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Geology and Assessment of Undiscovered Oil and Gas Resources of the Franklinian Shelf Province, Arctic Canada and North Greenland, 2008

Chapter H of
The 2008 Circum-Arctic Resource Appraisal

Professional Paper 1824

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Cover.
Northwestward view across the southern foothills of the Brooks Range along Akmagolik Creek, approximately 150 miles southwest of Prudhoe Bay, Alaska. Exposed rocks are part of the Mississippian–Pennsylvanian Lisburne Group and include a thrust-fault ramp at left. Photo includes two helicopters for scale, a blue-and-white one near the center and a red one at center-right at creek level. U.S. Geological Survey photograph by David Houseknecht.

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The 2008 Circum-Arctic Resource Appraisal

North Atlantic Ocean

Eurasia

Arctic Ocean

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Chapter H

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Abstract

In 2008, the U.S. Geological Survey assessed the potential for undiscovered oil and gas resources of the Franklinian Shelf Province of northern Canada and Greenland as part of the U.S. Geological Survey Circum-Arctic Resource Appraisal Program. The Franklinian Shelf Province lies along the northernmost edge of the North American craton in Greenland and Canada. It encompasses a Cambrian through Middle Devonian passive margin sequence deposited on the margin of an ocean formed by rifting and seafloor spreading that began in latest Precambrian time and continued into Ordovician time. In the Canadian part of the province, the passive margin sequence is overlain by a thick succession of Devonian clastic strata shed from uplifts produced by the Caledonian collision between Laurentia and Baltica that closed Iapetus Ocean. The late Silurian to Early Devonian Boothia-Cornwallis uplifts within the region, apparently a distal effect of earlier phases of the Caledonian collision, were local sources of clastic wedges within the predominantly carbonate shelf sequence. Much of the northern part of the province was subjected to folding and thrusting during Late Devonian to earliest Carboniferous Ellesmerian deformation, followed by a prolonged period of erosion. The eastern part of the province again experienced transpressive and compressive deformation as Greenland converged with North America during the early Tertiary Eurekan orogeny.

Potential source rocks include Ordovician to Lower Devonian shales that contain abundant oil-prone organic matter, deposited on the outer continental shelf and slope. The most likely source rocks are Silurian strata, deposited as the continental shelf was drowned by a marine transgression caused by regional subsidence most likely associated with thrust loading. Potential source rocks in Greenland also may include organic-rich Cambrian shales deposited on the continental shelf. Rapid burial by thick Caledonian-derived strata in Late Devonian time abruptly matured the source rocks and generated oil; continued rapid burial may have cracked much of the accumulated oil to gas. In North Greenland, oil generation may have resulted from burial by now-eroded Devonian strata or from burial by Ellesmerian thrust sheets. Widespread bitumen in outcrops and in exploration wells appears to confirm that oil was indeed generated.

Potential reservoirs include Cambrian nearshore clastic strata, Cambrian to Silurian carbonate bank strata, and Silurian to Middle Devonian reef buildups on the drowned shelf. Because Ellesmerian deformation postdated migration, only stratigraphic traps are likely, except in the area of the Boothia-Cornwallis uplift, a north-trending, structurally elevated zone, where structural traps formed by late Silurian to Early Devonian deformation are possible. It is unlikely that any large accumulations survived subsequent deformation or uplift and erosion.

Three assessment units were defined: the Western Franklinian Shelf, the Boothia-Cornwallis Uplift, and the Eastern Franklinian Shelf Assessment Units. These assessment units were not quantitatively assessed, mostly because of the high risk to timing and preservation.

Introduction

In 2008, the U.S. Geological Survey (USGS) completed an appraisal of undiscovered, technically recoverable, conventional oil and gas resources north of the Arctic Circle. Results of that assessment, the Circum-Arctic Resource Appraisal (CARA), include aggregate, probabilistic resource estimates for the entire Arctic region (Gautier and others, 2009, 2011) based on geological evaluation of all the basins wholly or partially north of the Arctic Circle. Basins considered to have at least a 10 percent chance of hosting an oil accumulation larger than 50 million barrels of oil (MMBO) or a gas accumulation larger than 300 billion cubic feet of gas (BCFG) were assessed using the methodology described in Charpentier and Gautier (2011) and Charpentier (this volume, chap. B). The location and extent of the basins evaluated are delimited in Grantz and others (2010, 2011). This report is a summary of the geologic information and evaluation that underlies the assessment of potential undiscovered oil and gas resources in the Franklinian Shelf Province.

Franklinian Shelf Province Description

Province Boundary Definition

The Franklinian Shelf Province consists of the lower Paleozoic passive margin of northernmost North America and Greenland, along with overlying Devonian foreland basin strata in the Canadian part of the province (fig. 1). The province extends from northwesternmost Canada near the Mackenzie Delta through the Arctic Islands and the northern Canadian mainland across Nares Strait to northern Greenland. The southern boundary of the province is defined as the unconformity along which the Paleozoic passive margin strata rest on Precambrian rocks. The boundary runs eastward near the northern coast of the Canadian mainland from the Northwest Territories to Baffin Island and along the east side of the Brodeur Peninsula on northwest Baffin Island. It skirts the western end of Lancaster Sound, crosses Devon Island to Ellesmere Island, parallels the east side of Ellesmere Island almost to its northeasternmost tip, and then follows the southern limit of Paleozoic strata across northern Greenland. The northern boundary of the province is defined as the contact of platform and overlying Mississippian and younger strata in the Canadian Arctic Islands and Greenland. Assessment units within the province project north of the province boundary in the subsurface of the Canadian Arctic Islands to the approximate position of the early Paleozoic shelf edge, now buried beneath the southern flank of the Sverdrup Basin. Southwest of the Sverdrup Basin, the northern boundary follows the northern extent of the platform sequence, where it is fragmented by Mesozoic rift basins, and continues southwest through Banks Island to an arbitrary junction with the northern boundary of the Northern Interior Basins Province.

Tectonic Evolution

Neoproterozoic northern Canada and Greenland are thought to have been part of a large intracratonic basin within the supercontinent Rodinia (Li and others, 2008). Between 1,270 Ma and 723 Ma, this basin accumulated fluvial and shallow marine sediments derived from the Grenville orogen far to the southeast in what is now eastern North America (Rainbird and others, 1996, 1997). Most reconstructions of Rodinia place Arctic Alaska adjacent to northern Canada, with Siberia beyond (for example, Li and others, 2008), indicating that the basin probably extended some distance to the north. Mafic, possibly plume-associated magmatism in northern Canada at 780 Ma and 723 Ma (Heaman and others, 1992; Harlan and others, 2003) signaled the impending breakup of Rodinia, although the precise time of the onset of Neoproterozoic seafloor spreading is uncertain. Breakup is bracketed by the eruption of basalt in the intracratonic basin at 723 Ma and by marine deposition in Early Cambrian time (Dewing and others, 2004). Dike swarms dated as 600 Ma farther south in the Appalachian orogen signal separation of the Laurentia and Baltica continents and likely beginning of oceanic crust generation in the intervening Iapetus Ocean at about that same time (Gee and others, 2008). Deposition of a Cambrian through Lower Devonian passive margin sequence followed, accumulating to as much as 9 kilometers (km) (Trettin and others, 1991; Higgins and others, 1991) of carbonate and mudstone with subordinate sandstone. Subduction of Iapetus oceanic crust beneath both Laurentia and Baltica probably began in Early Ordovician time (Dewing and Nowlan, 2006; Gee and others, 2008). By middle Silurian time, the Iapetus Ocean had closed, and sediments eroded from resulting uplifts were accumulating on the continental slope north of Greenland as the Peary Land Group, an extensive west-prograding submarine fan complex (Surlyk and Hurst, 1984). In late Silurian to Early Devonian time, Baltica underthrust Laurentia, creating the Caledonian collisional belt in what is now east Greenland and Scandinavia (Gee and others, 2008). During this collisional event in the late Silurian, a sliver of Proterozoic crust and overlying Paleozoic strata—the Pearya Terrane (Trettin, 1987; fig. 1)—accreted to northern Ellesmere Island.

To the south, the north-south trending Boothia-Cornwallis and Inglefield basement uplifts in northeastern Canada and northwestern Greenland were formed, apparently as a distal effect of concurrent Caledonian collision farther east. The uplifts shed local accumulations of sand and conglomerate into flanking lows during late Silurian to Early Devonian time (Okulitch and others, 1986; Okulitch, 1991; Smith and Okulitch, 1991; de Freitas and Mayr, 1993). In Middle and Late Devonian time, great volumes of clastic strata prograded southwestward from the Caledonian collisional welt, burying the Arctic passive margin under a foreland basin clastic wedge that approached 7 km in thickness (Embry, 1991; Patchett and others, 2004, Anfinson and others, 2013). During the later stages of clastic wedge deposition, the Ellesmerian orogeny, a relatively brief Late Devonian to Early Mississippian compressional event of uncertain origin, created a south-verging thrust belt along the former early Paleozoic shelf margin (Fox, 1985; Soper and Higgins, 1990; Okulitch, 1991; Harrison, 1995a, b; Higgins and others, 1998).

After Ellesmerian deformation ended, a Carboniferous episode of rifting, subsidence, and volcanism took place along the northern margin of the province in Canada, forming the Sverdrup Basin, evidenced by normal faulting and deposition of nonmarine lacustrine strata, alluvial and fluvial red beds, and evaporites. Marine transgression followed, with deposition of mostly shallow marine and deltaic strata in the Sverdrup Basin. Deposition continued from late Paleozoic through Mesozoic time, burying the northern flank of the Franklinian sequence to depths as great as 13 km. Similar sequences were deposited in areas to the east, in the Wandel Sea Basin (Håkansson and others, 1991) and probably in the Lincoln Sea (Sørensen and others, 2011). In Jurassic and Early Cretaceous time, rifting and seafloor spreading began north of the Sverdrup Basin, forming the Amerasian Basin of the Arctic Ocean, with intrusion of mafic dikes and normal faulting on the former Franklinian Shelf as a distal effect. Following this period of extensional tectonism, a major deformational episode began in Paleocene time and lasted through the Eocene. Contraction produced the southwest- and west-vergent Eurekan thrust belt in the eastern part of the province, where thrusts have lower Paleozoic strata in their hanging walls and Paleogene strata in their footwalls. Farther west, milder deformation prevailed, with uplift, folding, and faulting as far west as Prince Patrick Island (Harrison and Brent, 2005). Eurekan deformation was a result of relative motion between Greenland and North America as the Labrador Sea opened, beginning as transpression in Paleocene time about 62 Ma and transitioning to compressive motion that lasted until near the end of Eocene time (Harrison and others, 1999).

Province Stratigraphy and Structural Geology

Cambrian through Lower Devonian shelf strata of the Canadian part of the Franklinian Shelf Province (fig. 2) form a north-thickening wedge of mostly carbonate and shale that reaches total thicknesses of 9 to 10 km near the shelf edge, beyond which it grades to deepwater slope deposits of the

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Figure 1. Index map showing location of Franklinian Shelf Province (tan line) and the three defined assessment units (AUs) (dashed purple lines). The assessment units extend north in the subsurface to the lower Paleozoic shelf edge, beyond the surface boundary of the Franklinian Shelf Province with the overlying Sverdrup Basin Province. The province consists of the lower Paleozoic continental shelf, composed predominantly of Cambrian through Lower Devonian carbonates and shale, and overlying Middle to Upper Devonian clastic strata. Locations of cross sections in figures 4 and 5 are shown.

