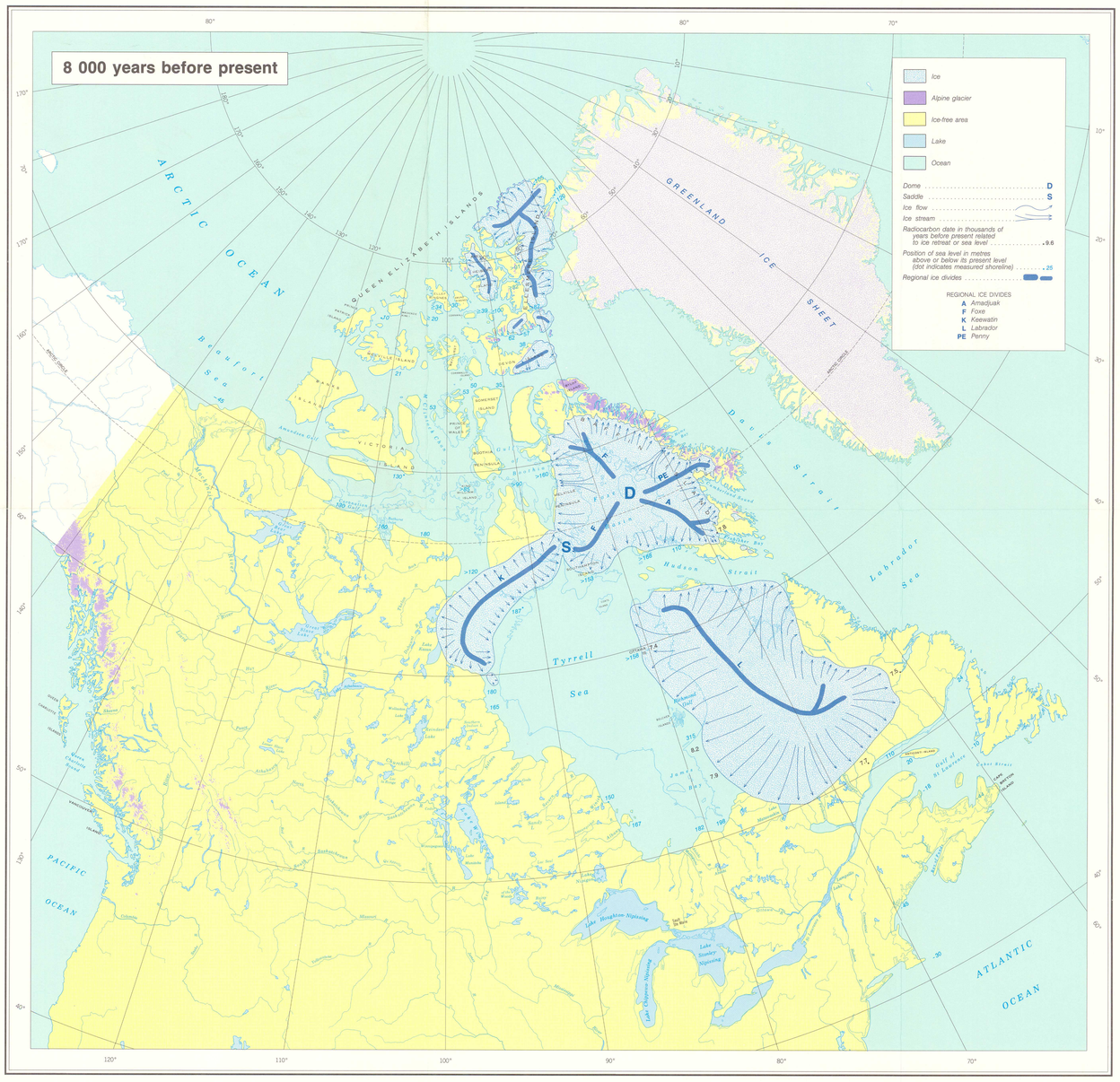
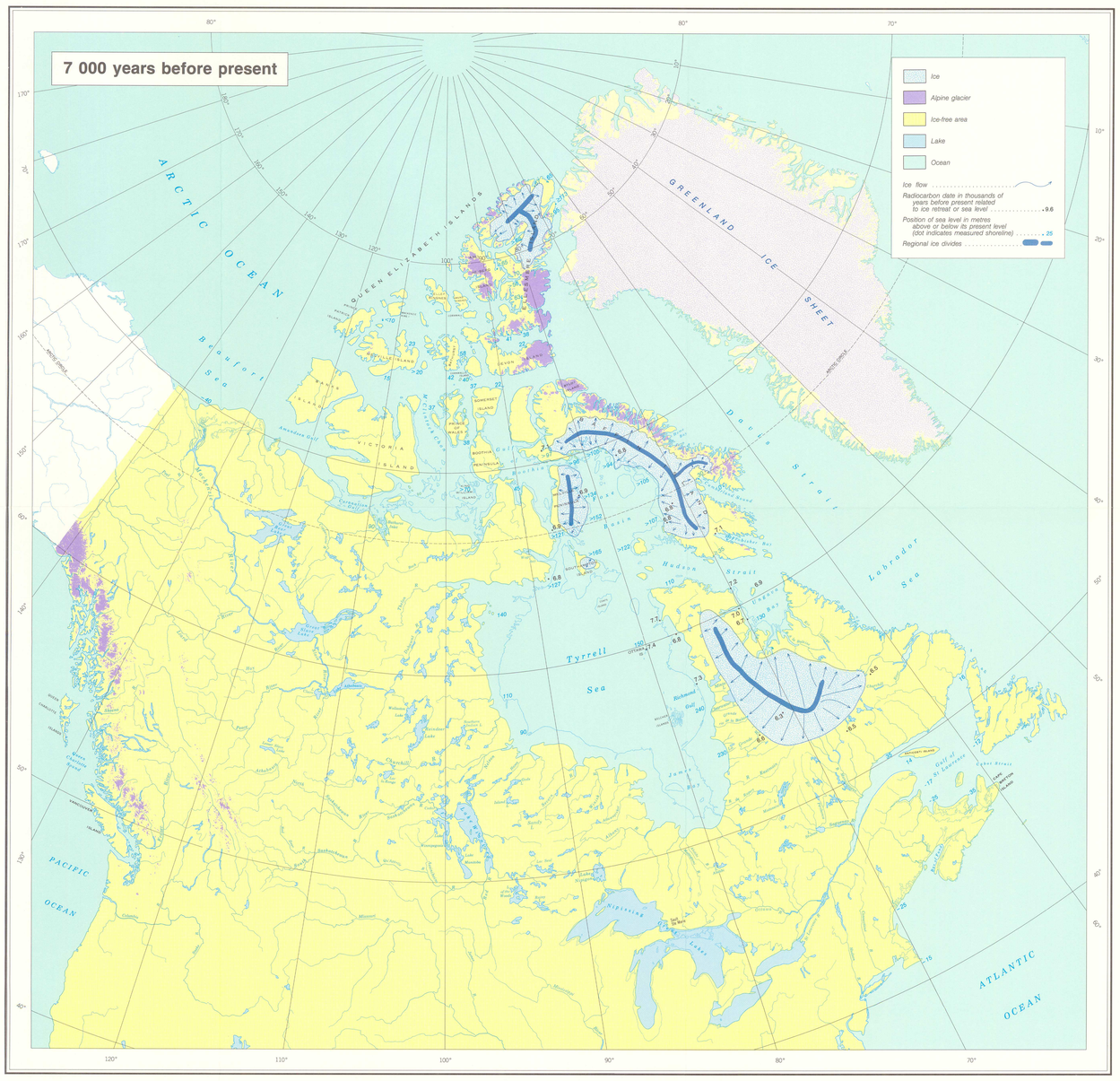
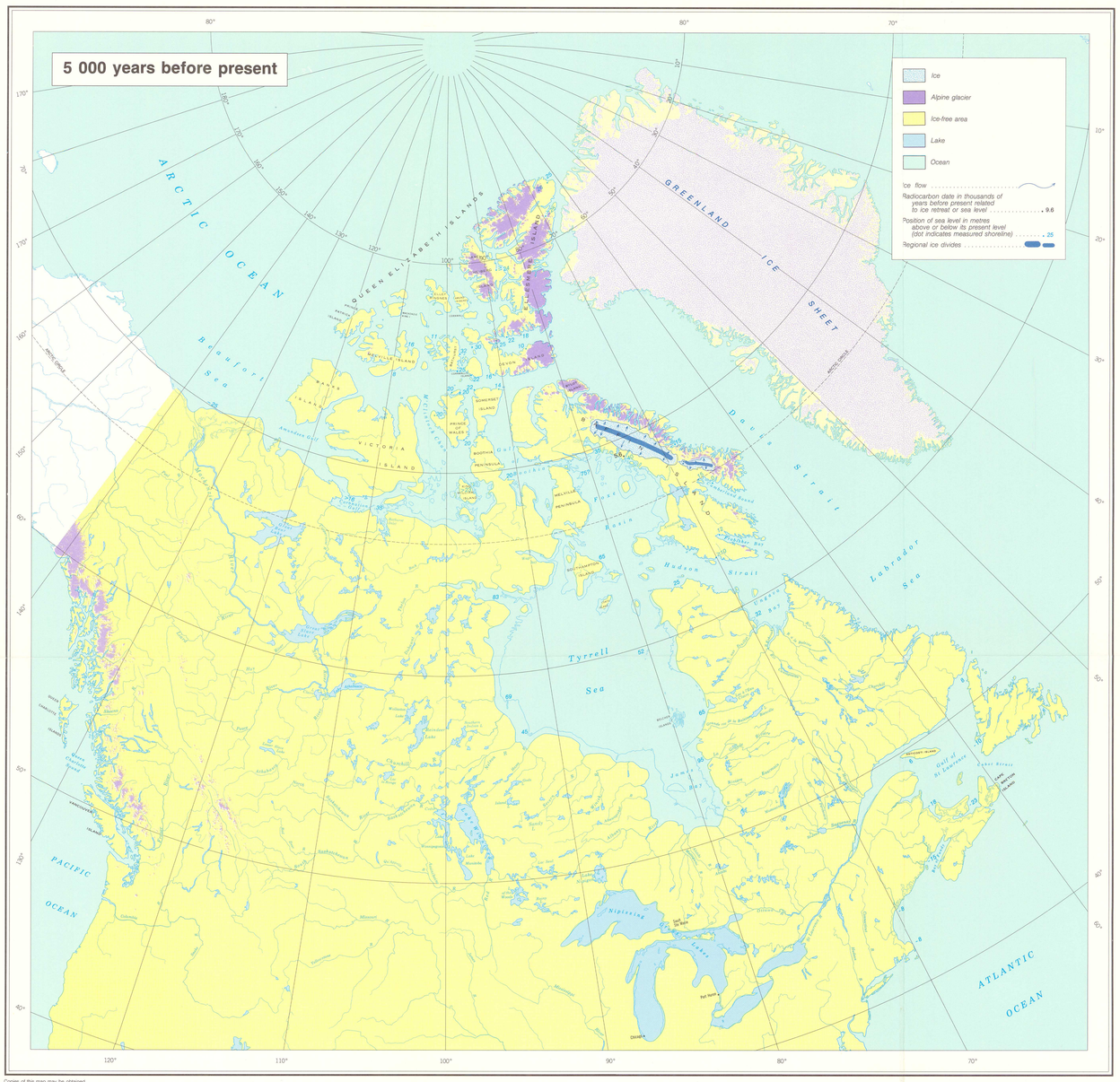
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES
MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES







EXPLANATORY NOTES

INTRODUCTION

"Laurentide Ice Sheet" is the name given to a large ice sheet which formed on the Canadian Shield some time after the last (Sangamon) interglaciation; at times of maximum expansion it covered large areas beyond the Canadian Shield. It is the earth's largest known former ice sheet. It probably expanded beyond the shield during Early Wisconsinan time (~80 000–65 000 years ago) but was somewhat smaller during the Middle Wisconsinan (65 000–23 000 years ago). It re-expanded to reach its last maximum during the early part of Late Wisconsinan time (23 000–18 000 years ago). Erosion caused by the ice sheet during its last expansion and retreat removed much of the geological record of earlier events so only the Late Wisconsinan (23 000–10 000 years ago) and Holocene (10 000 years ago to present) history of the ice sheet is well understood.

During its advance and retreat the ice sheet blocked the natural drainage of the northern part of the continent and this lead to an ever-changing pattern of proglacial lakes and rivers. Its weight depressed the earth's crust by hundreds of metres, leaving large areas below sea level upon retreat while the volume of water retained on land as ice in the ice sheet diminished the volume of the world's oceans and lowered global sea level. In the west the Late Wisconsinan Laurentide Ice Sheet coalesced with the Cordilleran Ice Sheet, in the southeast with the Appalachian Ice Complex and the Newfoundland Ice Cap, and in the north with the Queen Elizabeth Islands Ice Complex. Beyond the ice sheet in the northwest, in the mountains of Baffin Island and northern Labrador, were many independent alpine glaciers similar to those that exist there at present.

