in a much better end-product.

REFERENCES

Armstrong, D.K. 2011. Re-evaluating the hydrocarbon resource potential of the Hudson Platform: Interim results from northern Ontario; in Summary of Field Work and Other Activities 2011, Ontario Geological Survey, Open File Report 6270: 27-1 to 27-11.

Armstrong, D.K. 2014. Hudson Platform Project: Aggregate sampling and Paleozoic geology of the Moose River Basin, northern Ontario; in Summary of Field Work and Other Activities 2014, Ontario Geological Survey, Open File Report 6300: 30-1 to 30-10.

Armstrong, D.K. 2015. Hudson Platform Project: Paleozoic geology of the McFaulds Lake, South Moosonee, Ekwan River and Attawapiskat River areas, James Bay Lowland; in Summary of Field Work and Other Activities, 2015, Ontario Geological Survey, Open File Report 6313: 31-1 to 31-20.

Armstrong, D.K. and Lavoie, D. 2010. Re-evaluating the hydrocarbon resource potential of the Hudson Platform: Project introduction and preliminary results from northern Ontario; in Summary of Field Work and Other Activities 2010, Ontario Geological Survey, Open File Report 6260: 39-1 to 39-9.

Armstrong, D.K., McCracken, A.D., Asselin, E., and Brunton, F.R. 2013. The Hudson Platform Project: Stratigraphy of the Aquitaine Pen No. 1 core; in Summary of Field Work and Other Activities 2013, Ontario Geological Survey, Open File Report 6290: 34-1 to 34-21.

Bancroft, A.M., Brunton, F.R., and Kleffner, M.A. 2015: Silurian conodont biostratigraphy and carbon (δ13Ccarb) isotope stratigraphy of the Victor Mine (V-03-270-AH) core in the Moose River Basin. Canadian Journal of Earth Sciences, v. 52: 1169-1181.

Bibby, C.L. 2013. Sedimentology of the Upper Ordovician carbonate succession, Hudson Bay Platform, Northern Ontario; unpublished BSc thesis, University of Ottawa, Ottawa, Ontario, 45p.

Braun, M. 2016. Stratigraphy and lithofacies analysis of the Devonian Kwataboahegan Formation in the Moose River Basin, James Bay Lowlands, northern Ontario; unpublished BSc thesis, University of Manitoba, Winnipeg, Manitoba, 109p., plus Appendices A, B and C.

Braun, M., Armstrong, D.K., Chow, N., and Gouwy, S.A. 2016. Preliminary lithostratigraphy, chemostratigraphy and lithofacies analysis of the Devonian succession, Moose River Basin, northern Ontario; in Summary of Field Work and Other Activities, 2016, Ontario Geological Survey, Open File Report 6323: 27-1 to 27-13.

Chow, N., and Armstrong, D.K. 2015. Preliminary lithostratigraphy and chemostratigraphy of the Devonian Kwataboahegan Formation, Moose River Basin, northern Ontario: in Summary of Field Work and Other Activities, 2015, Ontario Geological Survey, Open File Report 6313: 33-1 to 33-12.

Cumming, L.M. 1975. Ordovician strata of the Hudson Bay Lowlands; Geological Survey of Canada, Paper 74-28, 93p.

Demski, M. W., Wheadon, B., Stewart, L. A., Elias, R. J., Young, G. A., Nowlan, G. S. and Dobrzanski, E. 2015. Hirnantian strata identified in major intracratonic basins of central North America: implications for uppermost Ordovician stratigraphy; Canadian Journal of Earth Sciences, v. 52: 68-76.

Dewing, K., and Copper, P. 1990. Upper Ordovician stratigraphy of Southampton Island, Northwest Territories;

Canadian Journal of Earth Sciences, 28: 283-291.

Dowling, D.B.., 1901. The west side of James Bay; Geological Survey of Canada, Summary Report IX, p. 109-117.

Duncan, B. J. 2012. Stratigraphy and facies analysis of uppermost Ordovician to lowermost Silurian strata in the Whitebear core, Hudson Bay Basin, northern Manitoba; University of Manitoba, Department of Geological Sciences, B.Sc. Thesis, 192 p.

Dyer, W.S. 1929. Limestones of the Moose River and Albany River basin; Ontario Department of Mines, Vol. XXXVIII, pt. 4, p. 31-33.

Eaton, D. W., and Darbyshire, F. 2010. Lithospheric architecture and tectonic evolution of the Hudson Bay region; Tectonophysics, v. 480: 1–22, doi:10.1016/j.tecto.2009.09.006

Eggie, L. A., Pietrus, E., Ramdoyal, A., and Chow, N. 2014. Diagenesis of the Lower Silurian Ekwan River and Attawapiskat formations, Hudson Bay Lowland, northern Manitoba (parts of NTS 54B, F, G); *in* Report of Activities 2014, Manitoba Mineral Resources, Manitoba Geological Survey, p. 161-171.

Fritz, M.A., Lemon, R.R.H., and Norris, A.W. 1957. Stratigraphy and palaeontology of the Williams Island Formation; Proceedings of the Geological Association of Canada, v. 9: 21-47.

Galloway, J. M., Armstrong, D. A., and Lavoie, D. 2012. Palynology of the INCO-Winisk #49204 core (54°18′30″N, 87°02′30″W, NTS 43L/6); Geological Survey of Canada, Open File 7065, 51 p., doi:10.4095/290985.

Hahn, K. E., Armstrong, D. K., Turner, E. C., and Nicolas, M. P. B. 2016. Toward a sequence stratigraphic framework for the Ordovician Hudson Bay and Moose River basins, northern Ontario; *in* Summary of Field Work and Other Activities 2016; Ontario Geological Survey, Open File Report 6323: 28-1 to 28-10.

Hahn, K. E., Turner, E. C., Armstrong, D. K., and Nicolas, M. P. B. 2017. Late Ordovician chemostratigraphy of the Hudson Bay and Moose River basin; *in* Program with abstracts, Geological Association of Canada-Mineralogical Association of Canada Annual meeting; Kingston, Ontario, May 14-17, poster presentation.

Heywood, W.W.; and Sanford, B.V. 1976. Geology of Southampton, Coats, and Mansel islands, District of Keewatin, Northwest Territories; Geological Survey of Canada, Memoir 382, 35p.

Hogg, N., Satterly, J. and Wilson, A.E. 1953. Drilling in the James Bay Lowland: Part 1 - Drilling by the Ontario Deprtment of Mines; Ontario Department of Mines, Annual Report 1952, Vol. LXI, Part 6, p. 115-140.

Hu, K., Dietrich, J., Dewing, K., Zhang, S., Asselin, E., Pinet, N., and Lavoie, D. 2011. Stratigraphic correlations for five offshore wells in the Hudson Bay basin, northern Canada; Geological Survey of Canada, Open File 7031.

Jin, J., Caldwell, W.G.E., and Norford, B.S. 1997. Late Ordovician brachiopods and biostratigraphy of the Hudson Bay Lowlands, northern Manitoba and Ontario; Geological Survey of Canada, Bulletin 513, 115p.

Jin, J., and Rudkin, D. 2003. Early Silurian microbial mounds of the Severn River Formation, Hudons Bay Lowlands, Ontario. Canadian Paleontological Conference – 2003; University of Alberta, Edmonton, Alberta, Sept, 19-20, 2003.