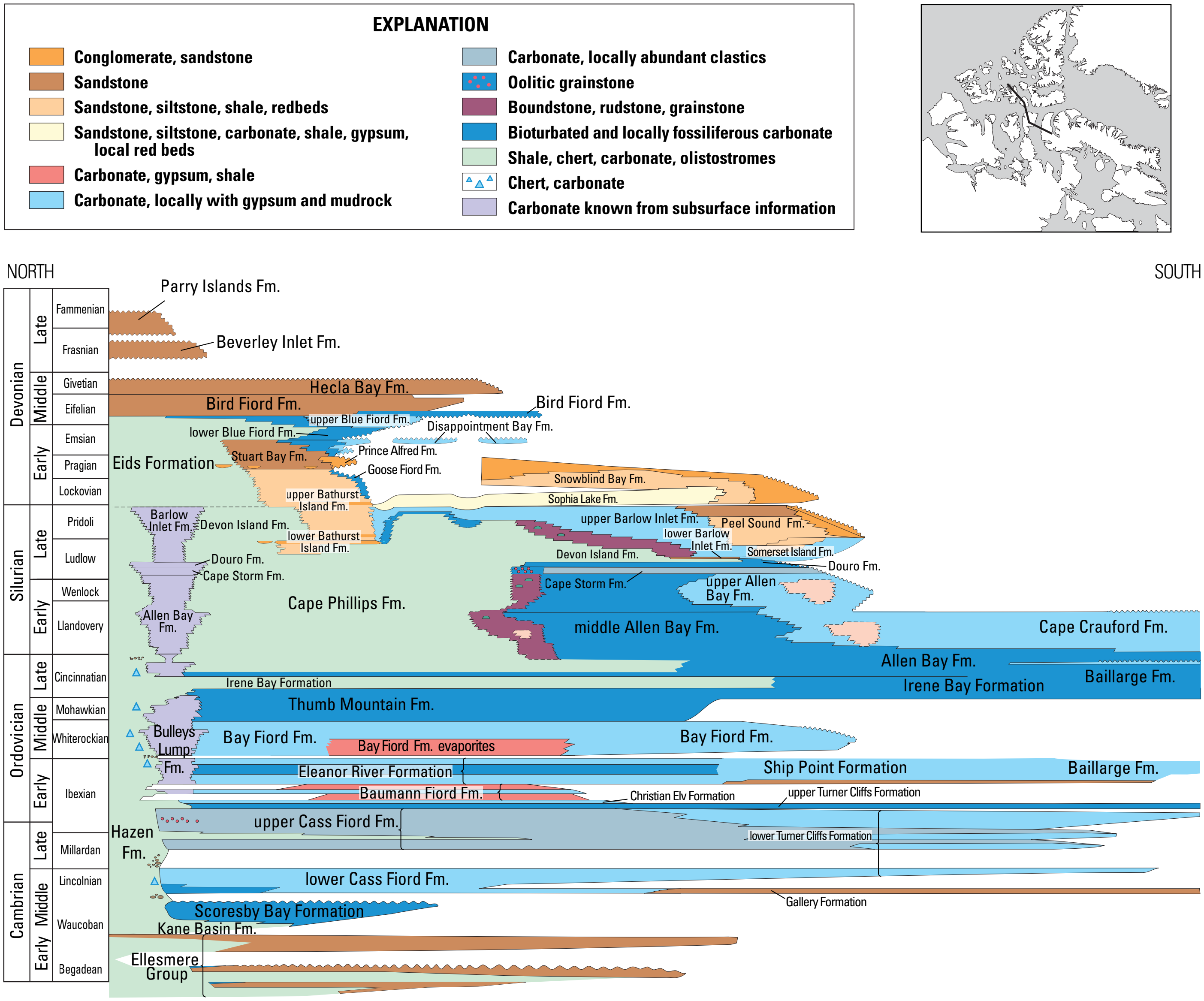

Figure 2. Stratigraphic chart for central part of Franklinian Shelf Province, modified from Dewing and Embry (2007). Fm., Formation.

Hazen Formation (Trettin and others, 1991; Harrison, 1995a). Thin, craton-derived shallow marine quartzose and arkosic sandstones are also present, particularly in the lower part of the wedge. The carbonate rocks consist dominantly of limestone and dolomite deposited on banks and reefs and calcareous mudstone deposited in deeper water between the banks. Cambrian and lower Lower Ordovician strata were deposited on an essentially planar carbonate ramp that terminated in a steep slope to the north. Later in Early Ordovician time, a string of shelf-edge carbonate buildups grew, isolating the shelf from the open ocean and leading to deposition of Ordovician evaporite and associated dolomite in intrashelf basins (Lower Ordovician Baumann Fiord and the Lower to Middle Ordovician Bay Fiord Formations). In Late Ordovician time, water depths increased, and a rim of "keep-up" reefs grew on the drowned shelf edge. The Silurian through Lower Devonian part of the shelf sequence is characterized by these shelf-edge buildups, the position of which shifted through time (de Freitas and others, 1992, 1993, 1999). An organic-rich mudstone shelf facies, the Cape Phillips Formation and equivalents, was deposited in the area between the buildups and the shallow-water carbonate strata (fig. 2).

Lower Paleozoic stratigraphy in northern Greenland (fig. 3) is similar to that of northern Canada, except for a greater proportion of coarse clastic strata in the Silurian part of the section. Lower to Middle Cambrian shallow marine clastic and dolomitic strata rest on crystalline basement or on Proterozoic strata and are overlain by an Upper Cambrian through lower Silurian carbonate platform, typically 3,000 to 4,000 meters (m) thick (Dawes and Soper, 1973; Christiansen, 1989; Higgins and others, 1991, Henriksen and Higgins, 1998). The carbonate platform was bounded on the north by a steep slope, the Navarana Fjord escarpment, north of which a much thinner sequence of starved-basin slope and basinal fine-grained mudstones was deposited. In early Silurian time, turbidites derived from the nascent Caledonian collisional belt to the east began to accumulate at the foot of the Navarana Fjord escarpment, forming a thick and extensive submarine fan system that has a thickness as great as 5,000 m (Hurst and others, 1983; Henriksen and Higgins, 1998). The fan system rapidly filled the offshore basin, loaded the continental margin, and lapped southward over the Navarana Fjord escarpment, drowning the carbonate bank and triggering the growth of more “keep-up” carbonate reef buildups as much as 800 m thick along the northern rim of the shelf (de Freitas and Nowlan, 1998). Upper Silurian (Ludlovian) strata include chert conglomerates shed from uplifted and eroded Ordovician starved-basin deposits as far as 600 to 800 km to the east (Henriksen and Higgins, 1998). Although strata younger than earliest Devonian are absent, Devonian rocks derived from the Caledonian orogenic belt may have been widely deposited across Greenland and later eroded (Patchett and others, 2004).

The north-trending Boothia-Cornwallis Uplift (Miall, 1986; Okulitch and others, 1986, 1991; de Freitas and Mayr, 1993; Dewing and others, 2007b; Jober and others, 2007) transects the province in the area of the Boothia Peninsula and Somerset, Cornwallis, and northwesternmost Devon Islands (fig. 1). A north-plunging core of Archean basement is exposed on the Boothia Peninsula beneath an arched carapace of shelf strata. These shelf strata are complexly deformed on the crest and flanks of the uplift. Flanking wedges of clastic sediments of late Silurian to Early Devonian age (Bathurst Island and Peel Sound Formations) were shed from the uplift into the adjacent shelf basin during deformation. Miall (1986) and Okulitch and others (1986, 1991) characterized the uplift as a distal effect of the Caledonian orogeny.

Throughout the northern Canadian Arctic Islands (but not northern Greenland) a thick sequence of Middle and Upper Devonian sandstone, mudstone, and conglomerate overlies the older carbonate shelf strata. Although its preserved thickness is about 4 to 5 km (Embry, 1991; Harrison, 1995a), its original thickness may have been significantly greater. Embry (1991) and Patchett and others (2004) estimated original thicknesses of 8 to 10 km, although Anfinson and others (2013) concluded that the maximum thickness was probably less than 7 km. In either case, burial by such great thickness is a crucial element in the timing of petroleum generation. Devonian strata probably covered the entire area of the Canadian Arctic Islands and northern Greenland but have been at least partially or in some areas completely eroded. These rocks indicate fluvial, deltaic, shallow marine, and slope environments arranged in an elongate, generally southwest-prograding wedge that encroached over the region from Caledonian uplifts that lay to the northeast in Greenland (Embry, 1991). Sandstone and mudstone are the dominant lithologies, but locally, in an area on northeastern Banks Island, exposed limestone reef strata that formed on progradational deltaic lobe deposits of the clastic wedge (Embry and Klovan, 1971; Copper and Edinger, 2009) present a possible analog for potential subsurface reservoir units elsewhere in Middle and Upper Devonian clastic wedge strata.

West of the northern part of the Boothia-Cornwallis Uplift is the Parry Islands fold belt. This Ellesmerian fold-thrust belt lies on a major detachment surface within Ordovician salt of the Bay Fiord Formation (Fox, 1985; Harrison, 1995a, b). Subsalt strata are deformed by south-verging thrusts and anticlines, but strata overlying the salt are folded into upright, concentric folds cut by reverse faults and duplexes (Harrison, 1995a; fig. 4). Devonian clastic wedge strata are involved in the deformation, which began near the end of Devonian time and lasted into early Carboniferous time. On the crest of the Boothia-Cornwallis Uplift, where Ellesmerian deformation transects older, Early Devonian folds, there is complex interference fold geometry (Jober and others, 2007; Dewing and others, 2007b). In Canada, east of the Boothia-Cornwallis uplift, Devonian and older rocks were also folded and thrust during Ellesmerian deformation (Okulitch, 1991). As in the Parry Islands fold belt, detachments are typically located within evaporites (Harrison and others, 1995; fig. 5), although the halite of the Parry Islands fold belt is not present. In North Greenland, Ellesmerian deformation produced open, upright folds and south-vergent thrusts within the carbonate platform strata, whereas in the thicker basinal section to the north, folds are tighter and north-vergent, the level of exposure is deeper, and the metamorphic grade is as high as amphibolite facies (Higgins and others, 1998).

Lower Paleozoic Composite Total Petroleum System

In the western part of the province, a principal potential source rock sequence is the widely present black graptolitic shale of the Upper Ordovician to Lower Devonian, chiefly Silurian Cape Phillips Formation. In the far westernmost part of the province, the equivalent Lower Devonian Eids Formation, Ordovician to Lower Devonian Ibbett Bay Formation, and upper Silurian to Lower Devonian Kitson Formation contain the most promising source rocks. They contain as much as 7 weight percent total organic carbon (TOC), mainly in oil-prone Type II organic matter (Powell, 1978; Dewing, 2006; Obermajer and others, 2007). Conodont color alteration indices (CAI) and graptolite reflectance data, however, indicate widespread overmaturity. An exception is that in areas near the lower Paleozoic shelf edge and on the Boothia-Cornwallis uplift, which was topographically high in Devonian time and not as deeply buried by the Devonian clastic wedge, somewhat lower maturity levels prevail (fig. 6; Goodarzi and others, 1992; Gentzis and Goodarzi, 1993; Stasiuk and Fowler, 1994; Gentzis and others, 1996; Dewing and others, 2007a; Harrison and others, 2008). The level of thermal maturity is also low in the southern part of the province and increases northward across a sharp gradient (Gentzis and others, 1996; Harrison and others, 2008) that probably represents the southern margin of thick Devonian strata.

