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LANDS DIRECTORATE

DIRECTION GÉNÉRALE DES TERRES

EARTH SCIENCES OF THE HUDSON BAY LOWLAND: LITERATURE REVIEW AND ANNOTATED BIBLIOGRAPHY

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Earth Sciences of the Hudson Bay Lowland: Literature Review and Annotated Bibliography

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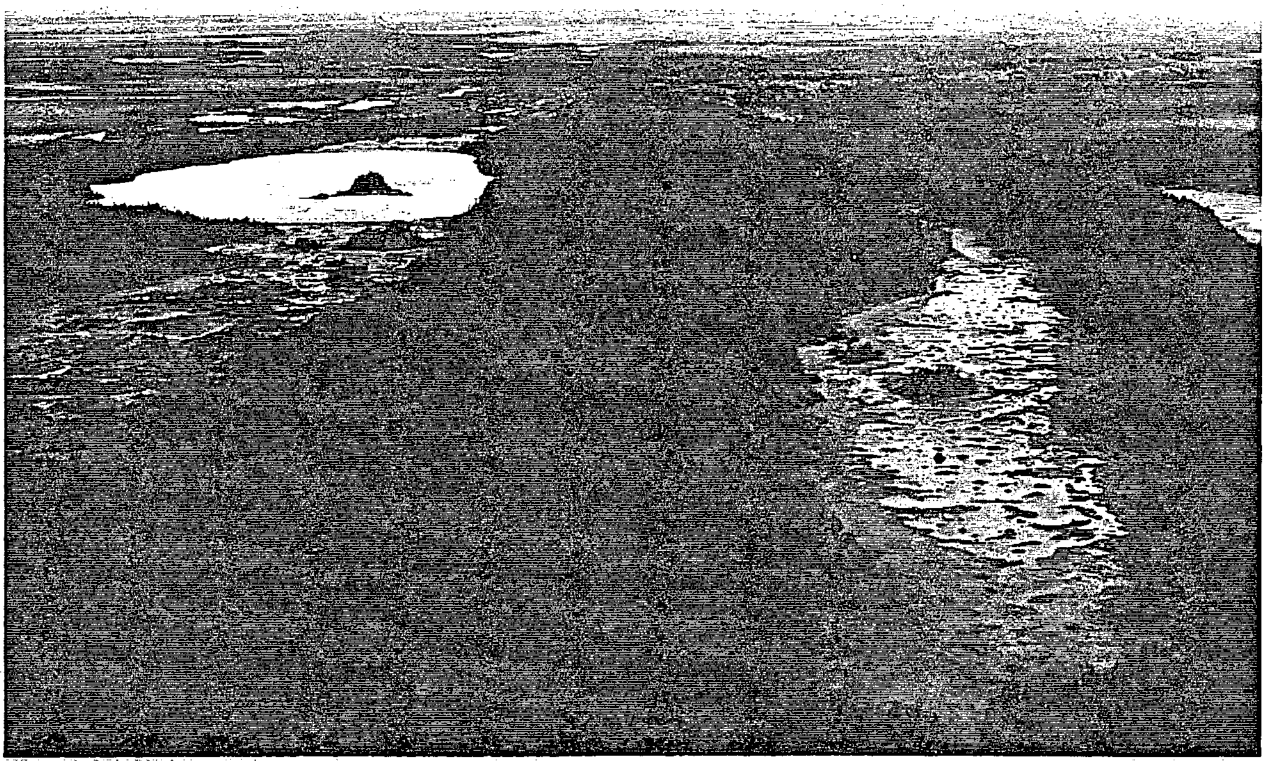

Frontispiece: Forested recurved spit - raised beach ridge complex (centre and upper right) surrounded by fen peatland. This feature is located midway between the Moose and Albany rivers about 65 km inland from James Bay.

ACKNOWLEDGEMENTS

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PREFACE

In 1976 the Department of the Environment (DOE) initiated environmental baseline studies in the Hudson Bay Lowland in Ontario. These studies developed in response to two major needs: the need to provide baseline information on the natural features of the area to serve as a foundation for environmental impact statements; and the need to provide information on wildlife habitats, especially for waterfowl, which are abundant along the James and Hudson Bay coastlines.

The Lands Directorate, together with the Canadian Wildlife Service, the Inland Waters Directorate, and the Canadian Forestry Service form the nucleus of the study group. In addition, a number of other workers from other directorates, universities and the Ontario Ministry of Natural Resources have participated in the planning and research, and input from these and other agencies will vary as the program develops.

The main emphasis of this program is on the natural environment; its physical and biological features. However, there has been an attempt to include social and economic considerations as they relate to the impacts that developments have had, and may be expected to have in the future, on the residents of the area.

This series is intended as an outlet for studies done in conjunction with the DOE baseline program in the Hudson Bay Lowland. Publications in the series are devoted to bibliographic compilations, literature reviews and research results.

Previous publications include the "Bibliography of Published and Unpublished Literature on the Hudson Bay Lowland" (Haworth, Cowell and Sims, 1978) and the

"Vegetation, Flora and Vegetational Ecology of the Hudson Bay Lowland: A literature Review and Annotated Bibliography" (Sims, Riley and Jeglum, 1979). Both of these reports were published in the Great Lakes Forest Research Centre (Sault Ste. Marie) Information Report Series. The present review and annotated bibliography concentrates on selected references from Haworth et al. (1978) dealing specifically with the earth sciences. This includes bedrock geology, glacial and postglacial events, deposits and landforms, soils, permafrost and physiography. Peatland ecology, characteristics and pattern are dealt with in Sims et al. (1979).

ABSTRACT

Over 240 selected references on the earth sciences are listed, annotated and critically reviewed. In addition each annotation includes Keyword and Location listings which are cross-indexed by author. The review is in four main sections covering introduction and study area; Precambrian to Mesozoic; Pleistocene Epoch; and Recent Epoch. References related to various aspects of bedrock and economic geology, surficial geology, glacio-isostacy, physiography, glaciation, deglaciation, permafrost, soils, geomorphology and so on. The bibliography is illustrated with photographs of the Hudson Bay Lowland; maps showing the geology, resources, geomorphology and areas covered by specific studies; and tables summarizing extractive resources and isostatic uplift determinations.

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1. INTRODUCTION

1.1 Study Area

The Hudson Bay Lowland is a unique region. It is a monotonous plain having an extremely gentle gradient throughout (0.5-1m/km) with the only area of significant relief being the Sutton Ridges (Figure 1). The Lowland is dominated by one major landscape process, i.e. the growth, decay and net accumulation of saturated organic deposits. In terms of scale it is one of the largest of the wetland regions of the world, about 125,000 mi^2 in size, of which 100,000 mi^2 are located in the Province of Ontario (Figure 1). It is continuously being enlarged and elevated by one of the fastest rates of isostatic rebound in the world (0.7 to 1 m/100 yrs., Section 3.1).

The Hudson Bay Lowland is the product of a long complex geological and geomorphological history which encompasses a variety of paleoenvironments including at least two previous wetland environments. The first occurred between 65 and 136 million years ago during the Cretaceous Period (Mesozoic Era - Section 2.1) occuping at least the southernmost portion of the Lowland where the peats, deposited at this time, are presevedas lignites (Mattagami Formation). The most recent occurred approximately 125,000 years Before Present (B.P.) during the Sangamon Interglacial of the Quaternary Period. Interglacial peats have been identified throughout most of the present Lowland. Repeated wetland development indicates the Lowland has been an area of low relief at least since the Paleozoic Era. Other evidence indicates that basinal structures have occupied the area almost since the Precambrian Era over 600 million years ago. This is shown by the presence of the two large Paleozoic sedimentary basins