The Laurentide Ice Sheet consisted of three sectors, which reflect its places of origin and pattern of growth; these are named the Labrador Sector, the Keewatin Sector, and the Baffin Sector. Each sector had a central dome from which radiated a system of primary ice divides. The regional divides are used to subdivide the sectors into dynamic units (e.g., Hudson Ice flowing from the Hudson Ice Divide; Plains Ice flowing from the Plains Ice Divide). The sectoral divide systems were connected at intersector saddles. Domes, divides, and saddles, and hence ice flow patterns, migrated slowly during ice sheet growth and retreat.

18 000 YEARS AGO

The Laurentide Ice Sheet stood at or near its last maximum extent almost everywhere 18 000 years ago. At that time a superdivide, named the Trans-Laurentide Ice Divide extended from the north end of the Keewatin Sector to the south end of the Labrador Sector. This divide and other long regional ice divides determined the pattern and style of flow within the ice sheet. The ice sheet, like the present Antarctic and Greenland ice sheets, exhibited two styles of flow: "sheet flow" or normal regional flow, and "stream flow" or sustained rapid flow. Fast flowing ice streams were set up in regions of confluent flow some distance out from ice divide junctions or from saddles. At 18 000 years ago there were at least 11 large ice streams in the ice sheet system. The largest occupied Hudson Strait and evacuated the enormous supply of ice provided by the confluence of all three ice sheet sectors in northern Hudson Bay. It had by far the largest drainage area of any ice stream. Other large ice streams were set up by the Cordillera-Laurentide confluence in Alberta and Montana and by the confluence of the Laurentide Ice Sheet and Appalachian Ice Complex in the St. Lawrence Estuary and Baie des Chaleurs. Other ice streams have been recognized from debris dispersal patterns in the northern part of the ice sheet.

The shoreline beyond the ice sheet 18 000 years ago was 100 m and more below its present level, so much of the Continental Shelf was dry land. In the Gulf of Maine, off the Coast of Labrador, in Lancaster Sound, and in the Beaufort Sea the ice sheet floated to form ice shelves.

14 000 YEARS AGO

The margin of the Laurentide Ice Sheet changed little between 18 000 and 14 000 years ago. But about 14 000 years ago the James and Des Moines lobes readvanced about 800 km and this readvance coincided with a major change in flow pattern over the Interior Plains. Flow into the James and Des Moines lobes 18 000 years ago had been from the northeast, from the Hudson Ice Divide. By 14 000 years ago flow was from the northwest, from the Plains Ice Divide. This change in flow may have been caused by melting of permafrost beneath the ice sheet and hence a change in the condition of the bed of the ice sheet from cold, hard, and dry to warm, soft, and wet.

The largest net retreat between 18 000 and 14 000 years ago was in the southeast where the ice margin withdrew from Long Island to near the International Boundary. The ice shelves in the Gulf of Maine and off Labrador probably broke up during this interval as well. A string of small ice dammed lakes rimmed the southwest margin.

The Cordilleran Ice Sheet continued to grow between 18 000 and 14 000 years ago and reached its maximum late in that interval.

13 000 YEARS AGO

Slow retreat between 14 000 and 13 000 years ago lead to separation of the Laurentide and Cordilleran ice sheets, and further retraction of the margin north of the Gulf of Mexico-Hudson Bay drainage divide led to formation and expansion of the series of ice dammed lakes. Retreat of the Appalachian Ice Complex led to separation of remnant ice caps over Nova Scotia and Prince Edward Island but the Newfoundland Ice Cap retreated little. The Laurentide Ice Sheet still held a near maximum configuration.

12 000 YEARS AGO

Net retreat of the Laurentide margin between 13 000 and 12 000 years ago was more rapid than previously everywhere from the extreme northwest margin to southeastern Labrador. Retraction of the west and south margins had led to expansion of glacial lakes. Lake Peace extended from the margin well into the area formerly covered by the Cordilleran Ice Sheet and drained northward toward Mackenzie River. Lake Leduc and lakes south of there drained along the ice margin and through proglacial spillways into Lake Agassiz which discharged into the Mississippi River. Lake Algonquin in the Michigan and Huron basins emptied into Lake Iroquois in the Ontario basin. This system emptied into the Goldthwait Sea (ancestral Gulf of St. Lawrence) around an ice barrier at Québec City.