Johnson, M.E., and Baarli, B.G., 1987. Encrusting corals on a latest Ordovician to earliest Silurian rocky shore, southwest Hudson Bay, Manitoba, Canada. Geology, v. 15, P. 15-17.

Johnson, M.E., Skinner, D.F., and MacLeod, K.G., 1988. Ecological zonation during the carbonate transgression of a late Ordovician rocky shore (Northeastern Manitoba, Hudson Bay, Canada). Palaeogeography, Palaeoclimatology, Palaeoecology, v. 65, p. 93-114.

Lapenskie, K. 2012. Depositional and faunal changes in the Upper Ordovician to Lower Silurian of core M-4-03, from hear Churchill, Manitoba; University of Manitoba, Department of Geological Sciences, B.Sc. Thesis, 211 p.

Lavoie, D., Pinet, N., Dietrich, J., Zhang, S., Hu, K., Asselin, E., Chen, Z., Bertrand, R., Galloway, J., Decker, V., Budkewitsch, P., Armstrong, D., Nicolas, M., Reyes, J., Kohn, B.P., Duchesne, M.J., Brake, V., Keating, P., Craven, J. and Roberts, B. 2013. Geological framework, basin evolution, hydrocarbon system data and conceptual hydrocarbon plays for the Hudson Bay and Foxe basins, Canadian Arctic; Geological Survey of Canada, Open File 7363, 210p.

LeFèvre, J.A., Barnes, C.R., and Tixier, M. 1976. Paleoecology of Late Ordovician and Early Silurian conodontophorids, Hudson Bay Basin; in Conodont Paleoecology, C.R. Barnes (ed.), Geological Association of Canada, Special Paper no. 15: 69–89.

Lemon, R.R.H., and Blackadar, R.G. 1963. Admirality Inlet area, Baffin Island, District of Franklin; Geological Survey of Canada, Memoir 328, 84 p.

Low, A.P. 1887. Exploration of country between Lake Winnepeg and Hudson Bay; Geological Survey of Canada Annual Report, new series 2, p. 18F

McCracken, A.D. 1990. Report On 38 Conodont Samples From Drill Core Of The Bad Cache Rapids Formation, Boas River Formation, And Churchill River Group In The Hudson Bay Lowlands (Clendenning River Map Sheet, Winisk River Area), Northern Ontario. Submitted By B.V. Sanford And A.C. Grant (GSC-AGC) (NTS 43L/6, 43L/12); Geological Survey of Canada, Paleontological Report 03-ADM-1990, 25 p.

McCracken, A.D. 2000: Middle and Late Ordovician conodonts from the Foxe Lowland of southern Baffin Island, Nunavut. In Geology and paleontology of the southeast Arctic Platform and southern Baffin Island, Nunavut. McCracken, A.D. and Bolton, T.E. (ed.). Geological Survey of Canada, Bulletin 557: 159-215.

McCracken, A.D. 2017a. Report on nine Silurian conodont samples from the Red Head Rapids, Severn River, Ekwan River and Kenogami River formations, northern Ontario, collected and submitted in 2014 by D.K. Armstrong, (Ontario Geological Survey) as part of GEM-2 Hudson-Ungava Program (D. Lavoie). NTS 42J/03, 42K/01, 42N/07, 43G/11. Con. No. 1800; Geological Survey of Canada, Paleontological Report 4-ADM-2016, 14 p.

McCracken, A.D. 2017b. Report on two Ordovician conodont samples from the Bad Cache Rapids Group, northern Ontario, collected by Derek Armstrong (Ontario Geological Survey) as part of GEM-2 Hudson-Ungava Program (Denis Lavoie). NTS 43C-12. Con. No. 1778; Geological Survey of Canada, Paleontological Report 3-ADM-2017, 5 p.

McCracken, A.D. 2017c. Report on six Ordovician and Silurian conodont samples from the Bad Cache Rapids Group, Red Head Rapids Formation, and Severn River Formation, northern Ontario, collected by Derek

Armstrong (Ontario Geological Survey) as part of GEM-2 Hudson-Ungava Program (Denis Lavoie). NTS 43F-09, 53P-08. Con. No. 1771; Geological Survey of Canada, Paleontological Report 4-ADM-2017, 6 p.

McCracken, A.D. 2017d. Report on eighteen Ordovician and Silurian conodont samples from the Bad Cache Rapids Group, Ekwan River and Kenogami River formations, northern Ontario, collected and submitted in 2013 by Derek Armstrong (Ontario Geological Survey) as part of GEM-2 Hudson-Ungava program (Denis Lavoie). NTS 32I/01, 42F/16, 42K/02, 42K/03, 42K/07, 42K/11, 42K/14, 42K/15, 42M/16, 43C/12, Con No. 1786 and 1787; Geological Survey of Canada, Paleontological Report 7-ADM-2017, 19 p.

McCracken, A.D., Armstrong, D.K., Lavoie, D., and Brunton, F.R. 2013. Conodonts from the Hudson Bay and Moose River basins, Ontario; 23rd Canadian Paleontological Conference, University of Alberta, Edmonton, Alberta; poster presentation.

McCracken, A.D., and Bolton, T.E. 2000. Geology and paleontology of the southeast Arctic Platform and southern Baffin Island. Geological Survey of Canada, Bulletin 557, 248 p.

McCracken, A.D., and Nowlan, G.S. 1989. Conodont paleontology and biostratigraphy of Ordovician carbonates and petroliferous carbonates on Southampton, Baffin, and Akpatok islands in the eastern Canadian Arctic, Canadian Journal of Earth Sciences, v. 26:1880–1903.

McGregor, D.C. and Camfield, M. 1976. Upper Silurian? to Middle Devonian spores of the Moose River Basin, Ontario; Geological Survey of Canada, Bulletin 263, 63p.

McGregor, D.C., Sanford, B.V. and Norris, A.W. 1970. Palynology and correlation of Devonian formations in the Moose River Basin, northern Ontario; Geological Association of Canada, Proceedings, v. 22: 45-54.

Melchin, M.J., McCracken, A.D., and Oliff, F.J. 1991. The Ordovician–Silurian boundary on Cornwallis and Truro islands, Arctic Canada: preliminary data., Canadian Journal of Earth Sciences, v. 28(11): 1854–1862.

Nelson, S. J. 1952. Ordovician palaeontology and stratigraphy of the Churchill and Nelson rivers, Manitoba. McGill University, Department of Geology, Ph.D. thesis, 190 p.

Nelson, S.J. 1963. Ordovician paleontology of the Hudson Bay lowland; Geological Society of America Memoir 90.

Nelson, S. J. 1964. Ordovician stratigraphy of northern Hudson Bay lowland, Manitoba; Geological Survey of Canada Bulletin 108, 36 p.

Nelson, S. J., and Johnson, M. E. 2002. Jens Munk Archipelago: Ordovician-Silurian islands in the Churchill area of the Hudson Bay Lowlands, northern Manitoba; Journal of Geology, v. 110: 577-589.

Nelson, S.J., and Johnson, R.D. 1966. Geology of Hudson Bay Basin; Bulletin of Canadian Petroleum Geology, v. 14: 520–578.