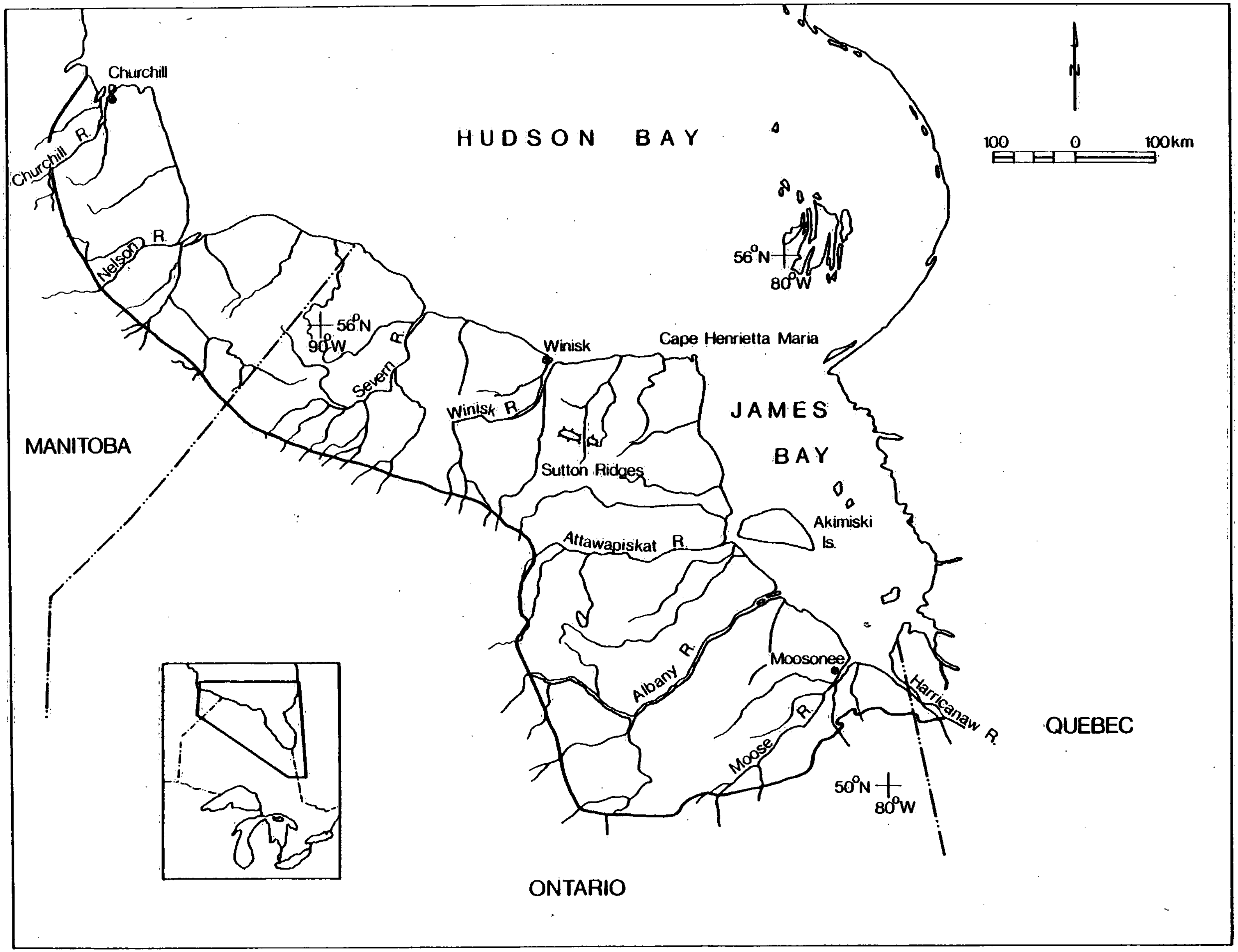

FIGURE 1. THE HUDSON BAY LOWLAND.

which overlie the crystalline Precambrian rocks of the Shield and define the limits of the present Hudson Bay Lowland. Also, the Lowland has provided the focus and outlets for much of the drainage of central North America as far west as the Rocky Mountains at least since the beginning of the Tertiary Period, 65 million years ago (Bird 1967, Cumming 1969). The third line of evidence for an historically depressed area is the late occupation by Wisconsin glacial ice at the end of the Pleistocene and subsequent rapid isostatic uplift in the order of 200 to 300 m to date (Andrews 1969).

During the Paleozoic Era, shallow, warm marine seas repeatedly covered much of North America. These deposited thick sequences of lime and other sediments which were preserved in places by subsequent downwarping of the Shield forming numerous structural basins, such as the Hudson Bay and Moose River basins as well as the Michigan Basin of southern Ontario, Ohio and Michigan. The seas retreated for the last time about 345 million years ago during the Devonian. Predominately terrestrial conditions became established sometime between then and 136 million years ago when the Cretaceous wetland occupied the James Bay Lowland.

Major river systems draining into and through the Hudson Bay Lowland include the Nelson and Churchill rivers which together account for most of the drainage of the Canadian Prairies. The Nelson Basin alone occupies 420,000 mi^2 (Newbury 1968). Preglacial rivers are believed to have flowed through the Lowland and Hudson Bay, which was above sea level at the time, draining into the sea in the vicinity of Hudson Strait. Pelletier (1969), for example, notes the presence of possible preglacial river channels beneath Hudson Bay.

The Hudson Bay basin was occupied by glacier ice during the Pleistocene. Glacial loading depressed the land mass permitting marine inundation during the interglacials and at the end of the Wisconsin. Kupsch (1967, p.158) notes that "a depression of the topographic surface of the earth's crust already existed between western Canada and the Hudson Bay region before the continental glacier developed. The weight of the ice emphasized this bowl shape but did not create it."

1.2 Literature Review and Bibliography Format

The Hudson Bay Lowland, as it exists today, is composed of three main physical components which form the basis of the three literature review chapters. These are the bedrock, including Mesozoic sediments, which forms the ultimate substrate and defines the extent of the Lowland; the Pleistocene sediments which were reworked to varying degrees by marine waters prior to emergence from the Tyrrell Sea; and the Recent peats, alluvial silts, gravel beach ridges and marine clay which compose the present surface. This environment interacts with fauna, flora and climates respresentative of high boreal and subarctic conditions resulting in unique physiographic, pedologic, cryoturbic and geomorphic characteristics and processes.

The annotated bibliography follows the review and is organized alphabetically by author's surname. Each citation includes an annotation, list of keywords and list of locations. The keywords and locations are cross-referenced separately in Sections 6 and 7. Keywords are based primarily on earth science subjects and the locations refer to the general area of the study; Ontario (Ont. H.B.L.), Manitoba (Man. H.B.L.), Québec (Qué. H.B.L.), all provinces (H.B.L.) or the Hudson Bay Region in general including all or most of the area surrounding Hudson and James Bays (H.B.R.). In addition, the river or rivers occurring in the study area are indicated in brackets, where applicable.

2. PRECAMBRIAN TO MESOZOIC

2.1 Bedrock Geology Review

2.1.1 Introduction

The Hudson Platform is the name given the region of sedimentary strata which overlies the Precambrian Shield in the vicinity of Hudson Bay (Stockwell *et al.* 1972). It consists of two basins, the Hudson and Moose River basins. They occupy most of Hudson and James bays and the Hudson Bay Lowland, and make up all or part of Southampton, Coats and Mansel islands (separating Hudson Bay from the Foxe Basin and Hudson Strait). The southern edge of the platform in Manitoba, Ontario and Québec essentially define the extent of the Hudson Bay Lowland. The strata are composed almost entirely of carbonates (limestone and dolomite, 55%) and siltstones (37%) with minor sandstone and gypsum (Sanford *et al.* 1968, Whitmore and Liberty 1968). They range from Ordovician to Mesozoic in age, spanning approximately 400 million years of geological time (Figures 2 and 3).

The Moose River Basin is the smallest of the two basins. It lies south of the Ekwan River and forms the southern extension of the Hudson Platform. Paleozoic and Mesozoic sediments in this basin reach a maximum thickness of 750 to 915 m within the Hudson Bay Lowland, approximately midway between the Missinaibi and Kwataboahegan rivers (Sanford *et al.*1968).

The Hudson Bay Basin is centred within Hudson Bay where Paleozoic sediments are between 1,800 and 3,050 m thick (Sanford *et al.*1968, Johnson 1971). The southern edge of the basin forms the main part of the Hudson Bay Lowland from Churchill, Manitoba to Cape

FIGURE 2 GEOLOGICAL TIME SCALE AND FORMATIONAL NOMENCLATURE FOR THE HUDSON BAY LOWLAND

FIGURE 2A Geological Time Scale

	Era	Period	Epoch	Millions of years ago (approx.)
	Cenozoic	Quaternary	Recent	.01
			Pleistocene	2.5
		Tertiary	Pliocene	7
			Miocene	26
			Oligocene	38
			Eocene	54
			Paleocene	65
	Mesozoic	Cretaceous		136
		Jurassic		190
		Triassic		225
	Paleozoic	Permian		280
		Pennsylvanian		325
		Mississippian		345
		Devonian		395
		Silurian		430
		Ordovician		500
		Cambrian		570
Pre-Cambrian	Proterozoic Archean			4600

FIGURE 2B Hudson Bay Lowland Stratigraphy

Period	Epoch/ Sub Period	Formation	Lithology
Quaternary	Recent		peat, alluvial silt, marine clay, gravel
	Pleistocene	Missinaibi (interglacial) and other units	till, sand, clay, silt, peat.
Cretaceous	Lower	Mattagami[2]	sand, clay, lignite
Jurassic-Miss.			
Devonian	Upper	Long Rapids[2]	black shale
	Middle	Williams Island[2]	limestone, shale
		Murray Island[2]	limestone
		Moose River[2]	limestone, gypsum
	Lower	Stooping River/Sextant	limestone/sandstone
Silurian	Upper	Kenogami River	siltstone, dolomite, shale, gypsum
	Middle	Attawapiskat	reefal limestone
	---- ? -----	Ekwan River	limestone, dolomite
	Lower	Severn River	limestone
Ordovician[1]	Upper	Chasm Creek	limestone
		Caution Creek	dolomite
		Surprise Creek	limestone
		Portage Chute	sandstone

[1] nomenclature for Hudson Bay Basin, Ordovician strata undifferentiated in Moose River Basin.