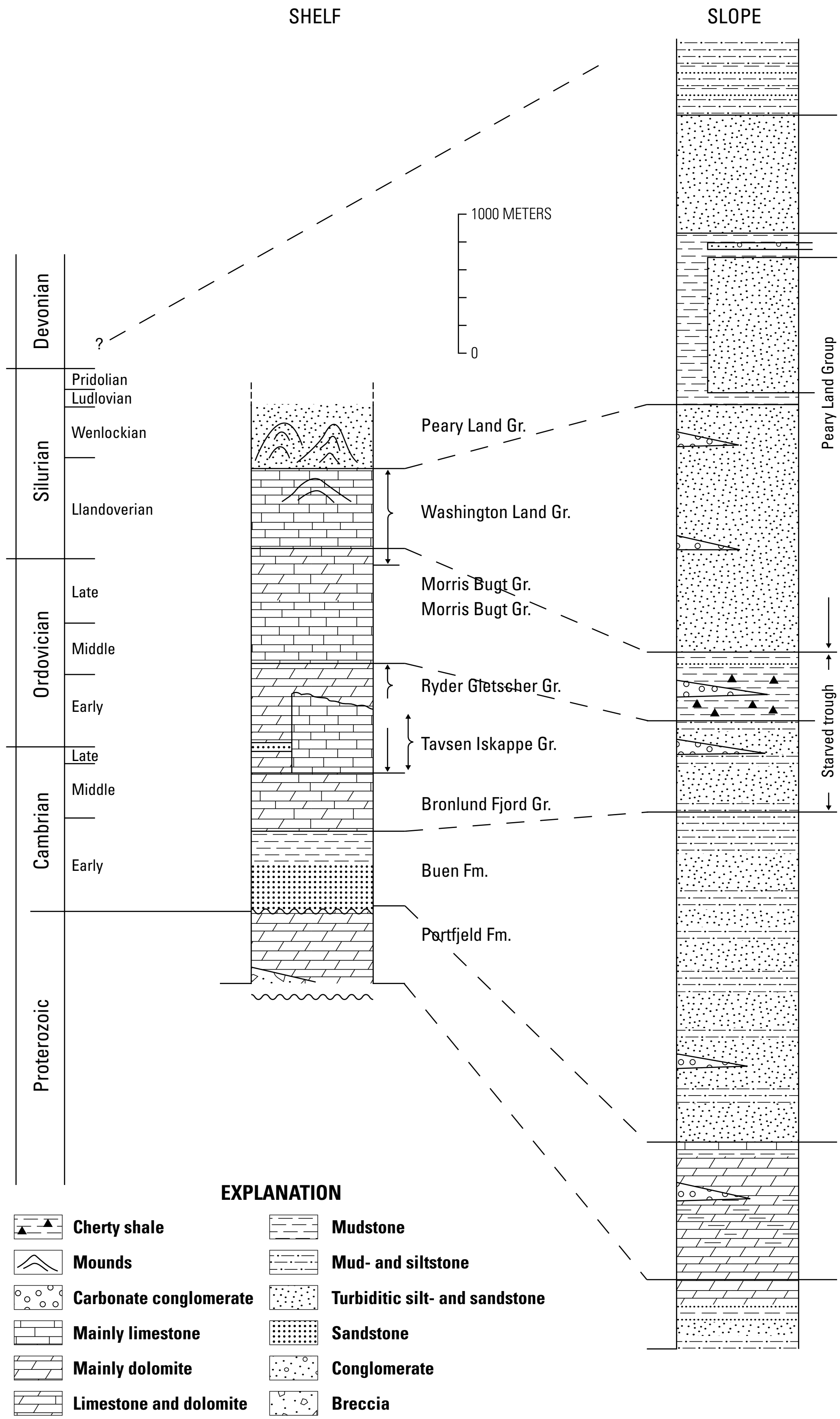

Figure 3. Stratigraphic columns in North Greenland showing typical stratigraphy on shelf (left column) and on continental slope and rise (right column). Modified from Henriksen and Higgins (1998). Base of Cambrian is shown at approximately the top of the Portfjeld Formation, rather than below Portfjeld Formation as in Henriksen and Higgins (1998, fig. 2), in accord with recent stratigraphic revisions (Dewing and others, 2004, 2008). Gr., Group; Fm., Formation.

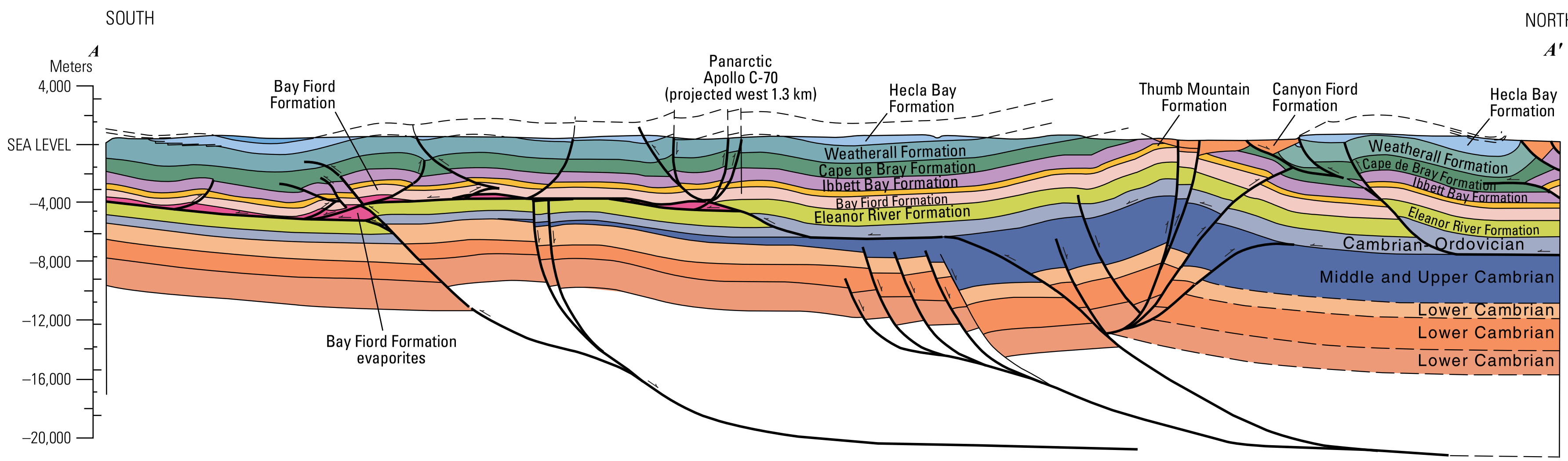

Figure 4. Cross section *A–A′* across Melville Island. Approximate location of section shown on figure 1. Down-to-the-north fault offsets within Cambrian strata demonstrate minor extension associated with passive margin formation. Some of these faults were apparently reactivated as reverse faults during subsequent Ellesmerian deformation in the Late Devonian. Ellesmerian folding and reverse faulting in Ordovician and younger rocks was detached on Ordovician Bay Fiord Formation halite in the area depicted on the southern half of section, whereas Ellesmerian deformation to the north, where the halite is absent, involved the entire lower Paleozoic section. The upper Carboniferous Canyon Fiord Formation, shown in orange at the surface toward the north end of the section, was deposited unconformably across eroded Ellesmerian structures during incipient Sverdrup Basin extension. Modified from Harrison (1995a).

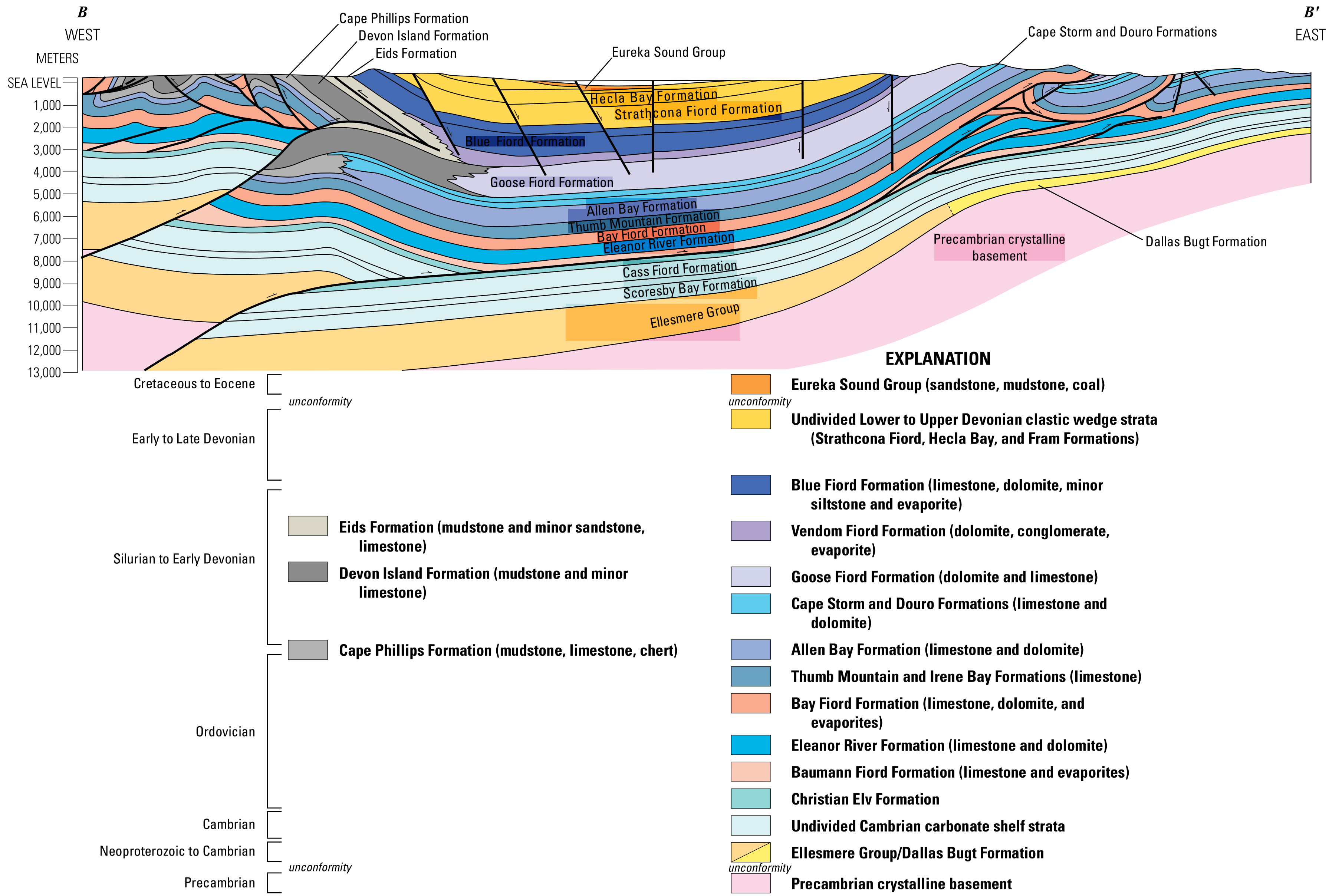

Figure 5. Cross section *B–B′* on Ellesmere Island. Approximate location of section is shown on figure 1. Folding and thrusting are presumably mostly Ellesmerian in age, but Paleogene reactivation during Eurekan deformation cannot be ruled out; farther east on Ellesmere Island, Paleocene strata are involved in thrusting. Modified from Thorsteinsson and others (2009).