Nicolas, M. P. B., and Lavoie, D. 2010. Hudson Bay and Foxe Basins Project: update on a Geo-mapping for Energy and Minerals program (GEM) initiative, northeastern Manitoba (part of NTS 54); *in* Report of Activities 2010, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 186-192.

Nicolas, M. P. B., and Lavoie, D. 2012. Oil shale and reservoir rocks of the Hudson Bay Lowland, northeastern Manitoba (part of NTS 54); *in* Report of Activities 2012, Manitoba Innovation, Energy and Mines, Manitoba

Geological Survey, p. 124-133.

Nicolas, M. P. B., and Young, G. A. 2014. Reconnaissance field mapping of Paleozoic rocks along the Churchill River and Churchill coastal area, northeastern Manitoba (parts of NTS 54E, L, K); *in* Report of Activities 2014, Manitoba Mineral Resources, Manitoba Geological Survey, p. 148-160.

Nicolas, M. P. B. 2016. Carbon and oxygen stable-isotope profiles of Paleozoic core from the Hudson Bay Basin, northeastern Manitoba (parts of NTS 54B7, 8, 54F8, 54G1); *in* Report of Activities 2016, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 142-149.

Nicolas, M. P. B., and Armstrong, D. K. 2017. Update on Paleozoic stratigraphic correlations in the Hudson Bay Lowland, northeastern Manitoba and northern Ontario; *in* Report of Activities 2017, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 133-147.

Norford, B.S. 1970. Ordovician and Silurian biostratigraphy of the Sogepet-Aquitaine Kaskattama Province No. 1 well, northern Manitoba. Geological Survey of Canada, Paper 69-8, 36 p.

Norris, A.W. 1993. Hudson Platform - Geology; in Chapter 8 of Sedimentary Cover of the Craton in Canada, D.F. Stott and J.D. Aitken (ed.), Geological Survey of Canada, Geology of Canada, The Geology of North America, v. D-1

Nowlan, G.S., and Haidl, F.M. 2001. Biostratigraphy and paleoecology of Late Ordovician conodonts from a composite section in the subsurface of Saskatchewan, in Summary of Investigations 2001. Saskatchewan Geological Survey, Saskatchewan Energy Mines, Misc. Rep. 2001-4-1, p. 14-31.

Parks, W.A. 1904. Devonian fauna of Kwatagoahegan River; Ontario Bureau of Mines, v. 13: 180-191.

Pietrus, E. 2013. Sedimentology of the Silurian Ekwan Formation, Hudson Bay Basin, northeastern Manitoba; University of Manitoba, Department of Geological Sciences, B.Sc. Thesis, 72 p.

Pinet, N., Lavoie, D.. Dietrich, J., Hu, K., and Keating, P. 2013a. Architecture and subsidence history of the Hudson Bay intracratonic basin; Earth Science Reviews, v. 125: 1–23, doi:10.1016/j.earscirev.2013.05.010.

Pinet, N., Lavoie, D., and Keating, P. 2013b. Did the Hudson Strait in Arctic Canada record the opening of the Labrador Sea?; Marine and Petroleum Geology, v. 48: 354–365, doi:10.1016/j.marpetgeo.2013.08.002.

Quinlan, G. M. 1987, Models of subsidence mechanisms in intracratonic basins, and their applicability to North American examples; in C. Beaumont and A. J. Tankard, eds., Sedimentary basins and basin-forming mechanisms: Canadian Society of Petroleum Geologists, Memoir 12: 463–481.

Ramdoyal, A. 2012. Lithofacies analysis, diagenesis and petroleum reservoir potential of the Lower Silurian Attawapiskat Formation, Hudson Bay Basin, northeastern Manitoba; University of Manitoba, Department of Geological Sciences, B.Sc. Thesis, 124 p.

Ratcliffe, L.M., and Armstrong, D.K. 2013. The Hudson Platform Project: 2013 field work and drill-core correlations, western Moose River Basin; in Summary of Field Work and Other Activities, 2013, Ontario Geological Survey, Open File Report 6290: 36-1 to 36-19.

Saltzman, M.R. and Thomas, E. 2012. Carbon isotope stratigraphy, Chapter 11; in The geologic time scale 2012, Elsevier, Amsterdam, p.207-232.

Sanford, B.V., and Grant, A.C. 1990. New findings relating to the stratigraphy and structure of the Hudson Platform; in Current Research, Part D, Geological Survey of Canada, Paper 90-1D: 17-30.

Sanford, B.V., and Grant, A.C. 1998. Paleozoic and Mesozoic geology of the Hudson Bay and southeast Arctic platforms; Geological Survey of Canada, Open File 3595, sheets 1 and 2.

Sanford, B. V., and Norris, A.W. 1973. The Hudson platform—Their geology and potential, in R. G. McCrossan, ed., Future petroleum provinces of Canada; Canadian Society of Petroleum Geologists, Memoir 1: 387–409.

Sanford, B.V, Norris, A.W., and Bostock, H.H. 1968. Geology of the Hudson Bay Lowlands (Operation Winisk); Geological Survey of Canada, Paper 67-60, p. 1–45, and Geological Map 17-1967.

Savage, T.E., and Van Tuyl, F.M. 1919. Geology and stratigraphy of the area of Paleozoic rocks in the vicinity of Hudson and James bays; Geological Society of America, Bulletin 30: 339-378.

St. Jean, N.F. 2012. Mineralogical, petrographic and geochemical characterization of organic-rich carbonate of the Upper Ordovician Boas River Formation in northern Ontario: Implications for petroleum exploration; unpublished BSc thesis, University of Ottawa, Ottawa, Ontario, 61p.

Suchy, D.R., and Stearn, C.W. 1993. Lower Silurian reefs and post-reef beds of the Attawapiskat Formation, Hudson Bay Platform, northern Ontario; Canadian Journal of Earth Sciences, v.30: 575-590.

Sweet, W.C. 1984. Graphic correlation of upper Middle and Upper Ordovician rocks, North American Midcontinent Province, U.S.A; *in*: Aspects of the Ordovician System. D.L. Bruton (ed.). Palaeontological Contributions from the University of Oslo, no. 295: 23–35.

Sweet, W.C. 1988. The Conodonta – morphology, taxonomy, paleoecology, and evolutionary history of a long-extinct animal phylum; Oxford Monographs on Geology and Geophysics, no. 10, 212 p.

Tillement, B.A., Peniguel., G., and Guillemin, J.P., 1976. Marine Pennsylvanian rocks in Hudson Bay. Bulletin of Canadian Petroleum Geology, v. 24, p. 418-439.

Trettin, H.P. 1969. Lower Palaeozoic sediments of northwestern Baffin Island, District of Franklin; Geological Survey of Canada, Bulletin 157, 70 p.

Trettin, H.P. 1975. Investigations of Lower Paleozoic geology, Foxe Basin, Northeastern Melville Peninsula and parts of northwestern and central Baffin Island; Geological Survey of Canada, Bulletin 251, 177 p.