[2] not recognized in Hudson Bay Basin but some or all of these likely occur there.

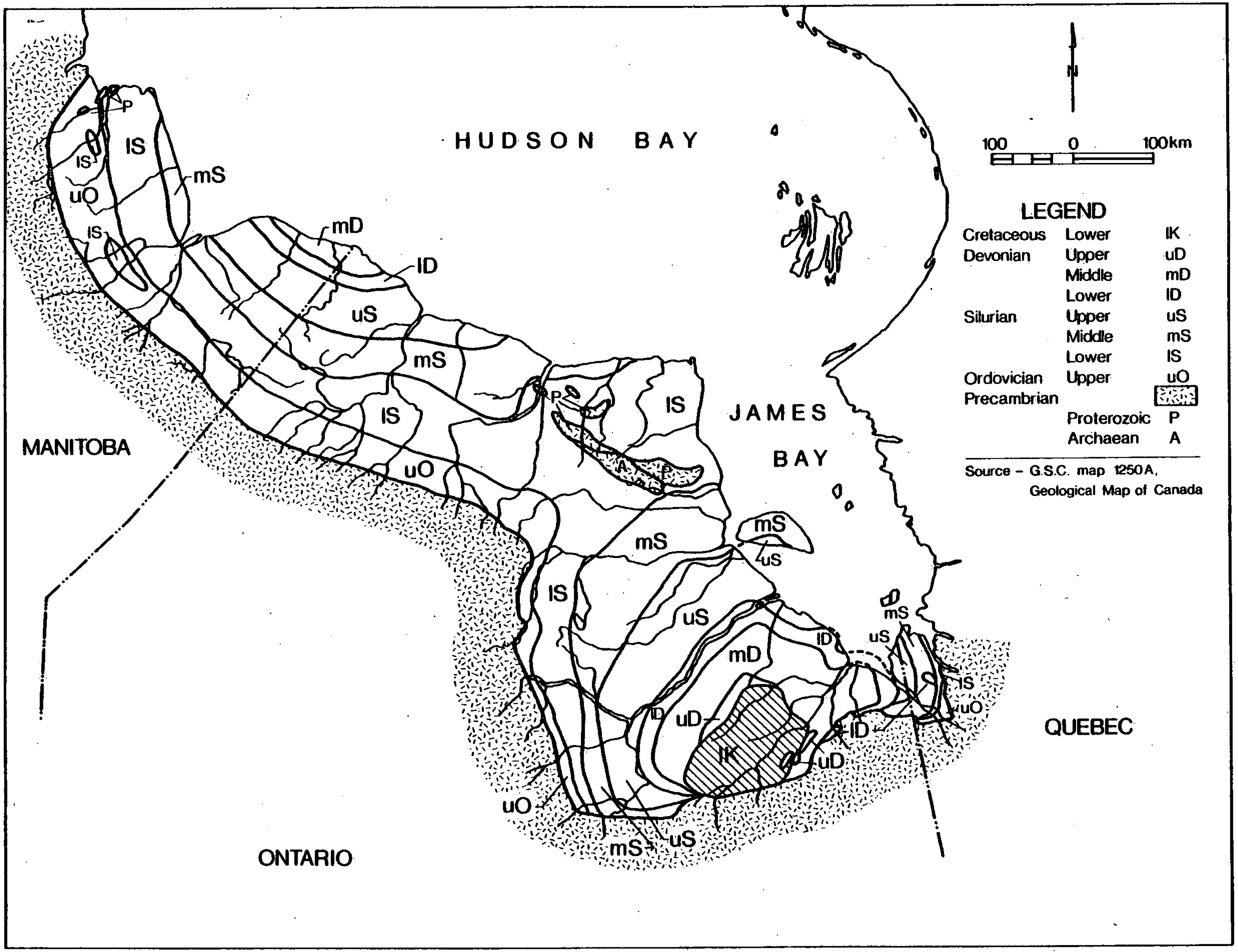

FIGURE 3. PRECAMBRIAN TO MESOZOIC GEOLOGICAL MAP (see FIG.2 for formational nomenclature and lithologies)

Henrietta Maria. The strata thin toward the south and west from a thickness of approximately 900 to 1,200 m along the coast in Manitoba.

The Hudson Basin joins the Moose River Basin along a broad arch which trends NE-SW between Winisk Lake and Cape Henrietta Maria (Figure 3). The arch, known as the Cape Henrietta Maria Arch, is a structural high within the Precambrian basement over which Paleozoic strata were deposited. The Paleozoics have since been greatly eroded and consequently are very thin where they overlap the arch. In fact several Precambrian inliers occur within the Lowland southwest and west of the Cape. The largest of these are the well known Sutton Ridges (Figures 4 and 5) which rise up to 120 m above the surrounding Lower and Middle Silurian limestones (Figures 2 and 6).

Except for these large Precambrian inliers and for numerous outcrops along the major rivers and tributaries, the bedrock of the Hudson Bay Lowland is buried beneath thick sequences of Pleistocene deposits and postglacial peat. This made early geological description and interpretation very difficult. It has also restricted more recent attempts at exploration and estimation of economic resources. Despite this problem the bedrock geology of the Hudson Bay Lowland is well documented and has the most complete literature representation of all the earth sciences describing the Lowland. This has been accomplished by a long history of geological exploration in this area beginning in the late 1800's and including two major aircraft-supported assaults between 1940 and 1970 as well as more recent drilling and airborne geophysical surveys.

2.1.2 Description, Mapping and Evaluation

The earliest published record of geological observations of the Hudson Bay Lowland is that of Isbister (1855, as reported in Cumming 1975) who made notes while traversing the west side of Hudson Bay for the Hudson Bay Company. According to Cumming these were "amazingly accurate". Much of the early geological information came from Robert Bell of the Geological Survey of Canada. Bell spent most of his summers between 1870 and 1887 making track surveys along the major rivers flowing into Hudson Bay and James Bay and along their coastlines. During this time, he surveyed

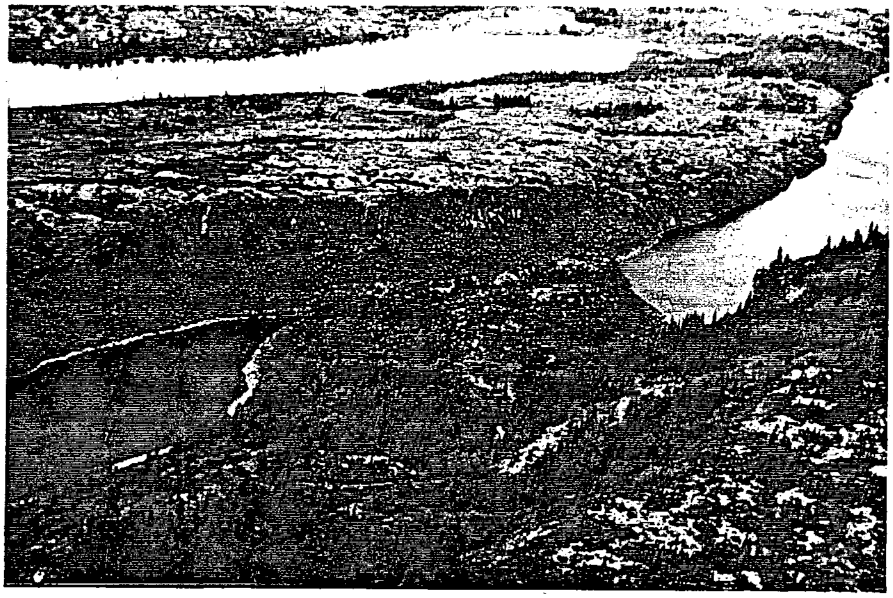

Figure 4: Aerial view of a portion of the Precambrian Sutton Ridges, southwest of Cape Henrietta Maria.

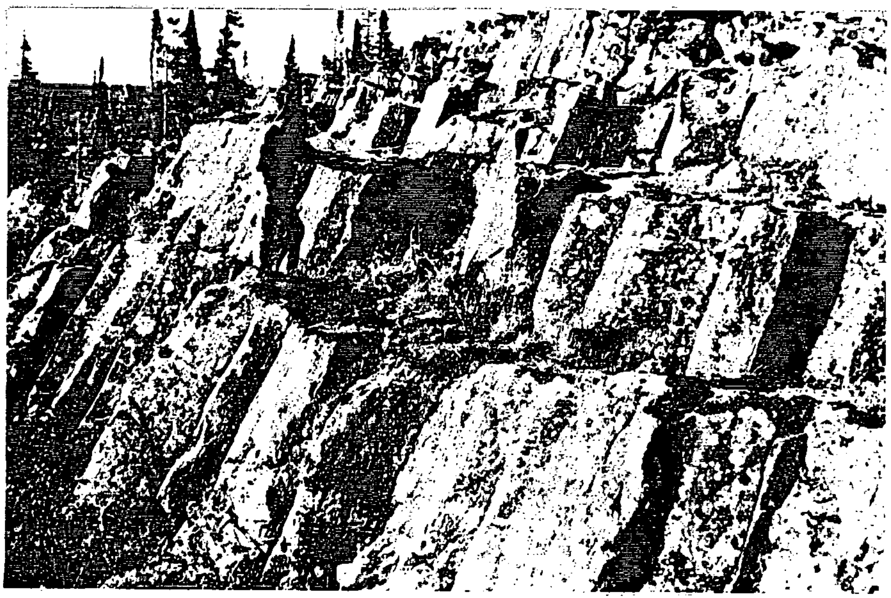

Figure 5: Columnar jointing in diabase sill of the Wachi Creek Precambrian inlier southeast of Winisk.