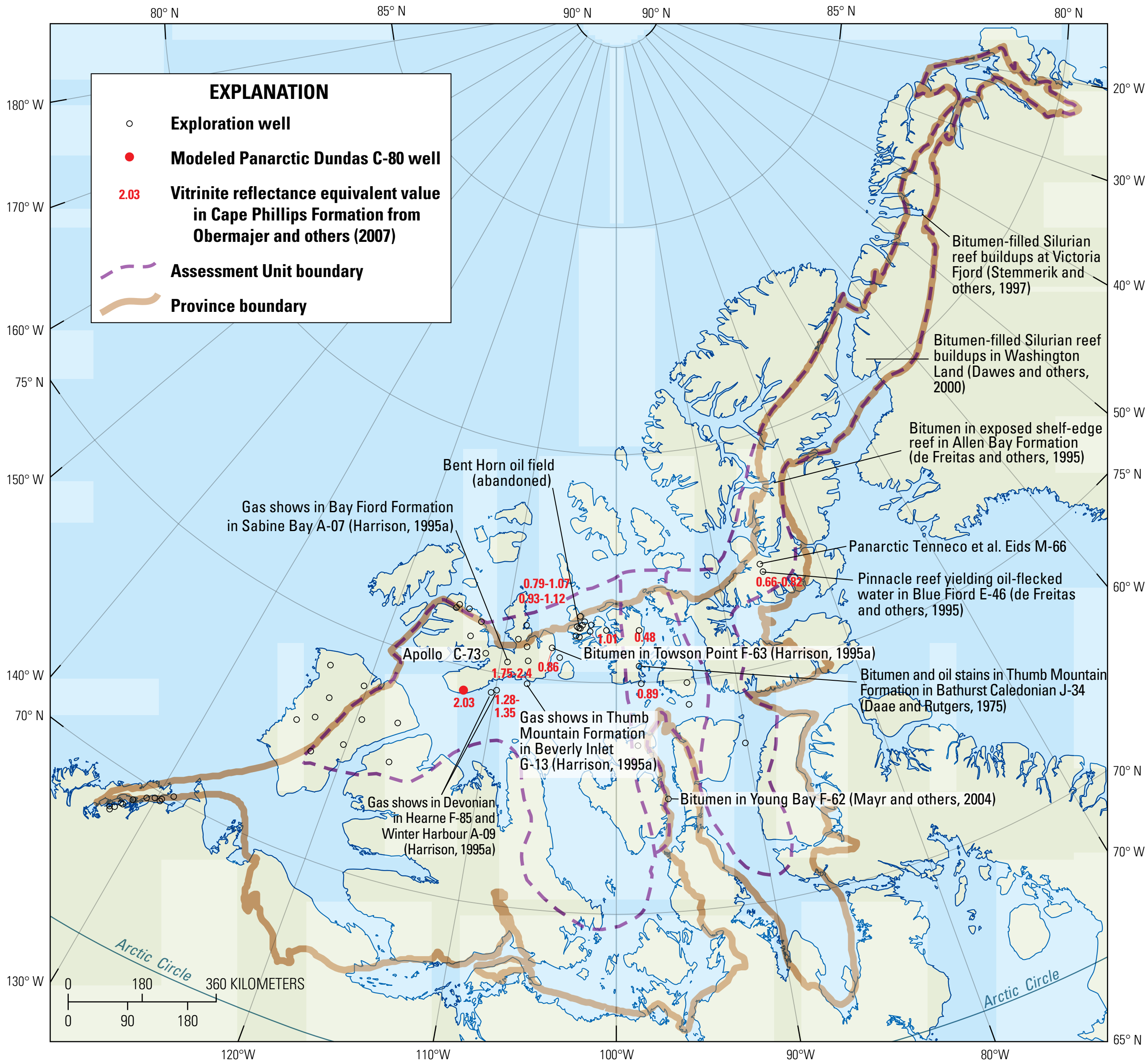

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Figure 6. Map of Composite Lower Paleozoic Petroleum System, showing locations of exploration wells that penetrated lower Paleozoic strata, indications of oil or gas in wells and surface outcrops, location of Bent Horn oil accumulation, and levels of thermal maturity of Cape Phillips Formation and equivalent strata penetrated in exploration wells, from Obermajer and others (2007). Panarctic Dome Dundas C-80 well was the source of stratigraphy and thermal maturity indicators used in petroleum generation modeling.

Bitumen and oil staining are widely present in lower Paleozoic strata in the Canadian part of the province, indicating that oil was once present. In a study of graptolite and bitumen reflectance in lower Paleozoic strata, Gentzis and others (1995, 1996) documented evidence of both lower-reflecting, pore-filling bitumen and higher-reflecting remnant graptolites in shales of the Cape Phillips Formation. The lower-reflecting bitumen was interpreted as evidence of migration of oil through the shale, whereas the higher-reflecting graptolites probably represent remnants of the original source macerals. Bitumen also locally fills porosity in shelf margin carbonates and isolated pinnacle reefs of the Silurian Allen Bay Formation on Ellesmere Island (de Freitas and others, 1995). Oil stains are present in Ordovician carbonates of the Thumb Mountain Formation (Rayer, 1981). Gas yields from subsurface penetrations of the Cape Phillips Formation are typically high (Powell, 1978).

Reconstruction of burial history and petroleum generation by Skibo and others (1991) for two wells on Melville Island (Panarctic Dome Dundas C-80 and Panarctic Apollo C-73) in the western part of the province, using the modeling program MATOIL, indicated that rapid, deep burial by Devonian strata derived from the eroding Caledonides caused oil generation beginning shortly after 380 Ma. Skibo and others (1991) estimated a minimum of 1,800 m of erosion of the upper part of the clastic wedge in the Panarctic Dome Dundas C-80 well and 4,235 m in the Panarctic Apollo C-73 well. The Panarctic Dundas C-80 well is just south of the Parry Islands fold belt, and the Panarctic Apollo C-73 well lies farther north within the deformed zone. We made a similar model of one of the same wells (Panarctic Dome Dundas C-80) for this study, instead using PETROMOD software. We found that significantly more erosion of the upper part of the clastic wedge—3,200 m—was required to match the vitrinite reflectance (R_o) values of strata penetrated in the well. Nevertheless, our results are otherwise very similar to those of Skibo and others (1991) and corroborate their conclusions. Oil generation is estimated to have taken place between about 380 and 360 Ma (fig. 7). Shortly thereafter, some of the generated oil would probably have begun to crack to gas. Using an entirely different approach, Selby and others (2005) dated bitumen in the Upper Ordovician Thumb Mountain Formation using ^{187}Re–^{187}Os geochronometry and concluded that the bitumen formed at 375±9 Ma, in excellent agreement with the timing of petroleum generation indicated by burial history modeling.

In Greenland, Silurian strata of the Peary Land Group have similar source potential to that of the Cape Phillips Formation and equivalents in Canada. In particular, the lower Silurian Lafayette Bugt Formation and Thors Fjord Member of the Wulff Land Formation are especially rich in oil-prone organic matter, with 2 to 6 weight percent TOC (Christiansen, 1989; Christiansen and others, 1991). In addition, the Cambrian Henson Gletscher Formation contains 2 to 5 weight percent TOC (Christiansen, 1989; Christiansen and others, 1991). Along the southern edge of the Paleozoic sequence, where it rests on Precambrian rocks, maturity levels are low, but maturity increases abruptly northward across a steep gradient that probably represents the edge of the area once buried by now-eroded Ellesmerian thrust sheets or by thick Devonian foreland basin strata.

As is the case in Canada, bitumen is widely present in northern Greenland. In Cambrian rocks, bitumen occurs in vuggy, veined dolomite and as stains in sandstone. In Silurian strata, bitumen is present in veins, vugs, or corals in debris-flow carbonate conglomerates (Christiansen and others, 1989a) or in bitumen-filled reefs (Stemmerik and others, 1997; Dawes and others, 2000). Christiansen and Hansen (1989) and Christiansen (1990) concluded from a variety of geological evidence that petroleum generation took place from late Silurian time through the time of the Late Devonian to earliest Mississippian Ellesmerian orogeny. No petroleum generation modeling studies using modern software have been published for northern Greenland. The thick Devonian clastic wedge sequence that matured Canadian source rocks is absent in Greenland but was inferred by Patchett and others (2004) to have been originally present and subsequently eroded. If this is correct, maturation history in northern Greenland was probably similar to that for the part of the province in Canada.

Potential reservoir lithologies in Greenland are dominantly carbonate rocks, although sandstone reservoirs could be present in Cambrian strata. Cambrian and Ordovician limestones and dolomites within the carbonate bank sequence could be reservoirs if they have sufficient porosity and permeability. However, the high degree of thermal maturation may have caused diagenetic degradation of any porosity and permeability that was originally present. In Silurian strata, the best potential reservoirs are carbonate reefs that grew upward from the drowned older shelf. These rocks form excellent traps because they are enclosed and sealed by shales.

Ellesmerian folds and faults in northern Greenland probably postdate petroleum generation and accordingly may not offer viable traps; exploratory wells that penetrate Ellesmerian traps have been unsuccessful. Potential traps are probably limited to stratigraphic traps, such as reefs or stratigraphic pinchouts, and flexures or steeply dipping faults that were active during deposition. If such traps were filled during generation, later remigration of the oil into younger Ellesmerian structural traps is a possibility, but both the failure of exploratory drilling and the depth of subsequent erosion are considered to significantly reduce the likelihood of such accumulations. Although oil and gas were almost certainly generated and probably migrated into any available traps just prior to Ellesmerian deformation, much or all of it was evidently destroyed by subsequent rupturing of traps and seals during deformation, uplift, and erosion. The bitumen that is widely present in lower Paleozoic carbonate rocks probably represents the remnants of uplifted, eroded, and degraded accumulations (Hamilton and Varney, 1982; Stemmerik and others, 1997).

Assessment Units

Three assessment units (AUs) were defined in the Franklinian Shelf Province (fig. 1). The Western Franklinian Shelf AU includes the part of the province west of the Boothia-Cornwallis uplift and comprises both undeformed Cambrian through Lower Devonian platform strata and folded and thrusted Cambrian through Upper Devonian rocks of the Parry Islands fold belt. The Eastern Franklinian Shelf AU lies east of the Boothia-Cornwallis uplift and is similar to the Western Franklinian Shelf AU, with undeformed platform strata on the south and a fold belt to the north. Because the geology of the northern part of Greenland is continuous with that of Ellesmere Island in northeasternmost Canada, the Franklinian shelf in North Greenland is included in the Eastern Franklinian Shelf AU. The third AU, the Boothia-Cornwallis AU, comprises strata affected by late Silurian to Early Devonian deformation probably associated with the Caledonian orogeny.