Turner, E.C., and Armstrong, D.K. 2015. Upper Ordovician stratigraphy of northern Ontario: Differential subsidence and deposition in 2 Late Ordovician basins contemporaneous with Hirnantian glaciation and the Taconic Orogeny; in Summary of Field Work and Other Activities, 2015, Ontario Geological Survey, Open File Report 6313: 32-1 to 32-22.

Verma, H. 1978. Bibliography of geology of the Hudson Bay lowland, Ontario; Ontario Ministry of Natural Resources. Un-numbered report, 67 p.

Wheadon, B. 2011. Ordovician-Silurian boundary interval near Churchill, Manitoba: lithostratigraphy, chemostratigraphy and biostratigraphy of Airport Cove West core and quarry samples; University of Manitoba, Department of Geological Sciences, B.Sc. Thesis, 171 p.

White, T. S., Witzke, B.J., and Ludvigson, G.A. 2000. Evidence for an Albian Hudson arm connection between the Cretaceous western interior seaway of North America and the Labrador Sea; Geological Society of America Bulletin, v. 112: 1342–1355, oi:10.1130/0016-7606(2000)

Wilson, W.J. 1902. Reconnaissance Surveys of four rivers, southwest of James Bay; Geological Survey of Canada, Annual Report v. 15A: 222-243A.

Wong, M. E. 2011. Lithofacies analysis and stratigraphic correlation of the Upper Ordovician Red Head Rapids Formation, Hudson Bay Basin, northeastern Manitoba; University of Manitoba, Department of Geological Sciences, B.Sc. Thesis, 72 p.

Workum, R.H., Bolton, T.E., and Barnes, C.R. 1976. Ordovician geology of Akpatok Island, Ungava bay, District of Franklin; Canadian Journal of Earth Sciences, v. 13: 157-178.

Zhang, S. 2008. New insights into Ordovician oil shales in Hudson Bay Basin: their number, stratigraphic position, and petroleum potential; Bulletin of Canadian Petroleum Geology, v. 56: 300–324.

Zhang, S. 2011. Late Ordovician conodont biostratigraphy and redefinition of the age of oil shale intervals on Southampton Island; Canadian Journal of Earth Sciences, 48: 619–643.

Zhang, S. 2012. Ordovician stratigraphy and oil shale, southern Baffin Island, Nunavut – preliminary field and post-field data; Geological Survey of Canada, Open File 7199, 26 p.

Zhang, S. 2013. Ordovician conodont biostratigraphy and redefinition of the age of lithostratigraphic units on northeastern Melville Peninsula, Nunavut; Canadian Journal of Earth Sciences, 50 (8): 808–825.

Zhang, S. 2018. Upper Ordovician conodont biostratigraphy and revised lithostratigraphy and geological map, Akpatok Island, Ungava Bay, Nunavut; Canadian Journal of Earth Sciences, 55(1): 52-69

Zhang, S., and Barnes, C.R. 2007. Late Ordovician – Early Silurian conodont biostratigraphy and thermal maturity, Hudson Bay Basin; Bulletin of Canadian Petroleum Geology, v. 55 (3): 179–216.

Zhang, S., and Riva, J. 2018. The stratigraphic position and the age of the Ordovician organic-rich intervals in the northern Hudson Bay, Hudson Strait and Foxe basins – evidence from graptolites; Canadian Journal of Earth Sciences

Zhang, S., Tarrant, G.A., and Barnes, C.R. 2011. Upper Ordovician conodont biostratigraphy and the age of the Collingwood Member, southern Ontario, Canada; Canadian Journal of Earth Sciences, v. 48: 1497–1522.

ANNEXES 1 to 6

Manitoba-Ontario, Hudson Bay Basin (onshore)							
Unit Name	Age range	Thickness maximum (reference core)	Main lithology (ies)	Secondary lithology (ies)	Diagnostic element	Location	Reference
Bad Cache Rapids Group	Edenian - Maysvillian (Late Ordovician) (as young as Richmondian in the vicinity of Cape Henrietta-Maria Arch)	97 m (Pen No. 1, Ontario)	**Portage Chute Fm**: light grey, slightly dolomitic, bioclastic, argillaceous, nodular wackestone to packstone	basal unit: light to dark grey, quartz-rich, poorly sorted, variably consolidated argillaceous sandstone	*Thalassinoides*-like mottles common; rich in corals, gastropods, trilobites, nautiloids, algae, and crinoids. Distinctive *Fisherites*(algae)-*Maclurites (gastropod)*megafossils.	Churchill River at Portage Chute (Manitoba); type section	Nelson (1964); Nicolas and Young (2014)
			Surprise Creek Fm: light to medium brown, dolomitic argillaceous mudstone to interbedded bioclastic dolowackestone to dolopackstone	Nodular anhydrite (in core); grey to brown chert beds (in outcrop only/or except in Pen and Kaskattama?)	grey to brown large chert nodules with tripolized rinds	Surprise Creek (tributary into Churchill River, Manitoba); type section	Nelson (1964); Nicolas and Young (2014)

	Maysvillian (Late Ordovician)	10 m (INCO-Winisk #49212, Ontario)	**Un-named organic-rich lithofacies**: dark brown to black, organic-rich, laminated lime mudstone to ostracod wackestone; fossils (petrographically identified) include ostracods, trilobites, crinoids, brachiopods. **(formerly Boas River Fm)**	grey, organic-poor, bioturbated lime mudstone to bio-wackestone;	dark brown to black organic-rich, fissile limestone	mineral exploration cores in Winisk River area (Ontario)	Sanford and Grant (1990); Armstrong and Lavoie (2010); St. Jean (2012)
Churchill River Group	early Richmondian (Late Ordovician)	66 m (M-2-2003, Manitoba)	**Caution Creek Fm**: light grey -brown burrow-mottled argillaceous wackestone to bioclastic packstone	argillaceous mudstone stringers; occasional grey chert nodules; dolomitic in places	burrow mottled with *Thalassinoides* and *Trypanites*; argillaceous content	Caution Creek, Chasm Creek and Surprise Creek (tributaries into Churchill River, Manitoba); type section area	Nelson (1964); Lavoie et al. (2013); Nicolas and Young (2014)
			Chasm Creek Fm: light to medium brown-grey nodular mudstone to bioclastic wackestone	mudstone to argillaceous mudstone beds	light brown colour; nodular; *Thalassinoides* and *Chondrities* burrows	Chasm Creek (tributary into Churchill River,	Nelson (1964); Lavoie et al. (2013); Nicolas and Young (2014)

			to packstone; dolomitic in places			Manitoba); type section	
Red Head Rapids Formation	late Richmondian to Hirnantian (Late Ordovician)	74 m (Pen No. 1, Ontario)	4 to 6 repetitive cyles of (in ascending order): light brown dolomudstone to dolowackestone; dark grey nodular to bedded anhydrite (occasionally gypsum) with shaly stringers; rare halite beds; and green-grey, argillaceous to silty, finely bedded dolomudstone	"chicken-wire" anhydrite; halite	metre-scale repetitive cycles; evaporite minerals or molds; tabular bedded dolomudstones	Red Head Rapids on the Churchill River; type section	Nelson (1964); Lavoie et al. (2013); Nicolas and Young (2014); Demski et al. 2015
			un-named organic-rich lithofacies: dark brown to black, organic-rich, laminated lime mudstone to ostracod wackestone; fossils (petrographically identified) include ostracods, trilobites, cephalopods, crinoids, brachiopods. **(very similar to former**	grey, organic-poor, bioturbated lime mudstone to bio-wackestone	dark brown to black organic-rich, fissile limestone	only known occurrence in outcrop on the Asheweig River. (Ontario)	Armstrong (2011); St, Jean (2012)