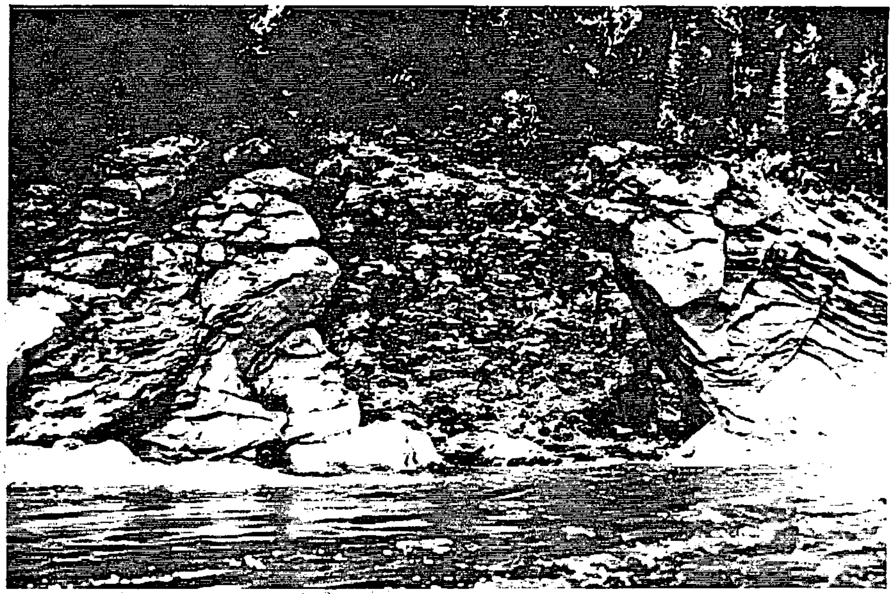

Figure 6: Biohermal reef enveloped in interreefal strata in the Attawapiskat formation on the Attawapiskat River.

all or parts of the Churchill, Nelson, Hayes, Attawapiskat, Albany, Moose, Missinaibi and Mattagami rivers of the Hudson Bay Lowland as well as these and other rivers on the shield between the Lowland and Lakes Superior and Winnipeg (Bell 1872, 1877, 1879 a and b, 1880, 1883, and 1887). He described and mapped numerous outcrops along these rivers, identified potential economic minerals such as the lignite, gypsum and iron ore of the Moose River Basin and collected fossils in order to establish the geochronology of their strata. He also made notes on the physiography, geomorphology, vegetation and wildlife of the areas he traversed. Bell was the first of the geological explorers to describe the coastline of Hudson and James bays and postulate uplift of the landmass (isostatic rebound) around the bays (Bell 1877, 1879a, 1896). Although this latter fact is well known today, he initiated controversy at the time and geologists such as A.P. Low (1889) suggested otherwise (see Section 3.2).

Bell's work was primarily of a reconnaissance nature but his descriptions and mapping were the first accurate surveys of these areas and served to stimulate further geological exploration in the Lowland and other areas surrounding Hudson Bay. Surveys similar to those carried out by Bell were continued into the early 1900's by other geologists. These covered most of the major rivers of the Lowland including the Kapiskau, Stooping, Kwataboahegan and Abitibi Rivers (W.J. Wilson 1906); the Ekwan River and Sutton Lake (Dowling 1912); the Severn River Basin (Low 1887, O'Sullivan 1908) and the Nelson, Churchill and Hayes rivers (Tyrrell 1916, Alcock 1916). Low (1889, 1899 and 1912) and O'Sullivan (1906, 1908b, 1912) also surveyed and described much of the coastline of Hudson and James bays in Ontario and Manitoba. The paper by Low (1889) is especially interesting because he describes all the islands in southern James Bay as well as Hannah Bay and Rupert Bay and attempts to discount Bell's hypothesis of isostatic rebound. Dowling's paper (1912) provides the first published descriptions of the Precambrian strata of the Sutton Ridges inliers.

These geologists all worked with the Geological Survey of Canada and published their results in the Survey's Annual Reports, Summary Reports and Reports of Progress[1]. It should be pointed out, however, that many of them published the same manuscripts in the Ontario Bureau of Mines (now, the Geological Survey of Ontario) Annual Report series at a later date. For example the paper by Robert Bell in the 1912 Annual Report of the Ontario Bureau of Mines is the same as that published in the 1887 Geological Survey of Canada Annual Report.

The first comprehensive study of the economic geology of part of the Lowland was published in 1904 by James Bell. He mapped and described all the outcrops of lignite, gypsum and iron in the Moose River drainage basin known to that time.

Track surveys and general reconnaissance type studies ended following the First World War. The trend was toward more technical geological description and mapping, with a great deal of attention focused on specific economic resources such as fire clays, lignite, gypsum, limestone and iron, particularly of the Moose River Basin. The literature dealing with these

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1 An excellent historical account of these geologist's travels and findings is provided by Morris Zaslow in Reading The Rocks, "The Story of the Geological Survey of Canada 1842-1972".

resources is discussed in Section 2.2. Savage and Van Tuyl (1919) and M.Y. Williams (1920) initiated this new trend by publishing the first reports which concentrated on the stratigraphy (lithology, formational nomenclature, paleontology and economic geology). For example, W.S. Dyer, after studying the Paleozoic rocks of southern Ontario, reported on the Paleozoic and Mesozoic strata of the southern Lowland (Dyer 1928, 1930 a and b, 1931) whereas J.E. Hawley concentrated on the Precambrian rocks of the Sutton Ridges (Hawley 1926). These studies helped to piece together the information obtained in earlier reconnaissance surveys, establish the geochronology, explain regional aspects of the lithology and structure of the bedrock, establish a regional nomenclature and correlate the strata with other regions (particularly southern Ontario). However, up to the Second World War there were still no accurate geological maps of the Hudson Bay Lowland and all information was based only on river exposures, except for a few shallow drill holes along the Moose River. Also, most of the post World War I studies were carried out in the southern Lowland and very little was published on the area north and west of the Sutton Ridges.

Much of what is known today about the geology of the Hudson Bay Lowland derives from two major aircraft-supported studies carried out following World War II. The first was initiated in 1946 by the Shell Oil Company and subsequently followed-up by the Ontario Department of Mines (1948-1953). This activity concentrated on the southern part of the James Bay Lowland (south of the Attawapiskat River). The second was an extensive effort in 1967 by the Geological Survey of Canada known as "Operation Winisk" to study and map the entire Hudson Bay Lowland.

The chief geologist with the Shell Oil Company in 1946, W.C. Gussow, compiled a geological map of the Lowland south of 56°N latitude based on what was known to that time (Gussow 1953 a and b). It became evident that this was a likely area to explore for oil and gas and in 1946 he and N.W. Martison mapped more than 23,000 mi^2 in a fixed-wing supported study. This resulted in the first accurate geological map of any portion of the Lowland (Ontario Department Mines Map 1952-3) and the first complete description of the stratigraphy of the Moose River Basin (Martison 1953). The Ontario Department of Mines began drilling operations in 1948 in order to better understand the structure and stratigraphy of the Moose River Basin as well as further explore the oil and gas potential (Martison 1953 and Hogg et al. 1953). Two deep holes were drilled into the Paleozoic strata, one at Jaab Lake (about midway between the Moose and Albany Rivers) and the other at Puskwuche Point on James Bay (midway between Moosonee and Fort Albany, Section 2.2). The first was 551 m deep and did not reach the Precambrian. The second penetrated the Precambrian at 466 m (Hogg et al. 1953).

A paleontological and stratigraphical study of Manitoba's portion of the Lowland was also undertaken at about this time by Nelson (1952) in a Ph.D. thesis (see also Nelson and Johnson 1966). As of 1953 essentially all that was known regarding the geology of the Hudson Bay Lowland was contained in the studies by Nelson and Martison.