Between 13 000 and 12 000 years ago ice divides started to shift from their maximum configuration but significant changes were limited to the Keewatin Sector. The M'Clintock Ice Divide shifted about 80 km eastward and the Plains Ice Divide had been severely shortened because of the asymmetry of the retreat pattern.

11 000 YEARS AGO

Retreat of the Laurentide margin between 12 000 and 11 000 years ago was substantial everywhere from its northwest extremity to the Lake Agassiz basin but was less between Lake Superior and Labrador. Hence, the largest changes in flow pattern were in the western part of the ice sheet. The M'Clintock Ice Divide shifted farther east and all but one of the westward branching secondary ice divides were eliminated. A readvance in Frobisher Bay, southeastern Baffin Island, formed an ice shelf at the local Late Wisconsinan glacial limit. By 11 000 years ago only small remnants of ice remained in northern Maine and in the Maritime Provinces; however, local ice caps on Nova Scotia possibly re-expanded about this time. The Newfoundland Ice Cap was much diminished and divided by 11 000 years ago, but retreat there had been delayed compared to that on the south side of the Gulf of St. Lawrence, possibly an effect of cooling by the Labrador Current.

10 000 YEARS AGO

By 10 000 years ago Cordilleran glaciers were not much more extensive than they are today, the Newfoundland Ice Cap persisted only as five small remnants, and the Appalachian Ice Complex had disappeared. But in the Queen Elizabeth Islands local ice probably remained close to its Late Wisconsinan maximum extent.

The same east-west contrasts in the Laurentide Ice Sheet retreat pattern persisted as during earlier times. The total length of ice margin standing in glacial lake waters 10 000 years ago was much longer than previously because of the vast northward expansion of Lake Agassiz and a comparable southward and eastward expansion of Lake McConnell. Lake Algonquin, however, had drained by opening of a new outlet at North Bay, Ontario, then much depressed below its present level. That outlet drained the Michigan and Huron basins to much lower than present levels and formed lakes Chippewa, Stanley, and Hough.

Ice divides of Keewatin and Hudson ice substantially migrated between 11 000 and 10 000 years ago. The saddle between the Ancestral Keewatin Ice Divide and the Hudson Ice Divide steepened as flow converged more strongly upon the re-entrant in the ice margin occupied by Lake Agassiz. A similar saddle formed along the eastern part of the Hudson Ice Divide as flow converged upon the re-entrant in the margin occupied by Lake Barlow. This created a sharp boundary between Hudson and Labrador ice; it also marked the demise of the Trans-Laurentide Ice Divide and increased autonomy of the regional ice masses.

9000 YEARS AGO

Between 10 000 and 9000 years ago, as before, the western ice masses retreated faster than the eastern ice masses. However, the ice shelf occupying Lancaster Sound and Gulf of Boothia broke up during this interval and the sea entered Hudson Strait along the corridor of the former Hudson Strait ice stream.

At 9000 years ago the south margin held up lakes Ojibway and Agassiz which possibly had merged due to retreat of the Hudson Ice margin well north of the Hudson Bay-Great Lakes drainage divide. Water from that large lake system spilled south to Ottawa River. The Agassiz basin also received runoff from the Saskatchewan, Assiniboine, and Red river systems. Thus drainage from much of the Interior Plains and the eastern slope of the southern Canadian Rockies, along with meltwater from about 25% of the ice sheet, now discharged to the Goldthwait Sea (ancestral Gulf of St. Lawrence) via Ottawa River. The upper Great Lake basins also continued to discharge via Ottawa River.

The eastern margin of Labrador Ice held up glacial lakes Naskaupi and MacLean, the largest glacial lakes of eastern Quebec-Labrador.

8400 YEARS AGO

By 8400 years ago the ice margin stood at the western end of Hudson Strait and the sea was about to enter Hudson Bay. The northern part of the ice sheet must have had a positive or balanced accumulation budget at this time because end moraines were deposited around much of the perimeter of Foxe Ice and along the northern margin of Keewatin Ice. This moraine construction followed an interval of rapid retreat of Keewatin Ice and was probably caused by increased snowfall on the northern part of the ice sheet.