			Boas River Formation)				
Severn River Formation	Rhuddanian to early Telychian, Llandovery (early Silurian)	118 m (Pen No. 1, Ontario)	**lower member**: brachiopod (*Virgiana*) and coral bearing wackestone to packstone. (mostly Rhuddanian)	wackestone to dolomitic lime mudstone ("ribbon limestone") towards base	abundant, thick-shelled *Virgiana* brachiopods; burrow-mottled	Churchill, Manitoba	Nicolas and Armstrong (2017); Nicolas and Young (2014); Armstrong et al. (2013); Savage and Van Tuyl (1919)
		81 m (Pen No. 1, Ontario)	**middle member**: cycles including: burrow-mottled, dolomitic, bio-wackestone; dolomudstone; anhydrite (or gypsum) bearing dolomustones; green, argillaceous dolomudstone to siltstone. (mostly Aeronian?)	anhydrite (or gypsum) beds	anhydrite (or gypsum) as nodules or beds; also evaporite mineral molds; stromatolitic; microbial mud mounds	formation type area along Severn River, south of Fawn River; also on Shammattawa and Winisk rivers and Cape Henrietta-Maria. (all Ontario)	Nicolas and Armstrong (2017); Lavoie et al. (2013); Armstrong et al. (2013); Jin and Rudkin (2003); Savage and Van Tuyl (1919);

		37 m (Pen No. 1, Ontario)	**upper member**: burrow-mottled bio-wackestone, with packestone and thin grainstone beds (mostly early Telychian?)	dolomudstone and green argillaceous dolomudstone or siltstone	burrow-mottling; grainstone to wackestone cycles, rarely progressing to dolomudstone.	formation type area along Severn River, in vicinity and north of Fawn River; also on Winisk and Mishamattawa rivers? (based on Sanford et al. 1968) (all Ontario)	Nicolas and Armstrong (2017); Lavoie et al. (2013); Armstrong et al. (2013); Savage and Van Tuyl (1919)
Ekwan River Formation	late Telychian, Llandovery (early Silurian)	45 m (Pen No. 1, Ontario)	fossiliferous, biostromal limestone: bio-wacke-packstone, grainstone and rudstone; fossils include locally abundant stromatoroids, tabulate corals and crinoidal material; also trilobites, brachiopods, gastropods and cephalopods; locally abundant chert nodules; includes metre scale bioherms	green, argillaceous bio-wackestone (with shelly fauna) occurs in the middle of the formation	very fossiliferous; chert-rich locally; mainly biostromal; generally coarser grained matrix than underlying Severn River Fm; disconformable base (especially in outcrop on Severn River)	sparse outcrops on Severn River (top and bottom of formation), Ontario; also mapped on Owl River and nearby Hudson Bay shoreline, Manitoba (Sanford et al. 1968)	Nicolas and Armstrong (2017); Lavoie et al. (2013); Armstrong et al. (2013); Savage and Van Tuyl (1919)

			in upper part; wacke-packstones may be burrow-mottled.				
Attawapiskat Formation	late Telychian, Llandovery (early Silurian)	81 m (Pen No. 1, Ontario)	biohermal limestone; fossiliferous, including corals, stromatoporoids, cephalods, crinoids,	flanking and draping bioclastic beds; inter-biohermal megalodont bivalve and gastropod lagoonal lithofacies	bioherms (classic reef structures)	Severn River; also mapped on Hudson Bay shore, west of Winisk River (Sanford et al. 1968) (all Ontario)	Nicolas and Armstrong (2017); Lavoie et al. (2013); Armstrong et al. (2013); Savage and Van Tuyl (1919)
Kenogami River Fm (lower member)	Sheinwoodian, Wenlock? (early Silurian)	46 m (Kaskattama No. 1, Manitoba)	gypsum and laminated to massive dolomudstone	dolomitic silty mudstone	gypsum as beds, nodules and fracture filling	laminated dolostones overlying Attawapiskat Fm bioherms on the Severn River, Ontario.	Nicolas and Armstrong (2017); Lavoie et al. (2013); Armstrong et al. (2013)

Annex 1: Summary of the stratigraphy of the Hudson Lowland, northeastern Manitoba and northern Ontario

References

Armstrong, D.K., McCracken, A.D., Asselin, E. and Brunton, F.R. 2013: The Hudson Platform Project: stratigraphy of the Aquitaine Sogepet et al. Pen No. 1 core; *in* Summary of Field Work and Other Activities 2013, Ontario Geological Survey, Open File Report 6290, p. 34-1–34-21.

Jin, J. and Rudkin, D. 2003. Early Silurian microbial mounds of the Severn River Formation, Hudson Bay Lowlands, Ontario. Canadian Paleontological Conference – 2003; University of Alberta, Edmonton, Alberta, Sept, 19-20, 2003.

Lavoie, D., Pinet, N., Dietrich, J., Zhang, S., Hu, K., Asselin, E., Chen, Z., Bertrand, R., Galloway, J., Decker, V., Budkewitsch, P., Armstrong, D., Nicolas, M. P. B., Reyes, J., Kohn, B. P., Duchesne, M. J., Brake, V., Keating, P., Craven, J. and Roberts, B. 2013: Geological framework, basin evolution, hydrocarbon system data and conceptual hydrocarbon plays for the Hudson Bay and Foxe basins, Canadian Arctic; Geological Survey of Canada, Open File 7363, 210 p.

Nelson, S. J. 1964: Ordovician stratigraphy of northern Hudson Bay Lowland, Manitoba; Geological Survey of Canada, Bulletin 108, 36 p.

Nicolas, M.P.B. and Young, G.A. 2014: Reconnaissance field mapping of Paleozoic rocks along the Churchill River and Churchill coastal area, northeastern Manitoba (parts of NTS 54E, L, K); *in* Report of Activities 2014, Manitoba Mineral Resources, Manitoba Geological Survey, p. 148-160.

Nicolas, M.P.B. and Armstrong, D.K. 2017: Update on Paleozoic stratigraphic correlations in the Hudson Bay Lowland, northeastern Manitoba and northern Ontario; *in* Report of Activities 2017, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 133–147.

Sanford, B.V. and Grant, A.C. 1990: New findings relating to the stratigraphy and structure of the Hudson Platform; *in* Current Research, Part D, Geological Survey of Canada, Paper 90-1D, p.17–30.

Sanford, B.V., Norris, A.W. and Bostock, H.H. 1968: Geology of the Hudson Bay Lowlands (Operation Winisk); Geological Survey of Canada, Paper 67-60, 118p.

Savage, T.E. and Van Tuyl, F.M. 1919: Geology and stratigraphy of the area of Paleozoic rocks in the vicinity of Hudson and James bays; Geological Society of America, Bulletin v. 30, p. 339-378.