Operation Winisk was a helicopter-supported survey carried out by the Geological Survey of Canada. It produced a great deal of geological information on the Hudson Bay Lowland and spawned several reports. The first was that of Sanford, Norris and Bostock (1968). This report established the current stratigraphic nomenclature (Figure 2b) by assembling previous terms and re-defining certain stratigraphic sections. It also provided the first complete geological map of the entire Hudson Bay Lowland (Geological Survey of Canada Map 17-1967). It is an excellent concise review of the geology of the Lowland. It was followed by more detailed reports and maps concentrating on strata of particular periods, for example: Bostock (1969, 1971) on the Precambrian of the Sutton Ridges area (Aquatuk River map-area); Cumming (1971, 1975) on the Ordovician; and Sanford and Norris (1975) on the Devonian. As yet, nothing has appeared specifically on the Silurian strata.

Since about 1960 the northernmost portion of the Hudson Bay Lowland and much of Hudson Bay has undergone fairly extensive geophysical exploration in order to determine the thickness of strata and the potential for oil and gas in the Hudson Bay Basin. These studies consisted of aeromagnetic and seismic programs, particularly during the 1960's, as well as actual drilling during the early 1970's (see Section 2.2). They helped complete initial geological investigations of the entire Hudson Platform and, for a short time, focused attention on the Hudson Bay Basin. The sediments in this basin are at least 2,400 m thick (Hood et al. 1969) and possibly as much as 3,050 m thick (Johnson 1971). For a while it was believed to have reserves of oil and gas as high as the Michigan Basin of southwestern Ontario and Michigan and possibly much higher. However, no discoveries were made and by 1974 drilling had ceased in the Hudson Bay area. Several papers published in the Earth Science Symposium on Hudson Bay (Hood 1969) summarize much of the information on geophysical programs in this area up to 1968, for example: Grant (p.136-143), Hobson (p.227-246), Hodgkinson (p.247-269) and Hood et al. (p.272-291).

The most recent concentrated geological studies in the Lowland were carried out by the Ontario Geological Survey between 1975 and 1978. These consisted of a series of geophysical studies and three drilling programs within the area of unconsolidated Mesozoic sediments in the Moose River Basin (Rogers et al. 1975, Utard 1975, Scintrex Surveys Ltd. 1976, Telford and Verma 1978, Verma et al. 1978, Guillet 1979). The objectives of these investigations were to determine the characteristics and extent of the various units of the Cretaceous deposits and establish their economic potential (Rogers et al. 1975, Telford et al. 1975).

During the winter of 1975, 6 drill holes were established and geophysical surveys carried out along a winter road which crossed the Mesozoic deposits from north to south (Rogers et al. 1975, Telford et al. 1975, Utard 1975).

Scintrex Surveys Ltd. (1976) carried out geophysical surveys in the Onakawana area to determine the extent of the lignite deposit and test geophysical methods for delineating the lignite. This work suggested the presence of lignite fields east of the Abitibi River which were previously not known and resulted in a drilling program in the area in 1977 by the Ontario Geological Survey (Verma et al. 1978). No evidence of commercial fields were discovered in 3 drill holes.

Further drilling was carried out in 1978 to examine the extent and economical potential of the Mesozoic deposits. Eight holes were drilled in an east-west direction across the southern edge of the basin between the Missinaibi and Abitibi rivers. These were spaced 8 to 14 km apart and resulted in the discovery of previously unknown lignite seams (Telford and Verma 1978, Guillet 1979).

The results of the 1975 and 1977 drilling programs are presented and thoroughly discussed in the report edited by Telford and Verma (1979) which includes papers on the history of geological exploration in the Moose River Basin (Verma 1979), Mesozoic stratigraphy (Telford 1979), Mesozoic and Pleistocene Stratigraphy (Hamblin 1979), Mesozoic Palynology (Norris 1979) and economic potential of the mineral resources (Vos 1979).

2.1.3 Paleontology

The paleontology of the Hudson Bay Lowland is well represented in the literature based on fossil collections made by various geologists beginning with Bell and Tyrrell in the late 1800's. These collections are usually published under the names of the paleontologists who identified the fossils, for example Whiteaves (1880-81, 1910) and Parks (1913). More recent publications of fossil lists are included in the reports by Cumming (1975) and Sanford and Norris (1975) as well as paleontological reports by Flower (1968 - Silurian cephalopods, Figure 7) and McGregor and Camfield (1976 - Silurian and Devonian spores). These collections were essential for establishing the geochronology of the Hudson Bay Lowland's stratigraphy. It is important to note, however, that there remains a lack of animal fossil information to determine precise ages of some parts of the Devonian or the exact position of the Silurian- Devonian boundary (McGregor and Camfield 1976). A provisional correlation based on fossil spores taken from drill hole samples have been established by McGregor and Camfield (1976).

The palynoflora of the Mesozoic sediments have recently been studied from holes drilled by the Ontario Geological Survey in the Moose River Basin during 1975 and 1977 (Telford et al. 1975, Norris 1979). This work has resulted in the determination of a Lower Cretaceous age (late Middle to late Albian) for the upper part of the Mattagami Formation, the establishment of 4 interval zones, the correlation of these palynofloras with Mesozoic deposits elsewhere in North America and the discovery of a Middle Jurassic series of, as yet, non-formational status ('Mistuskwia Beds') underlying

Figure 7: Silurian cephalopod and brachiopod on fossiliferous outcrop of the Attawapiskat Formulation, Attawapiskat River.

the Cretaceous Mattagami Formation in the northern part of the basin.

2.2 Economic Geology Review

2.2.1. Introduction

The sediments and geological structure of the Hudson Platform are very similar to the better known Michigan Basin of southwestern Ontario and Michigan. Its bedrock is composed of carbonates (limestone and dolomite), evaporites (gypsum and anhydrite), sandstones and shales and thus presents a marked contrast in composition and extractable minerals to the surrounding shield. Consequently there is potential for significant quantities of oil, natural gas, limestone, gypsum, salt, iron (siderite and limonite) and zinc (sphalerite-ZnS). Except for natural gas and zinc all these minerals have been found in the Lowland. However, those which are known to be of economic potential include only limestone and gypsum. Table 1 is a detailed listing of minerals which have been found in the Lowland indicating their location and reserves as well as literature references. The locations of these minerals and wells drilled for

TABLE 1. Review of extractive resources of the Hudson Bay Lowland, including Hudson Bay.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Oil	Whole Lowland	----	-no direct evidence but strata along all major rivers appear favourable and of similar age to other oil bearing forms.	Williams, 1920, p.10
Oil	Moose River Basin	----	-points out anticlinal structures along Abitibi and Moose Rivers and that deepest part of basin is west of James Bay between Albany and Moose Rivers but underestimates thickness by about ½ - good potential.	Williams, 1920, p.11
Oil shales	Long Rapids formation Moose River Basin ("Ohio Shales")	----	-outcrop on Mattagami and Abitibi Rivers and two analyses give 3.9% and 5.5% crude oil yield.	Williams, 1920, p.12
Oil and gas	Moose River Basin	----	-"no seepage or positive evidence of the presence of petroleum, other than in shales of the Long Rapids formation has yet been found in the James Bay Lowlands." -"porous reef structures containing traces of pyrobitumen have been recognized, but it remains for future exploration to determine whether conditions favourable to the accumulation and retention of petroleum and natural gas are present in the area."	Martison, 1953, p.iii
Oil and gas	Hudson Bay and Moose River Basins	Crude - 600 million barrels Gas - 800 billion ft^3	-figures at left are for Michigan and Southwestern Ontario but authors state that the Michigan Basin has about the same volume of sediment as the Hudson Platform and are therefore comparable in hydrocarbon potential. -this area is virtually untested because only 25 wells have been drilled compared to many thousands in Michigan and Ontario. -major fault system in the Moose River Basin (Coal River to Moosonee) might be a good exploration target. -Attawapiskat formation in lower part of Moose River Basin and offshore in Hudson Bay as well as Devonian similar to those in Ontario can be considered as favourable reservoir rocks.	Sanford, Norris and Bostock, 1968, p.44 & 45

TABLE 1. Cont'd

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Oil and gas	Hudson Bay	----	-"the Ordovician and Silurian equators as determined by paleomagnetic measurements...pass through Hudson Bay...The best chance of finding oil in economic quantities in Paleozoic formations seems to be in the paleolatitudes of less than 30°, Hudson Bay would appear to be a prime location for oil exploration."	Hood, Bower and Godby, 1969, p.215
Oil and Gas	Hudson Bay including south coast	----	-discusses history of exploration in the bay and companies doing exploration - most exploration in the bay since 1962.	Johnson and Nelson, 1969, p. 215
Oil and gas	Winisk River	----	-"small aeromagnetic anomalies near the mouth of the Winisk River may represent buried positive areas... may be sites of petroleum and natural gas accumulation because they are both structural traps and areas of possible reef growth.	Ayres, Bennett and Riley, 1969
Oil and gas	Whole Lowland	----	-"perhaps lower in the Moose River and Hudson Bay Basins (geologic basins) subsidence was sufficiently rapid to have permitted the development of pinnacle bioherms which would be worth searching for as possible sources of oil and gas".	Norris and Sanford, 1969
Oil and gas	Hudson Bay and Moose River Basins	Crude - 2.9 billion barrels* Gas - 17.4 trillion ft.^{3}* Crude - 9 billion barrels** Gas - 55 trillion ft.^{3}**	-gives history of drilling in Hudson Bay and emphasizes good potential of area for oil and gas (but still no direct evidence). -"one of these holes, Kaskattama #1, reveals traces of oil over a 1200 ft. interval occasionally as much as 30% of pore space" (this well was located on south shore of the Bay in Manitoba - see also Johnson & Nelson, 1969).	Johnson, 1971, p.43 & 52