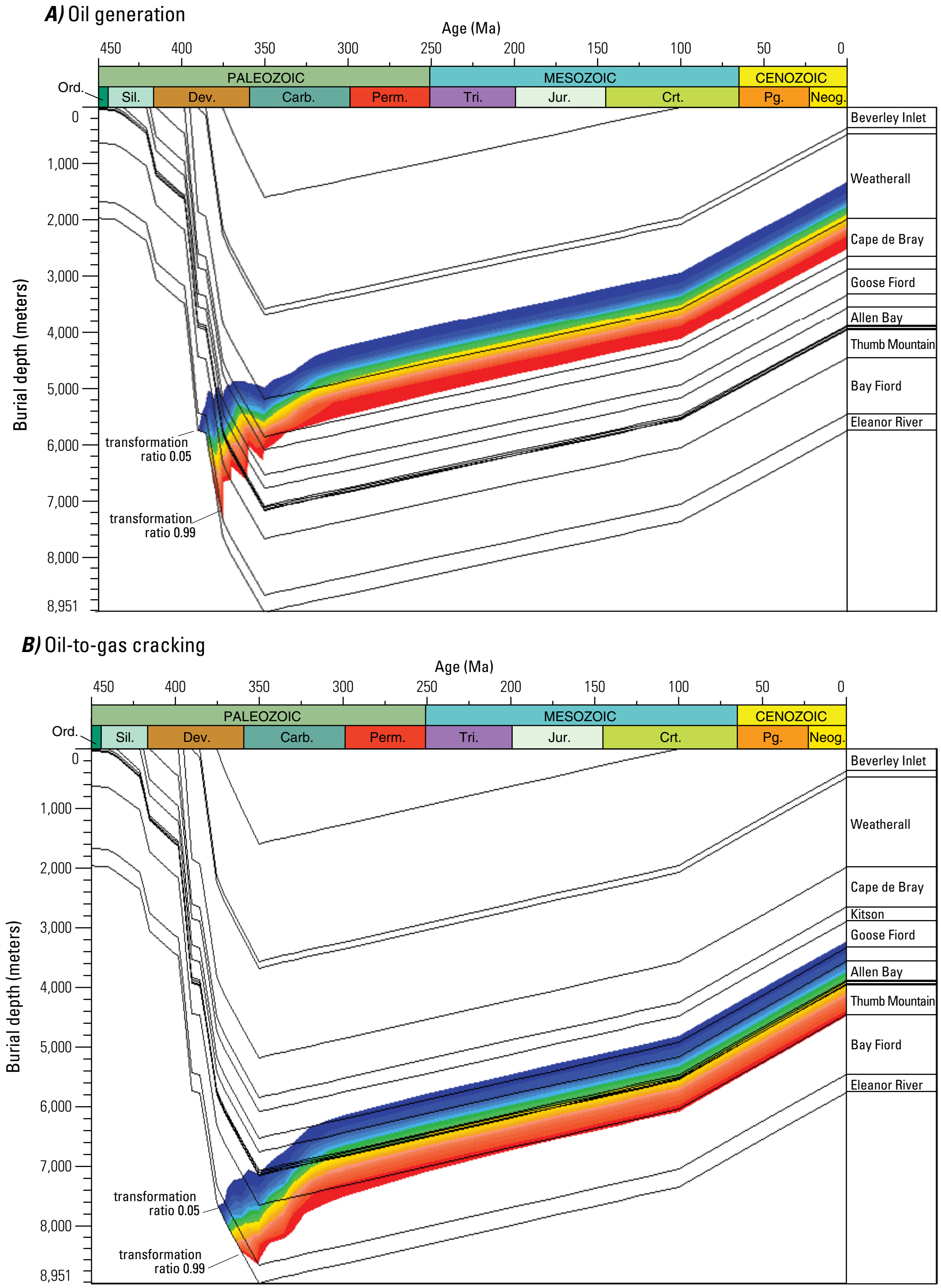

Figure 7. Petroleum generation model for Panarctic Dome Dundas C-80 well, assuming estimated 3,200 meters of erosion of Devonian clastic wedge strata of the Beverley Inlet and Parry Islands Formations. Color bands superimposed on burial history indicate successive levels of transformation from kerogen to oil and from oil to gas, respectively, in *A* and *B*. *A*, Oil generation began (transformation ratio 0.05) in Late Devonian time in shale of the Cape Phillips Formation (between Thumb Mountain and Allen Bay Formations) and other lower Paleozoic source rocks and was complete before the end of Devonian time (transformation ratio 0.99). *B*, Oil began cracking to gas at the end of Devonian time (transformation ratio 0.05) and was completely cracked to gas (transformation ratio 0.99) during Carboniferous time. Ord., Ordovician; Sil., Silurian; Dev., Devonian; Carb., Carboniferous; Perm., Permian; Tri., Triassic; Jur., Jurassic; Crt., Cretaceous; Pg., Paleogene; Neog., Neogene.

Western Franklinian Shelf AU

Exploration Maturity.—An extensive set of seismic reflection surveys was collected during a petroleum exploration campaign in the late 1960s through the mid-1980s; no modern or three-dimensional seismic data had been collected as of the time of this assessment. About 30 exploration wells were drilled to test prospects within this AU. One small oil accumulation was discovered, but it contains less than the minimum volume (50 MMBO) assessed in this study.

AU Description

The Western Franklinian Shelf AU includes the sedimentary section from the base of the Paleozoic to the top of Devonian clastic wedge strata. The petroleum system includes oil and gas generated from Ordovician through Devonian, mainly Silurian, organic-rich shale during burial by thick Upper Devonian clastic strata. Stratigraphic traps in carbonate rocks are the most likely trap type. Rocks in this AU have been penetrated in about 30 exploratory wells both onshore and offshore. In map view, the AU is bounded on the south by the 1.5 km isopach of the Franklinian shelf sequence as shown by Grantz and others (2010), on the north by the approximate northernmost position of the shifting lower Paleozoic shelf edge, and on the east by the approximate western limit of Early Devonian deformation associated with the Boothia-Cornwallis uplift. One oil discovery smaller than minimum size, the Bent Horn oil field, was found on southwestern Cameron Island (figs. 1, 6; Obermajer and others, 2009). The field is abandoned, with cumulative production of about 2.8 MMBO, 43° API oil, from fractured Devonian reef limestone.

Geologic Analysis of Assessment Unit Probability

The likelihood that the Western Franklinian Shelf AU contains at least one accumulation greater than the minimum field size of 50 million barrels of oil equivalent (MMBOE) is estimated to be less than ten percent, the minimum for quantitative assessment, based on the following interpretation of petroleum system/AU elements.

Charge.—(0.9) The probability of adequate charge was estimated to be very good, 0.9. Good potential source rocks are present within the lower Paleozoic section, although they are overmature in part of the area. Upper Ordovician to Lower Devonian black graptolitic shales of the Cape Phillips Formation and equivalent strata commonly contain several weight percent TOC and locally almost 7 weight percent TOC (Powell, 1978; Obermajer and others, 2007). The uppermost Silurian to lowermost Devonian Kitson River Formation in the western part of the AU, equivalent to the uppermost Cape Phillips Formation, consists of graptolitic shale that is similarly rich in organic matter, with 2 to 6 weight percent TOC (Powell, 1978; Obermajer and others, 2007). Organic matter is reported as Type II by Dewing (2006) on the basis of Rock-Eval analyses.

Bitumen is present in fractures in carbonates of the Middle Devonian Blue Fiord Formation at surface localities on eastern Melville Island and in Lower Devonian and Silurian carbonates in the Panarctic Towson Point F-63 well on the east coast of Melville Island (Harrison, 1995a). Porous dolomite of the Upper Ordovician Thumb River Formation is oil-stained in the Panarctic Towson Point F-63 well (Daae and Rutgers, 1975). Minor gas shows were present in a few wells on Melville Island, in Devonian sandstones (Dome et al. Winter Harbour and Dome Panarctic et al. Hearne F-85 wells) and in the Ordovician Bay Fiord Formation (Panarctic et al. Sabine Bay A-07 well) and Thumb Mountain Formation (Panarctic et al. Beverley Inlet G-13 well) (Harrison, 1995a).

The source of the oil in the one discovered field within the AU, the abandoned 3 MMBO Bent Horn oil field, was uncertain until recently. Most workers considered it likely to have been generated from basinal lower Paleozoic shales, but because the accumulation lies stratigraphically just below rocks deposited on the southern margin of the younger Sverdrup Basin, the possibility that the oil was generated from Triassic source rocks in the Sverdrup Basin could not be ruled out. Recent oil analyses by Obermajer and others (2009) indicate that the source was probably the Cape Phillips Formation because the oil is geochemically distinct from oils generated by younger Sverdrup Basin source rocks.

Rocks.—(0.5) The probability that adequate reservoirs, traps, and seals are present was estimated to be only about 50 percent. Potential reservoir rocks consist predominantly of various types of carbonate rocks, particularly reefs and buildups. Carbonate rocks of the uppermost Ordovician through Silurian Allen Bay and Read Bay Formations, laterally equivalent to the Cape Phillips Formation source facies, include buildups on the paleoshelf edge as well as carbonate shelf strata farther south, either of which could contain reservoir facies. The Lower to Middle Devonian Blue Fiord Formation, the reservoir for the Bent Horn discovery, consists of fossil fragmental limestone with dolomite, shale, and siltstone. The Bent Horn reservoir is an isolated biohermal reef (Rayer, 1981). More reefs could be present along the paleoshelf edge in Viscount Melville Sound south of Melville Island eastward to Cornwallis Island (Harrison, 1995a). Reefs similar to those on Banks Island, anchored on Devonian clastic wedge delta lobes (Embry and Klovan, 1971; Copper and Edinger, 2009), might be another reservoir possibility if they are more widely present in the subsurface.

Lower in the section, dolomite of the Upper Ordovician Thumb Mountain Formation is locally oil stained. The Middle Ordovician Eleanor River Formation consists of shelf carbonates that have the added advantage of an overlying salt seal. Reservoir quality in these older carbonates, however, is marginal (Meneley, 2006), although flows of water and gas shows have been noted in some wells. The substantial depth of burial of the potential reservoirs during the Devonian in much of this assessment unit probably detracts significantly from reservoir quality because of diagenetic alteration.

Potential seals consist mainly of shales interbedded with reservoir strata, but seal integrity may have been compromised by erosion and deformation subsequent to trapping (Meneley, 2006). Reservoirs in the Thumb Mountain Formation would be sealed by shale of the Irene Bay Formation. The Cape Phillips Formation and equivalents are a potential seal for reservoirs in the Read Bay and Allen Bay Formations. The Cape de Bray Formation at the base of the Devonian clastic wedge is the seal for the Bent Horn oil accumulation and would be the presumed seal for undiscovered reservoirs in Middle Devonian carbonates. Traps present at the time of generation would be mostly stratigraphic.

Timing and preservation.—(0.2) Modeling for this study indicates that generation of oil from organic-rich rocks of the Cape Phillips Formation and equivalents began as maximum burial was approached at about 375 Ma, similar to modeling results reported by Skibo and others (1991) and Gentzis and others (1996), as well as to ^{187}Re–^{187}Os dating reported by Selby and others (2005). Stratigraphic traps, mainly reefs and other carbonate buildups, would have been available to trap the oil, but structural traps in the Parry Islands fold belt had not yet begun to form at the time of generation. Modeling suggests onset of cracking of oil to gas within a few million years of generation because of the extreme burial indicated by preserved stratigraphy and the amount of inferred erosion suggested by surface vitrinite maturity. Generation would have been accompanied or followed immediately by deformation and then by uplift beginning in early Mississippian time, about 350 Ma. Uplift caused erosion of significant, although poorly constrained, thicknesses of uppermost Devonian clastic wedge strata. Shallower accumulations would have been eroded, and deeper oil accumulations would have been subject to gas coming out of solution, expanding, and displacing trapped oil downward past the spillpoint of the trap. Gas accumulations would probably have been at risk of remigration or trap rupture associated with unloading. Modeling indicates removal of about 3 km of strata, indicated by the level of thermal maturity of vitrinite in surface strata, although at least some of this erosion may have taken place during early Cenozoic Eurekan deformation. The bitumen and oil staining noted in outcrops and well penetrations of potential reservoir carbonates indicates that oil and gas accumulations were probably once present but have been lost. This assessment unit is therefore considered to have a very significant risk to preservation, with any surviving accumulations being exceptions and likely to be smaller than the 50 MMBOE minimum size.

The product of the assigned probabilities for charge, rocks, and timing is 0.09, less than the minimum probability (0.1) required for quantitative assessment.

Boothia-Cornwallis Uplift AU

Exploration Maturity.—Seismic reflection data were collected in the late 1960s through the mid-1980s, but no modern seismic surveys had been conducted as of the time of this assessment. About seven exploration wells were drilled to test prospects within this AU, but no commercial discoveries resulted.

AU Description

This AU encompasses a narrow, basement-cored uplift of lower Paleozoic shelf strata that were folded and thrust along north-south trends in late Silurian to Early Devonian time, shedding clastic detritus into flanking basins. The uplift was then buried to shallow depths by strata of the Caledonian-derived Devonian clastic wedge and subsequently deformed twice: first during the Late Devonian Ellesmerian orogeny and then again, much later, by the Paleogene Eurekan orogeny. In map view, the AU is bounded on the south by the depositional limit of Paleozoic strata on Precambrian crystalline basement, on the north by the approximate position of the lower Paleozoic shelf edge, and on the east and west by the approximate limits of deformation associated with the Boothia-Cornwallis uplift.

Geological Analysis of Assessment Unit Probability

(0.09) The likelihood that the Boothia-Cornwallis Uplift AU contains at least one accumulation greater than the minimum field size of 50 MMBOE is estimated to be 9 percent, based on the following interpretation of petroleum system/AU elements.

Charge.—(0.9) Charge for this AU came from Late Devonian maturation of organic-rich mudstone of the mostly Silurian Cape Phillips Formation in the areas east and west of the uplift. On the uplift, the Cape Phillips Formation displays good source rock characteristics. In one area on Cornwallis Island, it is reported to contain as much as 9 weight percent TOC in dominantly Type I organic matter from *Tasmanites* and other algae, graptolites, and bitumen. Carbonates at the base of the formation contain bitumen (Coniglio and Melchin, 1995). On Truro Island (west of Cornwallis Island) near the crest of the uplift, the Cape Phillips Formation locally contains more than 5 weight percent TOC, consisting of Type I and Type II organic matter, and has an average thermal maturity equivalent to R_o of 0.67 percent (Stasiuk and Fowler, 1994). The Lower Devonian Disappointment Bay Formation is also a potential source rock, with up to 2.4 weight percent TOC in Type I and Type II organic matter; maturity is equivalent to R_o of 0.55 percent, and the rocks show evidence of early petroleum generation (Stasiuk and Fowler, 1994). West of the uplift, maturity levels are higher (Obermajer and others, 2007). This suggests that east and west of the uplift, the Cape Phillips Formation generated petroleum by the time of maximum burial beneath the Devonian clastic wedge. Bitumen was observed in all seven wells drilled in this AU (Obermajer and others, 2007). “Dead bitumen” was reported in the Allen Bay Formation in the KMG Decalta Young Bay F-62 well (Mayr and others, 2004). “Bitumen and spotty oil stains” were reported from limestone and dolomite of the Upper Ordovician Thumb Mountain Formation in the Dominion Explorer Bathurst Caledonian J-34 well (Daae and Rutgers, 1975).