Ontario, Moose River Basin

Unit Name	Age range	Thickness maximum (reference core)	Main lithology (ies)	Secondary lithology (ies)	Diagnostic element	Location	Reference
Bad Cache Rapids Group	Edenian - Richmondian (Late Ordovician)	38 m (Mantle Resources DDH-08-002)	**Portage Chute Fm**: light tan-grey to grey-brown, bioclastic, burrow-mottled, fossiliferous, nodular dolostone to dolomitic limestone (wackestone to packstone); towards base becomes sandy dolostone with dark blue hardgrounds.	basal unit: light to dark grey to grey-green, quartz-rich, poorly sorted, calcareous to argillaceous sandstone; also sandy shale.	light brown mottles after *Thalassinoides*-like burrows; also networks of narrow, blue-rimmed burrows; fossils include: corals, gastropods, trilobites, nautiloids, and crinoids.	upper Ekwan, Muketie and Attawapiskat rivers	Armstrong (2011); Ratcliffe and Armstrong (2013); Armstrong (2015)
		21 m (KWG-Spider DR-94-10)	**Surprise Creek Fm**: greenish-grey, argillaceous, dolomite; gypsum nodules, beds and fracture-fillings.	sandy dolostone, sandstone (especially to the west and south)	Green-grey argillaceous content (shaly)	sparse outcrops; upper Ekwan River	Armstrong (2011); Ratcliffe and Armstrong (2013)
Churchill River Group	early Richmondian (Late Ordovician)	0 m (absent in Moose River Basin)					Armstrong (2011); Ratcliffe and Armstrong (2013)

Red Head Rapids Formation	late Richmondian to Hirnantian (Late Ordovician)	53 m (Canabrava? DDH 01-1530-01)	dolo-mudstones to -siltites and sandy mudstones to thin sandstones of various colours (red, tan, grey-green, white)	green-grey shale and argillaceous to silty dolomudstone; dolo-wackestone; intraformational breccias (especially at base)	brick red mudstones in core; chalky white to tan, tabular bedded dolomudstones; sharp lithologic contacts; shallow water sedimentary structures, including ripples and dessication cracks; evaporite minerals or molds; possible paleosols.	sparse outcrops; on Attawapiskat River, ~11.5km west of junction with Muketei River; and possibly on upper Ekwan River	Armstrong (2011); Ratcliffe and Armstrong (2013)
	early Rhuddanian (early Silurian)	5 m (KWG-Spider DR-94-19)	grey to brick red shale and sandy dolomitic shale	argillaceous dolomudstone	mainly siliciclastic unit above negative 13C isotopic anomaly that marks the Ordovician-Silurian boundary; gradationally overlain by grey argillaceous dolomudstone of the lower Severn River Formation	no outcrop; core KWG-94-19	Ratcliffe and Armstrong (2013); Hahn et al. (2017)
Severn River Formation	Rhuddanian to early Telychian, Llandovery (early Silurian)	26 m (Canabrava? DDH 01-1530-01)	**lower member**: brachiopod (*Virgiana*) and coral bearing wackestone to packstone. (mostly Rhuddanian)	dolomitic lime mudstone ("ribbon limestone") to wackestone; at base; dolomitic and/or argillaceous towards base	abundant, thick-shelled *Virgiana* brachiopods	one outcrop on Muketei River, 5 km northwest of Attawapiskat River	Armstrong (2011); Ratcliffe and Armstrong (2013); Nicolas and Armstrong (2017); Savage and Van Tuyl (1919)

		72 m (Canabrava? DDH 01-1530-01)	**middle member**: various rock types in crude cycles; mainly: light grey to tan-brown to grey-green (argillaceous) to chalky white dolomudstone to -siltstone (mostly Aeronian?)	burrow-mottled, dolomitic bio-wackestone; thin, dark brown to black, shales and bituminous limestone (up to 7.2% TOC); intraclastic breccias; stromatolitic; microbial mud mounds	thin, tabular-bedded, homogenous to laminated dolomudstones; with intraclastic breccias; local chert nodules; locally stromatolitic	sparse outcrops; Mississa River ~16km south of Attawapiskat River; Matateto River ~9km south of Ekwan River; Shamattawa River and Cape Henrietta-Maria	Armstrong (2011); Ratcliffe and Armstrong (2013); Nicolas and Armstrong (2017); Jin and Rudkin (2003); Savage and Van Tuyl (1919)
		46 m (KWG-Spider DR-94-19)	**upper member**: burrow-mottled bio-wackestone, with packestone and thin grainstone beds (mostly early Telychian?)	dolomudstone and green argillaceous dolomudstone or siltstone; thin intraclastic packstone beds	burrow-mottling; grainstone to wackestone cycles, rarely progressing to dolomudstone.	outcrops on Ekwan and Attawapiskat (including upper contact) rivers; outcrop on Shashiskau River (SE MRB) may be upper Severn R. Fm	Armstrong (2011); Ratcliffe and Armstrong (2013); Nicolas and Armstrong (2017); Savage and Van Tuyl (1919)

Ekwan River Formation	late Telychian, Llandovery (early Silurian)	32 m (KWG-Spider DR-94-19)	fossiliferous, biostromal limestone: bio-wacke-packstone, grainstone and rudstone; fossils include locally abundant stromatoroids, tabulate corals and crinoidal material; also trilobites, brachiopods, gastropods and cephalopods; locally abundant chert nodules	green, argillaceous bio-wackestone (with shelly fauna) occurs in the middle of the formation; includes isolated metre to decametre scale bioherms in upper part (possibly equivalent to lower Attawapiskat Fm).	very fossiliferous; locally chert-rich; mainly biostromal; wacke-packstones locally burrow-mottled; generally coarser grained matrix than underlying Severn River Fm; disconformable base (especially in outcrop on Attawapiskat River)	Ekwan, Attawapiskat, Albany, Little Current and Drowning rivers. Also on Kenogami, Nagagami and Kabinakagami rivers.	Armstrong (2011); Ratcliffe and Armstrong (2013); Nicolas and Armstrong (2017); Armstrong (2014); Armstrong (2015); Savage and Van Tuyl (1919)
Attawapiskat Formation	late Telychian, Llandovery (early Silurian)	41 m (DeBeers V03-270AH)	biohermal limestone; fossiliferous, including corals, stromatoporoids, cephalopods, crinoids, brachiopods, trilobites and more.	flanking and draping bioclastic beds; inter-biohermal megalodont bivalve and gastropod lagoonal lithofacies	bioherms (classic reef structures); massive bedding	Attawapiskat River (abundant bioherms); also on lower Ekwan River	Armstrong (2011); Ratcliffe and Armstrong (2013); Nicolas and Armstrong (2017); Armstrong (2014); Armstrong (2015); Suchy and Stearn (1993); Savage and Van Tuyl (1919)

Kenogami River Fm (lower member)	late Telychian, Llandovery (to Sheinwoodian, Wenlock?) (early Silurian)	53 m (Puskwuche Point No. 1)	laminated to massive, gypsum-bearing, argillaceous dolomudstone	dolomudstone; gypsum	tabular bedded dolomudstone; gypsum as beds, nodules and fracture filling; vuggy porosity after evaporites.	Fort Albany, Albany, Drowning, Kenogami, Nagagami, Kabinakagami and Coal rivers	Ratcliffe and Armstrong (2013); Armstrong (2014); Armstrong (2015); Sanford et al. (1968); Hogg et al. (1953); Dyer (1929)

Annexe 2: Summary of stratigraphy for the Moose River Basin, Ontario

References

Armstrong, D.K. 2011: Re-evaluating the hydrocarbon resource potential of the Hudson Platform: interim results from northern Ontario; in Summary of Field Work and Other Activities 2011, Ontario Geological Survey, Open File Report 6270, p.27-1 to 27-11.