*Canadian Petrolium Association
**This paper

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Oil and gas	Hudson Bay and Moose River Basins	---	-"all regions of Hudson Bay will see exploratory activity next year...offshore in Hudson Bay plus seismic surveys and stratigraphic tests in the Moose River Basin. -"very large oil and gas fields could be contained in the gentle but large structures of Hudson Bay 'probably as large as Prudhoe Bay field' according to Serge Rueff, one-time senior geologist with Aquitaine Company of Canada".	Oilweek, 1972, p.60
Oil and gas	Hudson Bay and Moose River Basins	Crude - 2.27 billion barrels Gas - 13.5 trillion $ft.^3$	-'ultimate reserves'	Cumming, 1975, p.7
Oil and gas	Hudson Bay and Moose River Basins	----	-most favourable Devonian strata = Kwataboahegan, Moose River, Murray Island and upper member of William Island formations. -"no evidence of oil or gas seeps known of in Devonian". -"only exception is slight oil staining in large vugs in core from upper part of Stooping River Formation penetrated by O.D.M. Puskwuche Pt. borehole...may be a contaminant from the drilling rig".	Sanford and Norris, 1975, p.92-93

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Limestone ($CaCO_3$)	Moose River Basin	(greater bulk of Hudson Bay and Moose River Basins composed of limestones and dolomitic limestones).	-Moose, Albany, Pagwachuan, Nettogami, Kwataboahegan, Abitibi, and Mattagami Rivers display numerous outcrops of high - Ca limestones. -both papers give analyses indicating between 40% and 99.8% $CaCO_3$ (mostly > 85%). -"limestones from this part of Ontario may prove to be of great value. As the clay belt along the Canadian National Railway and along the coastal plain of James Bay becomes settled...for building purposes, hydrated lime, portland cement, fertilizer...also in the chemical pulp and metallurgical industries". (Dyer, p.31). -Coral Rapids (Abitibi River) and Grand Rapids (Mattagami River) especially favourable because of proximity to rail line.	Dyer, 1930a Malcolm, 1924
Limestone	Moose River Basin Churchill area		-high quality Kwataboahegan, Murray Island, upper Williams Island formations - these are fairly wide-spread in southern part of basin. -Coral Rapids, Grand Rapids, William Island and Murray Island good potential quarry sites. -C.N. Railway crosses outcrop belt of Ordovician and some Silurian rocks between Nelson River and Churchill. -"extensive deposits of dolomitic limestones and limestone available for future exploitation occur along both the Nelson and Churchill Rivers".	Sanford, Norris and Bostock, 1968, p.42
Limestone	Moose River Basin		-readily accessible along Northern Ontario Railway. -besides formations listed on previous page are Stooping River and Kenagami River formations. -"since 1967 a quarry has been opened near Moosonee in the limestone of the Kwatagoahegan Formation to provide crushed rock for surfacing a new airport runway".	Sanford and Norris, 1975, p.90

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Gypsum ($CaSO_4 \cdot 2H_2O$)	Moose River Basin on Moose, Mattagami and Abitibi Rivers	----	-"although cut by cracks and solution channels which have allowed soil and clay to penetrate the beds, much gypsum is still little contaminated, and large masses of selenite and marbled gypsums occur". -total thickness not known but as much as 20 ft. occurs in some cliffs. -"they may be looked upon as a reserve to be drawn upon when transportation and market conditions make their exploitation possible".	Williams, 1919, p.10
Gypsum	Moose River Basin on Moose River, 10-12 mi. below mouth of Mattagami River	Estimated at 60,000,000 tons	-"there seems to be little doubt...the gypsum of the Moose River will prove a mineral asset of no little value". -attempts at mining gypsum on Moose River made from 1911 to 1926. -outcrop along 2½ miles of river - "rank among the largest and most extensive anywhere known on the American continent". -pure gypsum free of impurities, (33% CaO, 45% SO).	Lanning, 1926
Gypsum	Moose River Basin on Moose River (as above), Cheepash and Wakwayowkastic Rivers and "Gypsum Mountain" east of Onakawana	----	-gypsum beds of Moose River Formation (Devonian) -maximum known thickness of gypsum 24 ft. -Gypsum Mountain outcrop about 42 miles x 7 miles with banks up to 20 ft. high.	Sanford, Norris and Bostock, 1968, p.42, 43
Gypsum	Moose River Basin on Moose River (as above), Cheepash and Wakwayowkastic Rivers and "Gypsum Mountain" east of Onakawana	Up to 200 ft. of gypsum beds	-1963 Moosonee Gypsum and Exploration Company drilled 18 shallow holes over distance of 3 miles along south bank of Cheepash River up to 125 ft. of gypsum beds, with up to 85 ft. of continuous pure gypsum. -2 boreholes by James Bay Oil Company in 1929 intersected 96 and 200 ft. of gypsum interbedded with shale and limestone on Murray Island (Moose River).	Sanford and Norris, 1975, p.90-92

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Gypsum	South Hudson Bay Basin (south coast of Hudson Bay)	Unknown - thickest sections would be beneath Hudson Bay	-"only minor amount of evaporite associated with carbonate in Moose River formation penetrated by the Aquitaine - Segepet et al. Pen Nos. 1 and 2 wells". -some gypsum present in offshore wells in beds of Kwataboahegan, Williams Island and Long Rapids formations.	Sanford and Norris, 1975, p.92
Salt (NaCl) Anhydrite ($CaSO_4$)	Hudson Bay Basin - offshore	----	-some salt and anhydrite are present in the Moose River formation in the offshore area of Hudson Bay - found in Aquitaine Hudson Walrus A-71 well.	Sanford and Norris, 1975, p.92
Lead and zinc	Hudson Bay and Moose River Basins	None found	-Proterozoic (Sutton Ridges) and Paleozoic strata are potentially important as source of Pb and Zn. -similar Proterozoic strata on the east side of Hudson Bay have been found to contain Pb and Zn.	Sanford, Norris and Bostock, 1968, p.41 Bostock, 1971, p.54 Cumming, 1975, p.7
Fire-clays	Moose River Basin on Mattagami and Missinaibi Rivers	----	-Mesozoic clay, sand and lignite (now known as the Mattagami Formation). -claims were staked along the Missinaibi and Wabiskagami Rivers in 1911 - these white clays reach thicknesses of 74 to 100 ft. for a distance of up to a mile on the Missinaibi. -claims were also staked on the Mattagami River in 1917 - greatest thickness above the river about 8 ft. -these clays would be extremely important from an industrial point of view, if they were within reach of transportation.	Keele, 1920
Fire-clays	Moose River Basin on Mattagami River 7 mi. below Long Portage and Abitibi River 1 mi. above Little Abitibi River	----	-several firms and one laboratory tested the Mattagami Formation clays for their use in the manufacture of fire brick, pottery, sanitary porcelain and rockingham-ware. -found to be acceptable for all uses and one firm reported - "We have as yet to find any foreign clay than can equal it as far as purity is concerned ...these particular samples were tested against the Missouri high heat calcined fire-clay which... is the best mined in the United States".	Dyer and Montgomery, 1930 Montgomery, 1929

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Fire-clay, kaolin quartz sand, lignite	Mattagami formation of Moose River Basin	----	-only noted as occurring.	Sanford, Norris and Bostock, 1968
Fire-clay, kaolin silica sand, lignite	Mattagami formation of Moose River Basin	Extensive but variable	-based on up to date testing of the minerals for their commercial properties and on more recent drilling and geophysical work to outline the nature and extent of the deposits.	Vos, 1975, 1979 Guillet, 1979 Telford and Verma, 1979
Lignite	Moose River Basin on Abitibi, Mattagami and Moose Rivers	----	-on Missinaibi and Mattagami Rivers the thickest lignite seam is 3 ft. -"in 1926 1,096 mi. along the Abitibi, Moose and Mattagami Rivers was withdrawn by Ontario Government from staking in order to make a thorough geological survey. Since then, considerable time and money have been spent in developing the deposits. At Onakawana, core drilling and underground and open pit development have added greatly to the geological information". Dyer reported 2 seams 28 ft. and 21 ft. thick interbedded with fire-clays. -maximum thickness found was 68 ft. (Onakawana field). -highest seam is under 20 to 100 ft. of muskeg and till.	Dyer, 1932 Martison, 1953, p.46-48
Lignite	Moose River Basin at Onakawana	10,000,000 tons in two fields	-in 1966 Alberta Coal Ltd. of Calgary obtained licence to explore 375 mi. near Onakawana. -field A comprises 100 acres between Abitibi River and railroad track and field B 143 acres between track and Onakawana River. -"Scattered drilling beyond these two areas has indicated much larger reserves of lignite, but the seams are covered by a greater thickness of over-burden".	Sanford, Norris and Bostock, 1968, p.43-44 Stockwell *et al.*, 1972, p.145