Rocks.—(0.5) Potential reservoir units include (1) Ordovician platform carbonates in the Eleanor River Formation, sealed by evaporites of the overlying Bay Fiord Formation, with petroleum trapped in anticlines or fault traps; (2) Ordovician platform carbonates in the Thumb Mountain Formation, sealed by shale with petroleum trapped in anticlines or fault traps; (3) Upper Silurian to Lower Devonian nonmarine to deep marine clastic strata shed from the Boothia-Cornwallis uplift, in either stratigraphic or structural traps; and (4) carbonate banks, reefs, and buildups (Silurian to Devonian Read Bay, Allen Bay, and Blue Fiord Formations) along and seaward of the shelf edge that wrapped around the west flank and northern nose of the uplift.

Dolomite of the Allen Bay Formation, the target reservoir in the KMG Decalta Young Bay F-62 well on Prince Edward Island, showed porosity on logs and flowed watery drilling mud (Mayr and others, 2004). The Dominion Explorer Bathurst Caledonian J-24 well tested salt water on a drill stem test of the Thumb Mountain Formation (Daae and Rutgers, 1975). Despite these occurrences, however, the results of exploration indicate that porosity development is generally poor.

Timing and preservation.—(0.2) Cape Phillips Formation source rocks on both sides of the uplift matured as they were buried under the Middle to Upper Devonian clastic wedge, after the Boothia-Cornwallis Uplift and associated folds and faults had formed in late Silurian to Early Devonian time. Petroleum generated from source rocks of the Cape Phillips Formation could have migrated upward into the slightly older structural traps on the flanks of the uplift, as long as faults on the flanks did not act as barriers to migration. Carbonate shelf edge and reef traps would have been in place at the time of migration, as would stratigraphic or structural traps in the uplift-derived clastic rocks. Although late Silurian timing seems favorable, subsequent Devonian-Mississippian Ellesmerian and Paleogene Eurekan deformations present significant risk to preservation. The effects of these deformational events (Okulitch and others, 1986, 1991; de Freitas and Mayr, 1993; Harrison and others, 1993; Jober and others, 2007) were likely sufficient to destroy traps or allow the escape of accumulated petroleum, as indicated by bitumen and oil staining.

The product of the assigned probabilities for charge, rocks, and timing is an overall assessment unit probability of 0.09, less than the minimum probability (0.1) required for quantitative assessment.

Eastern Franklinian Shelf AU

Exploration Maturity.—Seismic reflection data have been collected, mainly in the Canadian part of the AU. About 7 exploration wells were drilled to test prospects within the Canadian part of this AU, but no discoveries resulted.

AU Description

The Eastern Franklinian Shelf AU encompasses eastern Devon and Ellesmere Islands in Canada and northern Greenland. It includes the sedimentary section from the base of the Paleozoic to the top of the uppermost Devonian strata, consisting of both undeformed strata of the Arctic platform on the south and rocks deformed during the middle Paleozoic Ellesmerian and early Tertiary Eurekan orogenic events in the north. In map view, the Canadian part of the AU is bounded on the south and east by the approximate location of the 1.5 km isopach of Franklinian shelf strata as shown by Grantz and others (2010), on the north by the approximate position of the early Paleozoic shelf edge, and on the west by the eastern limit of Silurian to Devonian deformation associated with the Boothia-Cornwallis uplift. In North Greenland, where regional isopachs are not available, the entire area underlain by lower Paleozoic strata is included in the AU.

Geological Analysis of Assessment Unit Probability

The likelihood that the Eastern Franklinian Shelf AU contains at least one accumulation greater than the minimum field size of 50 MMBOE is estimated to be 9 percent, based on the following interpretation of petroleum system elements.

Charge.—(0.9) The presence of mature source rocks, along with bitumen and oil shows in wells and surface outcrops, indicates that petroleum was almost certainly generated in this AU. Graptolitic, organic-rich shales of the Ordovician to Silurian Cape Phillips and Allen Bay Formations in Canada and the Peary Land Group in Greenland are the most likely lower Paleozoic source rock units. In the Canadian part of the AU, geochemical data are available from two wells on central Ellesmere Island. TOC values up to about 2 weight percent are reported from the Cape Phillips Formation in the Panarctic Arco et al. Blue Fiord E-46 well, and values of 2 to 8 weight percent TOC are reported from a shale facies in the Allen Bay Formation deeper in the same well (Powell, 1978; Obermajer and others, 2007). In the nearby Tenneco et al. Eids M-66 well, Powell (1978) reported TOC values between 2 and 5 weight percent for the Cape Phillips Formation and more than 4 weight percent for the Allen Bay Formation; Obermajer and others (2007) reported several values of more than 2 weight percent and one value more than 8 weight percent from Allen Bay Formation samples. Rock-Eval (T_{max}) results for samples of the Cape Phillips and Allen Bay Formations in both wells indicate that the strata are mature for oil generation. In North Greenland, Cambrian outer shelf strata of the Henson Gletscher Formation contain as much as 5 weight percent TOC (Christiansen and others, 1991). Silurian basinal deposits of the Peary Land Group, similar to the Cape Phillips Formation of the Canadian Arctic Islands, typically contain up to about 6 weight percent TOC, specifically in the Thors Fjord Member of the Wulff Land Formation and in the Lafayette Bugt Formation. The organic matter in these units is Type II (Buchardt and others, 1989; Christiansen, 1989, 1990; Christiansen and others, 1991).

A narrow zone of mature source rocks separates immature strata on the south and east from overmature strata on the north and west (Christiansen and others, 1989b; Harrison and others, 2008). This abrupt maturity gradient parallels the early Paleozoic shelf edge and the Ellesmerian fold belt, curving from a westerly trend in North Greenland to a southwesterly trend across Ellesmere Island. It may outline the limit of now-eroded

Ellesmerian thrust sheets or the possible southern extent of thick strata of the Devonian clastic wedge. In either case, it indicates that a wide belt of source rocks in the northern part of the assessment unit was buried through the petroleum generation window and likely expelled oil and gas updip toward the south and east.

Also, there is direct evidence that oil was indeed generated from lower Paleozoic source rocks. A pinnacle reef that was penetrated in the Blue Fiord E-46 well on Ellesmere Island contained “oil-flecked water,” and bitumen is present in similar reefs in outcrops nearby (de Freitas and others, 1995). Bitumen-filled Silurian reefs have been discovered at the surface in several localities in North Greenland, including the Victoria Fjord buildup in Wulff Land in central North Greenland (Stemmerik and others, 1997) and reefs in Washington Land just across Nares Strait from Ellesmere Island (Dawes and others, 2000). Penetrations of the Ordovician Thumb Mountain Formation have also revealed oil staining (Morrell and others, 1995). In an optical study of bitumen in the Cape Phillips Formation in the Canadian Arctic Islands, Gentzis and others (1995, 1996) found evidence that some of the bitumen had been deposited from oil that had been generated and migrated through the rock.

Rocks.—(0.5) Carbonate reefs and buildups are the most likely reservoir units, although the presence of adequate porosity and permeability is uncertain because these rocks were once deeply buried by the Devonian clastic wedge. De Freitas and others (1995) reported as much as 20 percent porosity in dolomitized reefs composed of stromatoporoid boundstone and coral microbial boundstone exposed on Ellesmere Island. The reservoir for Bent Horn oil field, the single discovered oil accumulation in this province (in the Western Franklinian Shelf AU), consists of fractured and cavernous Middle Devonian bioclastic limestone of the Blue Fiord Formation, described by Rayer (1981) as an isolated biohermal reef. The degree to which adequate porosity and permeability are present is unknown in the widely distributed Blue Fiord Formation; only one of the several wells drilled in the area of the Bent Horn oil field had adequate porosity and permeability to produce oil. Ordovician to Silurian reefs and reef-margin carbonate rocks that are laterally equivalent to the Cape Phillips Formation source rocks are also potential reservoirs. Oily water that flowed from the Blue Fiord E-46 well on Ellesmere Island was interpreted as indicative of adequate porosity in Silurian pinnacle reef rocks penetrated by the well (de Freitas and others, 1995). The Silurian Read Bay and Allen Bay Formations, reef carbonates, laterally equivalent to the Cape Phillips Formation, are also potential reservoirs. Middle Ordovician shelf carbonates of the Eleanor River Formation are another possible reservoir, although where they have been drilled in the other AUs in this province they have either lacked porosity or produced only water.

In the southern, unexplored part of the AU, transgressive Cambrian and Lower Ordovician sandstones could be present at the base of the Paleozoic section. Stratigraphic traps are possible where the sands lap onto basement and are overlain by younger sealing mudstones.

Devonian reef traps would be sealed by mudstones at the base of the Devonian clastic wedge. Older traps would be sealed by mudstones within the lower Paleozoic section.

Because migration was Late Devonian and preceded Ellesmerian deformation, traps are most likely to be stratigraphic, principally in Ordovician, Silurian, and Devonian reefs on the shelf and along the shelf margin.

Timing and preservation.—(0.2) The Paleozoic source rocks of this AU were almost certainly matured by abrupt burial beneath strata of the Devonian clastic wedge. Gentzis and others (1996) estimated that the Devonian clastic wedge was probably more than 7 km thick in the northern part of this AU, similar to thicknesses inferred for Melville Island. Anfinson and others (2013) estimated a comparable maximum thickness for the clastic wedge. Burial history and maturation modeling of the stratigraphy in the Dundas C-80 well on southern Melville Island for this study (fig. 7) suggests very rapid maturation in Late Devonian time, as did modeling of the same well by Skibo and others (1991). Dating of bitumen by ^{187}Re–^{187}Os as 374±9 Ma (Selby and others, 2005) in the Ordovician Thumb Mountain Formation on the Boothia-Cornwallis uplift also indicates that migration took place in Late Devonian time. Because Ellesmerian deformation began at almost the same time that maximum burial was reached, Ellesmerian structural traps are too young to have trapped oil generated during maximum burial; only undisturbed stratigraphic traps south of the main deformational zone are likely to be prospective. Furthermore, even stratigraphic traps were likely to have been disrupted by Ellesmerian deformation or by early Cenozoic Eurekan deformation. Erosion and exhumation of stratigraphically trapped accumulations is a significant risk. Modeling indicates that substantial uplift and erosion took place during and after Ellesmerian deformation. Skibo and others (1991) modeled about 1.8 km of exhumation, and modeling for this study (fig. 7) required about 3 km of post-Devonian uplift and erosion in order to match maturity levels indicated by R_o values.

The product of the assigned probabilities for charge, rocks, and timing is 0.09, less than the minimum probability (0.1) required for quantitative assessment.

References Cited

Anfinson, O.A., Leier, A.L., Dewing, K., Guest, B., Stockli, D.F., and Embry, A.F., 2013, Insights into the Phanerozoic tectonic evolution of the northern Laurentian margin; detrital apatite and zircon (U–Th)/He ages from Devonian strata of the Franklinian Basin, Canadian Arctic Islands: Canadian Journal of Earth Sciences, v. 50, no. 7, p. 761–768.

Buchardt, B., Christiansen, F.G., Nøhr-Hansen, H., Larsen, N.H., and Østfeldt, P., 1989, Composition of organic matter in source rocks, chap. 5 *in* Christiansen, F.G., ed., Petroleum geology of North Greenland: Grønlands Geologiske Undersøgelse Bulletin 158, p. 32–39.