Armstrong, D.K. 2014: Hudson Platform Project: Aggregate sampling and Paleozoic geology of the Moose River Basin, northern Ontario; in Summary of Field Work and Other Activities 2014, Ontario Geological Survey, Open File Report 6300, p.30-1 to 30-10.

Armstrong, D.K. 2015: Hudson Platform Project: Paleozoic geology of the McFaulds Lake, South Moosonee, Ekwan River and Attawapiskat River areas, James Bay Lowland; in Summary of Field Work and Other Activities 2015, Ontario Geological Survey, Open File Report 6313, p.31-1 to 31-20.

Dyer, W.S. 1929: Limestones of the Moose River and Albany River basin; Ontario Department of Mines, Vol. XXXVIII, pt. 4, p. 31-33.

Hahn, K. E., Turner, E. C., Armstrong, D. K. and Nicolas, M. P. B. 2017: Late Ordovician chemostratigraphy of the Hudson Bay and Moose River basin; in Program with abstracts, Geological Association of Canada-Mineralogical Association of Canada Annual meeting; Kingston, Ontario, May 14-17, poster presentation.

Hogg, N., Satterly, J. and Wilson, A.E. 1953: Drilling in the James Bay Lowland: Part 1 - Drilling by the Ontario Deprtment of Mines; Ontario Department of Mines, Annual Report 1952, Vol. LXI, Part 6, p. 115-140.

Jin, Jisuo and Rudkin, D. 2003: Early Silurian microbial mounds of the Severn River Formation, Hudons Bay Lowlands, Ontario. Canadian Paleontological Conference – 2003; University of Alberta, Edmonton, Alberta, Sept, 19-20, 2003.

Nicolas, M.P.B. and Armstrong, D.K. 2017: Update on Paleozoic stratigraphic correlations in the Hudson Bay Lowland, northeastern Manitoba and northern Ontario; *in* Report of Activities 2017, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 133–147.
Sanford, B.V., Norris, A.W. and Bostock, H.H. 1968: Geology of the Hudson Bay Lowlands (Operation Winisk); Geological Survey of Canada, Paper 67-60, 118p.

Ratcliffe, L.M. and Armstrong, D.K. 2013. The Hudson Platform Project: 2013 field work and drill-core correlations, western Moose River Basin; in Summary of Field Work and Other Activities, 2013, Ontario Geological Survey, Open File Report 6290, p.36-1 to 36-19.

Savage, T.E. and Van Tuyl, F.M. 1919: Geology and stratigraphy of the area of Paleozoic rocks in the vicinity of Hudson and James bays; Geological Society of America, Bulletin 30, p.339-378.

Suchy, D.R. and Stearn, C.W. 1993: Lower Silurian reefs and post-reef beds of the Attawapiskat Formation, Hudson Bay Platform, northern Ontario; Canadian Journal of Earth Sciences, v.30, p.575-590.

Southampton Island - Northern Hudson Bay Basin							
Unit Name	Age range	Thickness maximum (average)	Main lithology (ies)	Secondary lithology (ies)	Diagnostic element	Location	Reference
Bad Cache Rapids Group	Edenian - Maysvillian (Late Ordovician)	65 m (at measured section)	Dark grey or brownish grey fossiliferous limestone.	Basal sandstone	Rich in corals, gastropods, nautiloids, algae, and crinoids. Distinctive *Fisherites*(algae)-*Maclurites* (gastropod) megafossils.	Southampton Island	Zhang (2008, 2011); Zhang and Riva (2018)
Churchill River Group	early Richmondian (Late Ordovician)	unknown	Greenish grey or greyish brown argillaceous limestone		Argillaceous nature makes the formation forms ‘‘stair step’’ topography at the boundary between Churchill River and Bad Cache Rapids groups.		
Red Head Rapids Formation	late Richmondian (Late Ordovician)	57.4 m (at measured section)	Divided into 4 units: unit 1, thin-layered and laminated argillaceous dolomitic limestone; unit 2, massive breccia dolostone–limestone; unit 3, thick, massive biostromal dolostone and limestone; unit 4,	Oil shale in unit 1; hydrothermal dolomites in unit 2	Orange color		

			thin bedded dolomitic limestone with bioherms.				
Severn River Formation	Rhuddanian to early Telychian, Llandovery (early Silurian)	150 m	fine-grained, thin-bedded fossiliferous limestone	dolostone	*Virginia* beds		Norris (1993)
Ekwan River Formation	late Telychian, Llandovery (early Silurian)	90 m	well-bedded, skeletal and pelletoidal limestone	fine grained dolostone and biostromes; local chert			
Attawapiskat Formation	late Telychian, Llandovery (early Silurian)	50 m	coral and stromatoporoid bioherm	well bedded fossiliferous limestone	reefal		

Annex 3: Summary of stratigraphy for Southampton Island, Northern Hudson Basin

References

Norris, A.W. 1993.Hudson Platform - Geology; in Chapter 8 of Sedimentary Cover of the Craton in Canada, D.F. Stott and J.D. Aitken (ed.), Geological Survey of Canada, Geology of Canada,

Zhang, S. 2008. New insights into Ordovician oil shales in Hudson Bay Basin: their number, stratigraphic position, and petroleum potential. Bulletin of Canadian Petroleum Geology, v. 56, p. 300–324.

Zhang, S. 2011. Late Ordovician conodont biostratigraphy and redefinition of the age of oil shale intervals on Southampton Island. Canadian Journal of Earth Sciences, 48: 619–643.

Zhang, S. and Riva, J. 2018. The stratigraphic position and the age of the Ordovician organic-rich intervals in the northern Hudson Bay, Hudson Strait and Foxe basins – evidence from graptolites.

Offshore - Hudson Bay Basin							
Unit Name	Age range	Thickness maximum (average)	Main lithology (ies)	Secondary lithology (ies)	Diagnostic element	Location	Reference
Bad Cache Rapids Group	Edenian - Maysvillian (Late Ordovician)	94.5 m (78.94 m)	fossiliferous limestone, locally dolomitic and evaporitic	thin basal clastic rocks		Hudson Bay	Zhang and Barnes (2007); Hu et al. (2011)
Churchill River Group	early Richmondian (Late Ordovician)	130.5 m (103.94 m)	fossiliferous limestone in the lower part changing upward to dolostone and evaporite				
Red Head Rapids Formation	late Richmondian (Late Ordovician)	86.3 m (50.8 m)	dolostone, calcareous dolostone	evaporite			
Severn River Formation	Rhuddanian to early Telychian, Llandovery (early Silurian)	251.5 m (242.7 m)	fine-grained, thin-bedded fossiliferous limestone	dolostone			
Ekwan River Formation	late Telychian, Llandovery (early Silurian)	126.9 m (85.9 m)	well-bedded, skeletal and pelletoidal limestone	fine grained dolostone			
Attawapiskat Formation	late Telychian, Llandovery (early Silurian)	150 m	coral and stromatoporoid bioherm	well bedded fossiliferous limestone	reefal		
Kenogami River Formation (lower unit)	late Llandoverian to early Wenlockian ?	75 m	unfossiliferous limestone and dolostone	siltstone, evaporites			

Annex 4: Summary of stratigraphy for offshore Hudson Bay Basin

References

Hu, K., Dietrich, J., Dewing, K., Zhang, S., Asselin, E., Pinet, N., and Lavoie, D. 2011. Stratigraphic correlations for five offshore wells in the Hudson Bay Basin, Northern Canada. Geological Survey of Canada,

Zhang, S., and Barnes, C.R. 2007. Late Ordovician – Early Silurian conodont biostratigraphy and thermal maturity, Hudson Bay Basin. Bulletin of Canadian Petroleum Geology, 55 (3), p. 179–216.