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Lignite	Moose River Basin at Onakawana	Average recoverable lignite 189,000,000 tons	-Alberta Coal changed to Manalta Coal and in combination with Ontario Hydro and the Government of Ontario undertook feasibility study to recover lignite for power plant. -originally looked at in 1930's for locomotive fuel. -present scale of operation calls for annual production of 4 to 7 million tons. -heat content of these lignites in order of 5000 BTU/lb (medium grade lignite).	Onakawana Development Limited, 1973
Iron ore (siderite and limonite)	Moose River Basin on Mattagami River at Long Rapids	----	-in numerous solution cavities in limestone 30 ft. deep and 50 ft. across. -known as ironstone or bogore. -considerable quantities in some beds. -exposures about 4 mi. below Long Rapids and some streams issuing from limestone are coloured with iron hydroxides.	Williams, 1919, p.10
Iron ore (siderite and limonite)	Moose River Basin on Mattagami River at Long Rapids	----	-in Devonian Stooping River and Kwataboahegan formations. -discovered by R. Bell in 1875. -mineralization in solution cavities. -mainly siderite ($FeCO_3$) with minor amount of limonite ($FeO(OH)$). -maximum thickness of 25 ft. at head of rapids. -lateral extent unknown. -precise location given by Bennet et al. 1967, p.61.	Sanford, Norris and Bostock, 1968, p.43

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Iron ore (siderite and limonite)	Moose River Basin on Mattagami River at Grand Rapids	3 small ore bodies with maximum thickness of 25 ft.	-one ore body at lower end of Grand Rapids and two closely spaced near upper end. -"siderite itself is of good quality, but the amount of replacement is considered insufficient to warrant much economic interest".	Sanford and Norris, 1975, p.92
Manganese and iron ore (siderite)	Hudson Bay Basin and Moose River Basin	----	-high manganese and iron concentrations detected in older tills of Moose River Basin and in tills outside Lowland but derived from carbonate rocks of Hudson Bay Basin. -"The manganese is probably present in the rhodochrosite phase of the rhodochrosite-siderite solid-solution series..." -the fact that siderite is a major component of the heavy mineral suites of all tills...suggests that siderite deposits may be much more extensive than previously thought in the Paleozoic section.	Skinner, 1973b Shilts, 1980
Iron ore (hematite and magnetite)	Proterozoic inliers around Sutton Lake	----	-magnetic ores of iron are of economic importance and are freely distributed throughout the whole of the section (at Sutton Lake) but are not concentrated in thick enough beds. -richer parts could be economically worked-metallic iron 27.7% to 33.4%.	Dowling, 1912, p.156
Iron ore (hematite and magnetite)	Proterozoic inlier and Cape Henrietta Maria area	----	-"the iron formation at Sutton Lake...varies considerably in iron content from place to place and may therefore be economically prospective elsewhere on the Cape Henrietta Maria arch. The structure and stratigraphy of the area indicate that Proterozoic rocks be at shallow depth...broad region between Sutton Hills and Cape Henrietta Maria".	Sanford, Norris and Bostock, 1968, p.41 Ayres, Bennett and Riley, 1969

TABLE 1. Cont'd.

RESOURCE	LOCATION	RESERVES	REMARKS	REFERENCE(S)
Iron ore (hematite and magnetite)	Proterozoic Inlier and Cape Henrietta Maria area	----	-iron formations in Sutton Ridges 10-100 ft. thick. -one aeromagnetic anomaly in particular warrants further investigation - extends 10 miles in arc concave to southwest from 53^{o} 38' N 83^{o} 29' W to 53^{o} 32' N 83 17' W.	Bostock, 1971, p.53
Copper	Proterozoic Inlier and Cape Henrietta Maria area	----	-some traces observed in quartz-calcite vein between Sutton and Hawley Lakes. -Hawley in 1926 found bornite (Cu_5FeS_4) malachite ($Cu_2Co_3(OH)_2$), chalcopyrite ($CuFeS_2$) and azurite ($(Cu_3CO_3)_2(OH)_2$) in this vein. -Bostock notes there may be better copper mineralization in a possible extensive sill system centred about Hawley Lake.	Hawley, 1926 Bostock, 1971, p.53, 54
Diamonds (kimberlite)	Moose River Basin on Abitibi River at Coral Rapids	None found	-1962 the Canadian Rock Company obtained a licence to search for diamonds over 125 sq. miles from the mouth of Little Abitibi River south to the Pre-Cambrian contact. -horst block area running SW from Moosonee has mineral assemblages similar to diamond producing areas of South Africa - dikes cutting Devonian strata at Coral Rapids have proper mineralogy. -"it is possible that kimberlites in this area are the source of diamonds found in the glacial deposits of Wisconsin and Michigan".	Brown, Bennett and George, 1967, p.21 & 25
Peat, clay, sand and gravel	Whole Lowland	Unknown but substantial	-Pleistocene and recent peat and unconsolidated glacial material caps bedrock throughout lowlands. -thickness varies but anywhere from 20 ft. to > 700 ft.	Martison, 1953, p.49 & 50 Sanford, Norris and Bostock, 1971, p.41

oil and gas exploration are shown in Figure 8.

2.2.2 Oil and Gas

The presence of reef structures in the limestone, particularly in the Attawapiskat Formation (Figure 6), reports of oil seeps along some rivers and the occurrence of deep Paleozoic basins makes the Hudson Platform a favourable location for oil and gas exploration. Estimated reserves of oil and gas are as high as 9 billion barrels and 55 trillion cubic feet, respectively, of which 80 to 90 percent would occur offshore in the Hudson Bay Basin (Table 1, Johnson 1971). These figures are probably too high but the potential for finding economic reserves are very good (Sanford _et al_. 1968).

Prior to 1945 oil and gas exploration in the Hudson Bay Lowland consisted of the drilling of a few shallow wells in the Moose River Basin. These were near Moosonee and along the Moose River. They were drilled by a number of different interests including the now defunct James Bay Basin Oil Company in 1930 (Martison 1953). No oil was found. After 1945 exploration occurred in two phases or thrusts. The first phase was a major drilling and mapping project initiated by the Shell Oil Company of Canada in cooperation with the Ontario Division of Mines and under the direction of W.C. Gussow and N.W. Martison (Gussow 1953b, Martison 1953). It lasted from 1945 until 1951 and resulted in the production of the first geological map of this basin and two deep bore holes (Jaab Lake and Puskwuche Point, Figure 8), but no evidence of oil or gas.

The second phase concentrated on the Hudson Bay Basin along the shore of Hudson Bay and offshore. It began in the early 1960's with geophysical studies (seismic and magnetic surveys) carried out by the Geological Survey of Canada, Richfield Oil Corporation (now Atlantic-Richfield) and Sogepet Limited (Johnson and Nelson 1969). Sogepet Limited was formed in 1962 specifically to examine petroleum possibilities in the Hudson Bay region. Sogepet, Richfield Oil, Transalta Minerals and Mill City Petroleum acquired offshore oil and gas rights on a total of about 57 million acres and began extensive seismic and drilling operations in northern Manitoba and Hudson Bay. The first well to be drilled was sunk on the Hudson Bay coast in Manitoba at