Charpentier, R.R., and Gautier, D.L., 2011, U.S. Geological Survey Circum-Arctic Resource Appraisal (CARA); Introduction and summary of organization and methods, chap. 8 *in* Spencer, A.M., Embry, A.E., Gautier, D.L., Stoupakova, A.V., and Sørensen, K., eds., Arctic Petroleum Geology: Geological Society of London Memoir 35, p. 145–150.

Christiansen, F.G., ed., 1989, Petroleum geology of North Greenland: Grønlands Geologiske Undersøgelse Bulletin 158, 92 p. plus plates.

Christiansen, F.G., 1990, A future Arctic exploration target—lower Paleozoic in North Greenland: Oil and Gas Journal, v. 88, no. 7, p. 56–58.

Christiansen, F.G., Buchardt, B., Jensenius, J., Jepsen, H.F., Nøhr-Hansen, H, Thomsen, E., and Østfeldt, P., 1989a, Bitumen occurrences, chap. 7 *in* Christiansen, F.G., ed., Petroleum geology of North Greenland: Grønlands Geologiske Undersøgelse Bulletin 158, p. 61–72.

Christiansen, F.G., and Hansen, K., 1989, Timing of thermal episodes, chap. 8 *in* Christiansen, F.G., ed., Petroleum geology of North Greenland: Grønlands Geologiske Undersøgelse Bulletin 158, p. 73–77.

Christiansen, F.G., Koch, C.J.W., Nøhr-Hansen, H., Stouge, S., Thomsen, E., and Østfeldt, P., 1989b, Thermal maturity, chap. 6 *in* Christiansen, F.G., ed., Petroleum geology of North Greenland: Grønlands Geologiske Undersøgelse Bulletin 158, p. 41–60.

Christiansen, F.G., Piasecki, S., and Stemmerik, L., 1991, Petroleum resources, North Greenland, chap. 20 *in* Trettin, H.P., ed., Geology of the Innuitian orogen and Arctic platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada Series no. 3 [also Geological Society of America, The Geology of North America, v. E], p. 525–529.

Coniglio, M., and Melchin, M.J., 1995, Petrography and isotope geochemistry of diagenetic carbonates in the lower Cape Phillips Formation, Cornwallis Island, Arctic Archipelago, Canada: Bulletin of Canadian Petroleum Geology, v. 43, no. 3, p. 251–266.

Copper, P., and Edinger, E., 2009, Distribution, geometry and palaeogeography of the Frasnian (Late Devonian) reef complexes of Banks Island, NWT, western Arctic, Canada, *in* Königshof, P., ed., Devonian change; case studies in palaeogeography and palaeoecology: Geological Society of London Special Publication 314, p. 109–124.

Daae, H.D., and Rutgers, T.C., 1975, Geological history of the Northwest Passage: Bulletin of Canadian Petroleum Geology, v. 23, no. 1, p. 84–108.

Dawes, P.R., and Soper, N.J., 1973, Pre-Quaternary history of North Greenland, *in* Pitcher, M.G., ed., Arctic Geology: American Association of Petroleum Geologists Memoir 19, p. 117–134.

Dawes, P.R., Frisch, T., Garde, A.A., Iannelli, T.R., Ineson, J.R., Jensen, S.M., Pirajno, F., Sonderholm, M., Stemmerik, L., Stouge, S., Thomassen, B., and van Gool, J.A.M., 2000, Kane Basin 1999; mapping, stratigraphic studies and economic assessment of Precambrian and lower Palaeozoic provinces in north-western Greenland: Geology of Greenland Survey Bulletin 186, p. 11–28.

de Freitas, T.A., Dixon, O.A., and Mayr, U., 1993, Silurian pinnacle reefs of the Canadian Arctic: Palaios, v. 8, no.2, p. 172–182.

de Freitas, T.A., Harrison, J.C., Mayr, U., and Thorsteinsson, R., 1995, Stratigraphic controls on potential hydrocarbon and mineral accumulation of central Ellesmere Island, *in* Bell, J.S., Bird, T.D., Hillier, T.L., and Greener, P.L., eds., Proceedings of the Oil and Gas Forum ’95, Energy from sediments [March 28–29, 1995, Calgary]: Geological Survey of Canada, Open File 3058, p. 175–180.

de Freitas, T.A., and Mayr, U., 1993, Middle Paleozoic tear faulting, basin development, and basement uplift, central Canadian Arctic: Canadian Journal of Earth Sciences, v. 30, no. 3, p. 603–620.

de Freitas, T.A., Mayr, U., and Harrison, J.C., 1992, Lower Paleozoic T-R sequence stratigraphy, central Canadian Arctic: International Conference on Arctic Margins Proceedings, p. 123–128.

de Freitas, T.A., and Nowlan, G.S., 1998, A new, major Silurian reef tract and overview of regional Silurian reef development, Canadian Arctic and north Greenland: Bulletin of Canadian Petroleum Geology, v. 46, no. 3, p. 327–349.

de Freitas, T.A., Trettin, H.P., Dixon, O.A., and Mallamo, M., 1999, Silurian System of the Canadian Arctic Archipelago: Bulletin of Canadian Petroleum Geology, v. 47, no. 2, p. 136–193.

Dewing, K., 2006, Lower Paleozoic hydrocarbon plays in the Canadian Arctic Islands [abs.]: Yellowknife, Northwest Territories, Canada, 34th Annual Yellowknife Geoscience Forum, November 21–23, 2006, p. 17–18.

Dewing, K., and Embry, A.F., 2007, Geological and geochemical data from the Canadian Arctic Islands; Part I, Stratigraphic tops from the Arctic Islands oil and gas exploration boreholes: Geological Survey of Canada, Open File 5442, 7 p.

Dewing, K., Harrison, J.C., Pratt, B.R., and Mayr, U., 2004, A probable late Neoproterozoic age for the Kennedy Channel and Ella Bay Formations, northeastern Ellesmere Island and its implications for passive margin history of the Canadian Arctic: Canadian Journal of Earth Sciences, v. 41, no. 9, p. 1013–1025.

Dewing, K., Mayr, U., Harrison, J.C., and de Freitas, T., 2008, Upper Neoproterozoic to Lower Devonian stratigraphy of northeast Ellesmere Island, *in* Mayr, U., ed., Geology of northeast Ellesmere Island adjacent to Kane Basin and Kennedy Channel, Nunavut: Geological Survey of Canada, Bulletin 592, p. 31–108.

Dewing, K., and Nowlan, G., 2006, Onset of subduction in the Early Ordovician of the Canadian Arctic Islands [abs.], *in* Kirkwood, D., Lavoie, D., Malo, M., and Osadetz, K., organizers, The history of convergent and passive margins in the polar realm—sedimentary and tectonic processes, transitions, and resources: International Lithosphere Program, September 18–22, 2006, Quebec, Canada, p. 19.

Dewing, K, Obermajer, M, and Goodarzi, F., 2007a, Geological and geochemical data from the Canadian Arctic Islands; Part III, organic matter reflectance data: Geological Survey of Canada, Open File 5476, 8 p.

Dewing, K., Sharp, R.J., and Turner, E.C., 2007b, Synopsis of the Polaris Zn-Pb-Cu District, Canadian Arctic Islands, Nunavut, *in* Goodfellow, W., ed., Mineral resources of Canada; A synthesis of major deposit-types, district metallogeny, the evolution of geological provinces, and exploration methods: Geological Association of Canada, Mineral Deposit Division Special Paper 5, p. 655–672.

Embry, A.F., 1991, Middle-Upper Devonian clastic wedge of the Arctic Islands, chap. 10 *in* Trettin, H.P., ed., Geology of the Innuitian orogen and Arctic platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada Series no. 3 [also Geological Society of America, The Geology of North America, v. E], p. 263–279.

Embry, A.F., and Klovan, J.E., 1971, A Late Devonian reef tract on northeastern Banks Island, N.W.T: Bulletin of Canadian Petroleum Geology, v. 19, no. 4, p. 730–781.

Fox, F.G., 1985, Structural geology of the Parry Islands fold belt: Bulletin of Canadian Petroleum Geology, v. 33, no. 3, p. 306–340.

Gautier, D.L., Bird, K.J., Charpentier, R.R., Grantz, A., Houseknecht, D.W., Klett, T.R., Moore, T.E., Pitman, J.K., Schenk, C.J., Schuenemeyer, J.H., Sørensen, K., Tennyson, M.E., Valin, Z.C., and Wandrey, C.J., 2009, Assessment of undiscovered oil and gas in the Arctic: Science, v. 324, p. 1175–1179.

Gautier, D.L, Bird, K.J., Charpentier, R.R, Grantz A., Houseknecht, D.W., Klett, T.R., Moore, T.E., Pitman, J.K., Schenk, C.J., Schuenemeyer J.H., Sørensen K., Tennyson, M.E. Valin, Z.C., and Wandrey C.J., 2011, Oil and gas resource potential north of the Arctic Circle, chap. 9 *in* Spencer, A.M., Embry, A.E., Gautier, D.L., Stoupakova, A.V., and Sørensen, K., eds., Arctic Petroleum Geology: Geological Society of London Memoir 35, p. 151–161.

Gee, D.G., Fossen, H., Henriksen, N., and Higgins, A.K., 2008, From the early Paleozoic platforms of Baltica and Laurentia to the Caledonide orogen of Scandinavia and Greenland: Episodes, v. 31, no. 1, p. 44–51.

Gentzis, T., and Goodarzi, F., 1993, Regional thermal maturity in the Franklinian Mobile Belt, Melville Island, Arctic Canada: Marine and Petroleum Geology, v. 10, no. 3, p. 215–230.

Gentzis, T., de Freitas, T., and Goodarzi, F., 1995, Regional maturity in Arctic Canada using graptolite reflectance, *in* Bell, J.S., Bird, T.D., Hillier, T.L., and Greener, P.L., eds., Proceedings of the Oil and Gas Forum ’95, Energy from sediments [March 28–29, 1995, Calgary]: Geological Survey of Canada, Open File 3058, p. 389–393.

Gentzis, T., de Freitas, T., Goodarzi, F., Melchin, M., and Lenz, A., 1996, Thermal maturity of Lower Paleozoic sedimentary successions in Arctic Canada: American Association of Petroleum Geologists Bulletin, v. 80, no. 7, p. 1065–1084.

Goodarzi, F., Gentzis, T., Harrison, C., and Thorsteinsson, R., 1992, The significance of graptolite reflectance in regional thermal maturity studies, Queen Elizabeth Islands, Arctic Canada: Organic Geochemistry, v. 18, no.3, p. 347–357.

Grantz, A., Scott, R.A., Drachev, S.S., and Moore, T.E., 2010, Map showing the sedimentary successions of the Arctic region (58°–64° to 90°N) that may be prospective for hydrocarbons, 2nd edition: Tulsa, Okla., American Association of Petroleum Geologists, accessed February 22, 2017, at http://www.datapages.com/gis-map-publishing-program/gis-open-files/geographic/sedimentary-successions-of-the-arctic-region-by-grantz-et-al-2010.

Håkansson, E., Heinberg, C., and Stemmerik, L., 1991, Mesozoic and Cenozoic history of the Wandel Sea Basin area, North Greenland, *in* Peel, J. S., and Sønderholm, M., eds., Sedimentary basins of North Greenland: Bulletin Grønlands Geologiske Undersøgelse, v. 160, p. 153–164.

Hamilton, J.K., and Varney, G.R., 1982, Cores from the Canadian Arctic Archipelago, Geology and hydrocarbon occurrences, *in* Cutler, W.G., ed., Canada’s giant hydrocarbon reservoirs: Canadian Society of Petroleum Geologists, Calgary, June 1982, p. 5–29.

Harrison, J.C., 1995a, Melville Island's salt-based fold belt: Geological Survey of Canada, Bulletin 472, 331 p.