Melville Peninsula, Rowley well, Southern Baffin Island - Foxe Basin							
Unit Name	Age range	Thickness maximum (average)	Main lithology (ies)	Secondary lithology (ies)	Diagnostic element	Location	Reference
Ship Point Formation	latest Early Ordovician (Blackhillsian), maybe extended to earliest Middle Ordovician	nearly 80 m	Two different rock types: sandstone and dolostone which are divided into 4 units: unit 1, sandstone; unit 2, crystalline and argillaceous dolostone with sandy beds at the base; unit 3, platy and laminated, microcrystalline dolostone, the dominant lithology of the Ship Point Formation; unit 4, thin-bedded, laminated mottled algal and vuggy dolostone, containing abundant trace fossils.	Sandstone, algal mounds	Sandstone and dolostone; trace fossils	Melville Peninsula	Sanford and Grant (2000); Zhang (2013)

Frobisher Bay Formation	late Chatfieldian (Late Ordovician)	about 15 m	thin-to-medium-bedded microcrystalline limestone	dolomitic limestone	distinctive *Gonioceras* (cephalopod) -*Labyrinthites* (coral) megafossils	Melville Peninsula; southern Baffin Island	Sanford & Grant (2000); Zhang (2012, 2013)
Amadjuak Formation	Edenian - Maysvillian (Late Ordovician)	42 m on Melville Peninsula; 68-103 m on southern Baffin Island	dark grey or brownish grey fossiliferous limestone	chert-rich (bedded, nodule) and locally organic-rich black shale near the base	Algae *Fisherites* and gastropod *Maclurites* are characteristic .	Melville Peninsula; southern Baffin Island	Sandofrd and Grant (2000); Zhang (2012, 2013); Zhang & Riva (2018)
Akpatok Formation	early Richmondian (Late Ordovician)	Partially eroded to unknown on Melville Peninsula and southern Baffin Island	grey to dark brownish grey, thin-medium layered limestone	argillaceous limestone	argillaceous nature causing low topography	Melville Peninsula; southern Baffin Island	
Foster Bay Formation	late Richmondian (Late Ordovician)	Previously assumed present on southern Baffin; unknown on Melville	thin-medium bedded dolomitic limestone	massive breccia dolomitic limestone	dolomitic nature	Melville Peninsula	Zhang (2013); Zhang & Riva (2018)
informal lower Silurian	lower Silurian	135 m	Fossiliferous dolomitic limestone	dolostone	*Virginia* beds	Rowley well and Prince Charles Island	Trettin (1975)

Annex 5: Summary of stratigraphy for Melville Peninsula, Rowley well, Southern Baffin Island, Foxe Basin

References:

Sanford, B.V. and Grant, A.C. 2000. Geological framework of the Ordovician system in the southeast Arctic Platform, Nunavut. In Geology and Paleontology of the southeast Arctic Platform and southern Baffin Island. A.D. McCracken and T.E. Bolton (eds). Geological survey of Canada Bulletin 557, pp 13-38.

Trettin, H.P. 1975. Investigations of Lower Paleozoic geology, Foxe Basin, Northeastern Melville Peninsula and parts of northwestern and central Baffin Island. Geological Survey of Canada, Bulletin 251, 177 p.

Zhang, S. 2012. Ordovician stratigraphy and oil shale, southern Baffin Island, Nunavut – preliminary field and post-field data. Geological Survey of Canada, Open File 7199, 26 p.

Zhang, S. 2013. Ordovician conodont biostratigraphy and redefinition of the age of lithostratigraphic units on northeastern Melville Peninsula, Nunavut. Canadian Journal of Earth Sciences, 50 (8): 808–825

Zhang, S. and Riva, J. 2018. The stratigraphic position and the age of the Ordovician organic-rich intervals in the northern Hudson Bay, Hudson Strait and Foxe basins – evidence from graptolites Canadian Journal of Earth Sciences.

Akpatok - Hudson Strait Basin							
Unit Name	Age range	Thickness maximum (average)	Main lithology (ies)	Secondary lithology (ies)	Diagnostic element	Location	Reference
Ungava Formation	latest Early Ordovician (Blackhillsian), maybe extended to earliest Middle Ordovician	180 m	Clastics (sandstone and conglomerate)	Limestone, shale		Akpatok well	Workum et al (1976); Sanford and Grant (2000); Zhang (2018)
Frobisher Bay Formation	late Chatfieldian (Late Ordovician)	15 m	Calcareous shale and argillaceous limestone	Limestone and shale interbeds			
Amadjuak Formation	Edenian - Maysvillian (Late Ordovician)	50 to 80 m	Dark brown micrite	Chert layers and nodules	Chert and gastropod *Maclurites*	Akpatok Island	Zhang (2018); Zhang and Riva (2018)
Akpatok Formation	early Richmondian (Late Ordovician)	70 m	grey to dark brownish grey, thin-medium layered limestone	thin layered argillaceous limestone	Argillaceous nature		
Foster Bay Formation	late Richmondian (Late Ordovician)	150 m	thin bedded calcareous dolostone and dolomitic limestone	massive breccia dolomitic limestone; thin bituminous argillaceous limestone			

Annex 6: Summary of stratigraphy for Akpatok Island, Hudson Strait Basin

References:

Sanford, B.V. and Grant, A.C. 2000. Geological framework of the Ordovician system in the southeast Arctic Platform, Nunavut. In Geology and Paleontology of the southeast Arctic Platform and southern Baffin Island. A.D. McCracken and T.E. Bolton (eds). Geological survey of Canada Bulletin 557, pp 13-38.

Workum, R.H., Bolton, T.E., and Barnes, C.R. 1976. Ordovician geology of Akpatok Island, Ungava bay, District of Franklin. Canadian Journal of Earth Sciences, v. 13, pp. 157-178.

Zhang, S. 2018. Upper Ordovician conodont biostratigraphy and revised lithostratigraphy and geological map, Akpatok Island, Ungava Bay, Nunavut. Canadian Journal of Earth Sciences, 55(1): 52-69

Zhang, S. and Riva, J. 2018. The stratigraphic position and the age of the Ordovician organic-rich intervals in the northern Hudson Bay, Hudson Strait and Foxe basins – evidence from graptolites. Canadian Journal of Earth Sciences.