At 8400 years ago and subsequently the south margin of Hudson Ice surged repeatedly into lakes Ojibway and Agassiz forming thin floating ice tongues (small ice shelves) in the lakes. These surges, known as the Cochrane surges in the James Bay region, helped thin the central part of Hudson Ice and thus made it easier for the sea to penetrate Hudson Bay from the north. Before entry of the sea, however, the ice margin had retreated north of the present south shores of Hudson and James bays in places. The final Cochrane surge in the James Bay area occurred only 75 years before entry of the sea into Hudson Bay, so the final disintegration of Hudson Ice probably occurred in less than a century.

8000 YEARS AGO

The Laurentide Ice Sheet was eliminated as a single, contiguous ice mass about 8000 years ago when the sea entered Hudson Bay. When the ice dam separating Lake Ojibway from the sea broke, the lake drained and water level dropped almost instantaneously by about 250 m.

Upon entry of the sea into Hudson Bay, Keewatin Ice was by far the smallest of the remaining ice masses; Labrador Ice, though reduced, was by far the largest. The ice divides of Labrador and Keewatin ice were close to their final positions 8000 years ago.

The sea stood about 315m above its present level in southeastern Hudson Bay.

7000 YEARS AGO

Foxe Ice withstood marine incursion for 1000 years after the sea invaded Hudson Bay, but by 6800 years ago nearly all of Foxe Basin was ice free and Foxe Ice remnants were restricted to Baffin Island, Melville Peninsula, and Southampton Island. A substantial remnant of Labrador Ice also survived at this time but had melted completely by about 6500 years ago.

5000 YEARS AGO

The only remnants of the Laurentide Ice Sheet left at 5000 years ago were on Baffin Island where there were two ice caps, one much larger than the other. The larger remnant was centred on the present Barnes Ice Cap, the smaller on the Penny Ice Cap. Penny and Barnes ice probably separated shortly after 5500 years ago.

The coastline configuration was approaching that of today in most areas although Tyrrell Sea was still much higher and larger than present Hudson Bay, and Prince Edward Island had not yet separated from the mainland.

Andrews, J.T.
Quaternary geology of the northeastern Canadian Shield; in Chapter 3 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Borns, H.J.W., LaSalle, P., and Thompson, W.B. (ed.) 1985: Late Pleistocene history of northeastern New England and adjacent Quebec; Geological Society of America, Special Paper 197, 159 p.

Clayton, L. and Moran, S.R. 1982: Chronology of Late Wisconsin glaciation in middle North America; Quaternary Science Reviews, v. 1, p. 55-82.

Dredge, L.A. and Cowan, W.R.
Quaternary geology of the southwestern Canadian Shield; in Chapter 3 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Dyke, A.S.
1974: Deglacial chronology and uplift history: northeastern sector, Laurentide Ice Sheet; University of Colorado, Institute of Arctic and Alpine Research, Occasional Paper No. 12, 113p.

Dyke, A.S. and Dredge, L.A.
Quaternary geology of the northwestern Canadian Shield; in Chapter 3 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

[1] Dyke, A.S. and Prest, V.K.
1987: Late Wisconsinan and Holocene retreat of the Laurentide Ice Sheet; Geological Survey of Canada, Map 1702A, scale 1:5 000 000.

[2] 1987: Late Wisconsinan and Holocene history of the Laurentide Ice Sheet; Géographie physique et Quaternaire, v. XLI.

Dyke, A.S., Vincent, J-S., Andrews, J.T., Dredge, L.A., and Cowan, W.R.
The Laurentide Ice Sheet and an introduction to the Quaternary geology of the Canadian Shield; in Chapter 3 of the Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Flint, R.F., Colton, R.B., Goldthwait, R.P., and Willman, H.B.
1959: Glacial map of the United States east of the Rocky Mountains; Geological Society of America, scale 1:1 750 000.