Harrison, J.C., 1995b, Tectonics and kinematics of a foreland folded belt influenced by salt, Arctic Canada, *in* Jackson, M.P.A., Roberts, D.G., and Snelson, S., eds., Salt tectonics—a global perspective: American Association of Petroleum Geologists Memoir 65, p. 379–412.

Harrison, J.C., and Brent, T.A., 2005, Basins and fold belts of Prince Patrick Islands and adjacent areas, Canadian Arctic Islands: Geological Survey of Canada, Bulletin 560, 173 p.

Harrison, J.C., de Freitas, T., and Thorsteinsson, R., 1993, New field observations on the geology of Bathurst Island, Arctic Canada; Part B, structure and tectonic history: Geological Survey of Canada, Paper 93–1B, p. 11–21.

Harrison, J.C., de Freitas, T., and Thorsteinsson, R., 1995, Structural controls on potential hydrocarbon accumulations of central Ellesmere Island, *in* Bell, J.S., Bird, T.D., Hillier, T.L., and Greener, P.L., eds., Proceedings of the Oil and Gas Forum '95, Energy from sediments [March 28–29, 1995, Calgary]: Geological Survey of Canada, Open File 3058, p. 199–204.

Harrison, J.C., Mayr, U., McNeil, D.H., Sweet, A.R., McIntyre, D.J., Eberle, J.J., Harington, C.R., Chalmers, J.A., Dam, G. and Nohr-Hansen, H., 1999, Correlation of the Cenozoic sequences of the Canadian Arctic region and Greenland; implications for the tectonic history of northern North America: Bulletin of Canadian Petroleum Geology, v. 47, no. 3, p. 223–254.

Harrison, J.C., Nowlan, G.S., and Lehnert, O., 2008, Thermal maturity of Cambrian to Devonian rocks of northeastern Ellesmere Island, *in* Mayr, U., ed., Geology of northeast Ellesmere Island adjacent to Kane Basin and Kennedy Channel, Nunavut: Geological Survey of Canada, Bulletin 592, p. 169–185.

Harlan, S.S., Heaman, L., LeCheminant, A.N., and Premo, W.R., 2003, Gunbarrel mafic magmatic event—a key 780 Ma time marker for Rodinia plate reconstructions: Geology, v. 31, no. 12, p. 1053–1056.

Heaman, L.M., LeCheminant, A.N., and Rainbird, R.H., 1992, Nature and timing of Franklin igneous events, Canada; Implications for a Late Proterozoic mantle plume and the break-up of Laurentia: Earth and Planetary Science Letters, v. 109, nos. 1–2, p. 117–131.

Henriksen, N., and Higgins, A., 1998, Early Palaeozoic basin development of North Greenland—part of the Franklinian Basin: Polarforschung, v. 68, no.1, p. 131–140.

Higgins, A.K., Ineson, J.R., Peel, J.S., Surlyk, F., and Sonderholm, M., 1991, Cambrian to Silurian basin development and sedimentation, North Greenland, chap. 7 *in* Trettin, H.P., ed., Geology of the Innuitian orogen and Arctic platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada Series no. 3 [also Geological Society of America, The Geology of North America, v. E], p. 111–162.

Higgins, A.K., Soper, N. J., and Leslie, A.G., 1998, The Ellesmerian and Caledonian orogenic belts of Greenland: Polarforschung, v. 68, no. 1, p. 141–151.

Hurst, J.M., McKerrow, W.S., Soper, N.J., and Surlyk, F., 1983, The relationship between Caledonian nappe tectonics and Silurian turbidite deposition in North Greenland: Journal of the Geological Society of London, v. 140, no. 1, p. 123–131.

Jober, S., Dewing, K., and White, J.C., 2007, Structural geology and Zn-Pb mineral occurrences of northeastern Cornwallis Island; implications for exploration of the Cornwallis Fold Belt, northern Nunavut: Bulletin of Canadian Petroleum Geology, v. 55, no. 2, p. 138–159.

Li, Z.X., Bogdanova, S.V., Collins, A.S., Davidson, A., De Waele, B., Ernst, R.E., Fitzsimons, I.C.W., Fuck, R.A., Gladkochub, D.P., Jacobs, J., Karlstrom, K.E., Lu, S., Natapov, L.M., Pease, V., Pisarevsky, S.A., Thrane, K., and Vernikovsky, V., 2008, Assembly, configuration, and break-up history of Rodinia—a synthesis: Precambrian Research, v. 160, nos. 1–2, p. 179–210.

Mayr, U., Brent, T.A., de Freitas, T., Frisch, T., Nowlan, G.S., and Okulitch, A.V., 2004, Geology of eastern Prince of Wales Island and adjacent smaller islands, Nunavut: Geological Survey of Canada, Bulletin 574, 78 p.

Meneley, R., 2006, Exploration in the Parry Islands and Cornwallis fold belts, Canadian Arctic [abs.]: Calgary, 2006 Canadian Society of Petroleum Geologists - Canadian Society of Exploration Geophysicists -Canadian Well Logging Society Annual Convention, p. 104–111. [Available at http://cseg.ca/assets/files/resources/abstracts/2006/185S0131.pdf.]

Miall, A.D., 1986, Effects of Caledonian tectonism in Arctic Canada: Geology, v. 14, no. 11, p. 904–907.

Morrell, G.R., Fortier, M., Price, P.R., and Polt, R., 1995, Petroleum exploration in northern Canada, a guide to oil and gas exploration and potential: Northern Oil and Gas Directorate, Indian and Northern Affairs Canada, 110 p., accessed February 22, 2017, at https://www.aadnc-aandc.gc.ca/eng/1320162078672/1320162175853.

Obermajer, M., Stewart, K.R., and Dewing, K., 2007, Geological and geochemical data from the Canadian Arctic Islands; Part II, Rock-Eval/TOC data: Geological Survey of Canada, Open File 5459, 27 p.

Obermajer, M., Dewing, K., and Fowler, M., 2009, Geochemistry of crude oil from Bent Horn field (Canadian Arctic Archipelago) and its possible Paleozoic origin: Organic Geochemistry, v. 41, no. 9, p. 986–996.

Okulitch, A.V., 1991, Late Devonian–Early Carboniferous deformation of the central Ellesmere and Jones Sound fold belts, section F, chap. 12 *in* Trettin, H.P., ed., Geology of the Innuitian orogen and Arctic platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada Series no. 3 [also Geological Society of America, The Geology of North America, v. E], p. 318–320.

Okulitch, A.V., Packard, J.J., and Zolnai, A.I., 1986, Evolution of the Boothia Uplift, Arctic Canada: Canadian Journal of Earth Sciences, v. 23, p. 350–358.

Okulitch, A.V., Packard, J.J., and Zolnai, A.I., 1991, Late Silurian–Early Devonian deformation of the Boothia Uplift, section C, chap. 12 *in* Trettin, H.P., ed., Geology of the Innuitian orogen and Arctic platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada Series no. 3 [also Geological Society of America, The Geology of North America, v. E], p. 302–307.

Patchett, P.J., Embry, A.F., Ross, G.M., Beauchamp, B., Harrison, J.C., Mayr, U., Isachsen, C.E., Rosenberg, E.J., and Spence, G.O., 2004, Sedimentary cover of the Canadian Shield through Mesozoic time reflected by Nd Isotopic and geochemical results for the Sverdrup Basin, Arctic Canada: Journal of Geology, v. 112, no. 1, p. 39–57.

Powell, T.G., 1978, An assessment of the hydrocarbon source rock potential of the Canadian Arctic Islands: Geological Survey of Canada, Paper 78–12, 82 p.

Rainbird, R.H., Jefferson, C.W., and Young, G.M., 1996, The early Neoproterozoic sedimentary Succession B of northwestern Laurentia; Correlations and paleogeographic significance: Geological Society of America Bulletin, v. 108, no.4, p. 454–470.

Rainbird, R.H, McNicoll, V.J., Theriault, R.J., Heaman, L.N., Abbott, J.G., Long, D.G.F., and Thorkelson, D.J., 1997, Pan-continental river system draining Grenville orogen recorded by U-Pb and Sm-Nd geochronology of Neoproterozoic quartzarenites and mudrocks, northwestern Canada: Journal of Geology, v. 105, no.1, p. 1–17.

Rayer, F.G., 1981, Exploration prospects and future petroleum potential of the Canadian Arctic Islands: Journal of Petroleum Geology, v. 3, no. 4, p. 367–412.

Selby, D., Creaser, R.A., Dewing, K., and Fowler, M., 2005, Evaluation of bitumen as a ^{187}Re–^{187}Os geochronometer for hydrocarbon maturation and migration—a test case from the Polaris MVT deposit, Canada: Earth and Planetary Science Letters, v. 235, nos. 1–2, p. 1–15.

Skibo, D.N., Harrison, J.C., Gentzis, T., and Goodarzi, F., 1991, Organic maturity/time-temperature models of the Ellesmerian (Paleozoic) Orogeny, Melville Island, Northwest Territories: Current Research, Part E, Geological Survey of Canada, Paper 91–1E, p. 165–175.

Smith, G.P., and Okulitch, A.V., 1991, Early Devonian movements of the Inglefield uplift, section D, chap. 12 *in* Trettin, H.P., ed., Geology of the Innuitian orogen and Arctic platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada Series no. 3 [also Geological Society of America, The Geology of North America, v. E], p. 308–309.

Soper, N.J., and Higgins, A.K., 1990, Models for the Ellesmerian mountain front in North Greenland; a basin margin inverted by basement uplift: Journal of Structural Geology, v. 12, no.1, p. 83–97.

Sørensen, K., Gautier, D.L., Pitman, J.K., Jackson, H.R., and Dahl-Jensen, T., 2011, Geology and petroleum potential of the Lincoln Sea Basin, offshore North Greenland, chap. 44, *in* Spencer, A.M., Embry, A.F., Gautier, D.L, Stoupakova, A.V., and Sørensen, K., eds., Arctic Petroleum Geology: Geological Society of London Memoir 35, p. 673–684.

Stasiuk, L.D., and Fowler, M.G., 1994, Paleozoic hydrocarbon source rocks, Truro Island, Arctic Canada; organic petrology, organic geochemistry, and thermal maturity: Bulletin of Canadian Petroleum Geology, v. 42, no. 4, p. 419–431.

Stemmerik, L., Sonderholm, M., and Bojesen-Koefoed, J.A., 1997, Palaeo-oil field in a Silurian carbonate buildup, Wulff Land, North Greenland; project 'Resources of the sedimentary basins of North and East Greenland' *in* Higgins, A.K., and Ineson, J.R., Review of Greenland Activities 1996: Geology of Greenland Survey Bulletin 176, p. 24–28.

Surlyk, F., and Hurst, J.M., 1984, The evolution of the early Paleozoic deep-water basin of North Greenland: Geological Society of America Bulletin, v. 95, no. 2, p. 131–154.

Thorsteinsson, R., Harrison, J.C., and de Freitas, T.A., 2009, Phanerozoic bedrock geology, Vendom Fiord area, Ellesmere Island, Nunavut: Geological Survey of Canada, Map 2142A, scale 1:125000.

Trettin, H.P., 1987, Pearya: a composite terrane with Caledonian affinities in northern Ellesmere Island: Canadian Journal of Earth Sciences, v. 24, no. 2, p. 224-245.

Trettin, H.P., Mayr, U., Long, G.D.F., and Packard, J.J., 1991, Cambrian to Early Devonian basin development, sedimentation, and volcanism, Arctic Islands, chap. 8, *in* Trettin, H.P., ed., Geology of the Innuitian orogen and Arctic platform of Canada and Greenland: Geological Survey of Canada, Geology of Canada Series no. 3 [also Geological Society of America, The Geology of North America, v. E], p. 163–238.

Appendixes

Appendix files are available online only, and may be accessed at https://doi.org/10.3133/pp1824H.

1. Input data for the Western Franklinian Shelf Assessment Unit.
2. Input data the Boothia-Cornwallis Uplift Assessment Unit.
3. Input data for the Eastern Franklinian Shelf Assessment Unit.

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