Grant, D.R.
Quaternary geology of the Canadian Atlantic Appalachian region; Chapter 5 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Hodgson, D.A. (co-ord.)
Quaternary geology of the Queen Elizabeth Islands; Chapter 6 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Survey of Canada, The Geology of North America, v. K-1). (in press)

Hughes, O.L., Rutter, N.W., Matthews, J.V., Jr, and Clague, J.J.
Unglaciated areas (Regional Quaternary history and stratigraphy of the Canadian Cordillera); in Chapter 1 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Karrow, P.F.
Quaternary geology of the Great Lakes subregion; in Chapter 4 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Karrow, P.F. and Calkin, P.E. (ed.)
1985: Quaternary evolution of the Great Lakes; Geological Association of Canada, Special Paper 30.

Klassen, R.W.
Late Wisconsinan deglaciation (Quaternary history of the southern Canadian Plains); in Chapter 2 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1).

Mathews, W.H.
1980: Retreat of the last ice sheets in northeastern British Columbia and adjacent Alberta; Geological Survey of Canada, Bulletin 331, 22 p.

Occhietti, S.
Quaternary geology of St. Lawrence Valley and adjacent Appalachian subregion; in Chapter 4 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Piper, D.J.W., Mudie, P.J., Fader, G.B., Josenhans, H., MacLean, B., and Vilks, G.
Quaternary geology of the east coast offshore; Chapter 11 in Geology of the Continental Margin off Eastern Canada, M.J. Keen and G.L. Williams (ed.); Geological Survey of Canada, Geology of Canada, no. 2 (also Geological Society of America, The Geology of North America, v. I-1). (in press)

Prest, V.K.
1969: Retreat of Wisconsin and Recent ice in North America; Geological Survey of Canada, Map 1257A, scale 1:5 000 000.

Prest, V.K., Grant, D.R., and Rampton, V.N.
1968: Glacial map of Canada; Geological Survey of Canada, Map 1253A, scale 1:5 000 000.

Rampton, V.N., Gauthier, R.C., Thibault, J., and Seamen, A.A.
1984: Quaternary geology of New Brunswick; Geological Survey of Canada, Memoir 416, 77 p.

Ryder, J.M. and Clague, J.J.
British Columbia (Regional Quaternary stratigraphy and history); in Chapter 1 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

Teller, J.T. and Clayton, L.
1983: Glacial Lake Agassiz; Geological Association of Canada, Special Paper 26, 451 p.

Thompson, W.B. and Borns, H.W.
1985: Surficial geological map of Maine; Maine Geological Survey, scale 1:5 000 000.

Vincent, J.S.
Quaternary geology of northern Interior Plains of Canada; in Chapter 2 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press) Quaternary geology of the southeastern Canadian Shield; in Chapter 3 of Quaternary Geology of Canada and Greenland, R.J. Fulton, J.A. Heginbottom, and S. Funder (ed.); Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The Geology of North America, v. K-1). (in press)

[1] Map 1702A summarizes the entire ice retreat sequence.
[2] This report summarizes and discusses the paleogeographic sequence shown on Map 1703A.

Copies of this map may be obtained
from the Geological Survey of Canada
601 Booth Street, Ottawa, Ontario K1A 0E8
3303-33rd Street, N.W., Calgary, Alberta T2L 2A7
100 West Pender Street, Vancouver, B.C. V6B 1R8

Recommended citation:
Dyke, A.S. and Prest, V.K.
1987: Paleogeography of northern North America, 18 000 – 5 000 years ago; Geological Survey of Canada, Map 1703A, scale 1:12 500 000

Printed by Surveys and Mapping, Published 1987

MAP 1703A
SHEET 3 OF 3

PALEOGEOGRAPHY OF NORTHERN NORTH AMERICA, 8 000 – 5 000 YEARS AGO

Scale 1:12 500 000 - Échelle 1/12 500 000

Kilometres 500 0 500 1000 Kilomètres

Lambert Conformal Conic Projection, Standard Parallels 49°N and 77°N
Modified Polyconic Projection, North of Latitude 80°

© Crown Copyrights reserved © Droits de la Couronne réservés

Paleogeography by A.S. Dyke and V.K. Prest, 1986

Geological cartography by the Geological Survey of Canada

Base map at the scale of 1:12 500 000 prepared by the Geographical Services Division, Surveys and Mapping; Energy, Mines and Resources with modifications by the Geological Survey of Canada

This map has been reprinted from a scanned version of the original map
Reproduction par numérisation d'une carte sur papier

MAP 1703A
SHEET 3 OF 3
PALEOGEOGRAPHY OF NORTHERN NORTH AMERICA
8 000 - 5 000 YEARS AGO

Canada