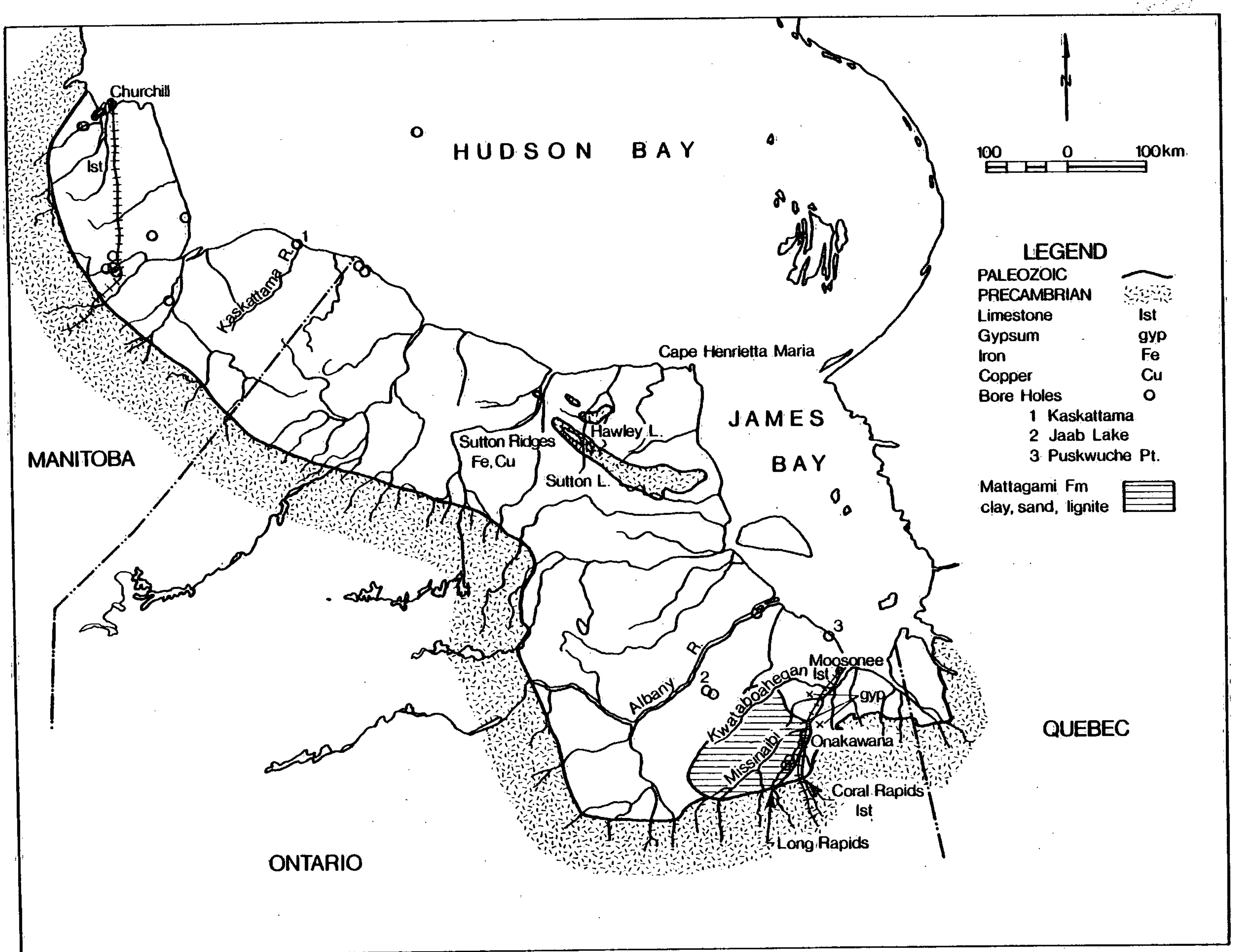

FIGURE 8. ECONOMIC MINERALS AND THE LOCATION OF BORE HOLES IN THE HUDSON BAY LOWLAND

the mouth of the Kaskattama River (Figure 8). It was begun in the fall of 1966 and reached a depth of about 915 m in 1967. The Kaskattama well was drilled by Sogepet in association with Aquitaine of Canada, Bralorne Petroleum, French Petroleum, Texas Gulf, Sun Oil and Decalta Petroleum (Johnson and Nelson 1969). It was one of the most promising wells ever drilled showing traces of oil (up to 30% of pore space) over a 365 m interval (Johnson 1971). This phase of exploration reached a peak in 1973 and included the drilling of several more wells in northern Manitoba and Ontario as well as three in Hudson Bay and one near the old Jaab Lake well in the Moose River Basin (Figure 8, Oilweek 1972). Extractable reserves were not found and interest quickly shifted to the more promising Mackenzie Valley and Arctic Islands. Except for the Kaskattama well the only crude oil known to occur in the Lowland is in the oil shales of the Devonian Long Rapids Formation in the Moose River Basin. Their presence have been known since before 1920 and analyses show a crude oil yield between 3.9 and 5.5 percent (Williams 1920, Martison 1953). The shales have a possible extent of 9,600 km^2 but much of this is covered by Cretaceous clay, sand and lignite and they are thus not yet considered economical.

2.2.3 Limestone

Limestone outcrops occur beneath peat and Pleistocene sediments along much of the routes of the two rail lines which terminate in the Hudson Bay Lowland (Figure 8). In the south good outcrops are found at Coral Rapids on the Abitibi River and Grand Rapids on the Mattagami River. According to Malcolm (1924) and Dyer (1930a) these exposures and others along the Moose, Albany and Pagwachuan Rivers are relatively pure, high Ca^{++} limestones suitable for building stone, hydrated lime, Portland cement, fertilizer and as a chemical in the pulp and paper and metallurgical industries. They are as yet uneconomical for extraction, except for local needs as is the case of the small limestone quarry in Moosonee (Moose River Formation), but may become much more significant as those in southern Ontario become depleted or removed from production by restrictive land use policies.

2.2.4 Gypsum

Gypsum is found at and near the surface along the Moose River where the rail line crosses it and in an extensive exposure 8 to 10 km east of Onakawana. The latter outcrop is known as Gypsum Mountain but the "mountain" rises only 7 to 9 m above the surrounding peatland (Bell 1904, Guillet 1964). Lanning (1926) discusses the extent of gypsum on the Moose River and the early commercial interests in the deposits. He estimated a potential yield of gypsum "in the neighbourhood of 60,000,000 tons". Apparently 12 forty-acre claims were registered in 1911 but these have never been worked.

2.2.5 Cretaceous Fire Clays and Lignite

The Cretaceous sediments are referred to as the Mattagami Formation. These are the youngest pre-Pleistocene unconsolidated deposits in Ontario. They cap the Moose River Basin between the Mattagami and Kwataboahegan Rivers (Figure 8) and represent a sharp change in environment from that of the earlier strata. Mattagami clays have been tested for their refractory properties in the manufacture of fire brick, pottery, sanitary porcelain and rockingham-ware. They were tested by the Ontario Bureau of Mines and by several commercial manufacturers between 1910 and 1930 and found to be of good quality (Table 1). Several claims were staked in 1911 along the Missinaibi and Wabiskagami Rivers where the clays reach thicknesses of up to 30 m (Keele 1920) but none have been worked.

The lignite seams of the Mattagami Formation have been a subject of more recent interest. In 1972 Onakawana Development Limited in agreement with the Government of Ontario and Ontario Hydro undertook a feasibility study concerning the development of the lignite deposits, particularly in the vicinity of Onakawana on the Abitibi River (Onakawana Development Limited 1973, Figure 8). Although the lignite covers a large part of the Moose River Basin the study concentrated on the Onakawana area because it was here the coal was first discovered and Onakawana is located on the rail line. In fact, the presence of the deposit was part of the reason the Northern Ontario and Timiskaming Railroad (now the Ontario Northland Railroad) was extended north of Cochrane in 1930 (Onakawana Development Limited 1973). Table 2 outlines the chronological development in the Onakawana area.

The coal lies in three fields within 3 miles of the northwest bank of the Abitibi River, covering a total of 44km^2 and made up of 2 seams. The seams vary in thickness from 1.2 to 18 m with between 18 and

TABLE 2. Chronology of development including drilling and sampling of the Onakawana lignite field (after Vos, 1975).

1927-1928	- Geological Surveys (Dyer and Crozer, 1933).
1929	- Sample (500 lbs.) of lignite tested by Gilmore (1929).
1929-1932	- Drilling: 116 holes = 305 m centres - approximate total depth 5,200 m. - Shafts : 1st shaft 23.5 m deep. 2nd shaft 41.5 m deep. - Drilling: 389 m at two levels. - Geophysical (electric, gravity) surveys.
1932	- Testing of samples from shafts performed in Europe.
1933	- Technical Report by Ontario Research Foundation (1933).
1939-1942	- Development and production of coal by Temiskaming and Ontario Northland Railway. - Drilling: 182 holes - 5,120 m total depth.
1942	- Takeover of lignite development by Ontario Government. - Construction of steam drying plant at Onakawana initiated.
1945	- Destruction at Onakawana of garage - machine shop - warehouse building by fire in February. - Construction of process plant completed in November; experimental run showed that inflammable dust created in the process caused an explosion hazard.
1946	- Experimental work in processing discontinued. - Stripping of overburden completed to make available an emergency supply of coal for winter 1946/47.
1947	- All operations discontinued. - Plant and equipment removed.
1966	- Alberta Coal Company acquires Exploratory License of Occupation #13902.
1968	- Drilling: 55 holes - 2,219 m total. - Sampling: 5 tons of lignite shipped to Canadian Combustion Research Laboratory, E.M.R., Ottawa; drill cuttings retained by Alberta Coal Co.
1972	- Drilling and sampling: 78 holes - total 3,618 m (average depth 41 m). - Agreement between Government of Ontario, Ontario Hydro and Manalta Coal (successor to Alberta Coal Co.) to undertake feasibility study on development of Onakawana lignite.

TABLE 2. Cont'd.

1973	- Report by the Shawiningan Engineering Company Limited: Recoverable reserves 189 million tons. Total area mineable field - approximately 2,590 ha.
1974-1975	- Drilling by Ontario Division of Mines in Cretaceous Formations west of Onakawana (Rogers et al., 1975, Telford et al., 1975).
1975	- Withdrawal from staking of Surface and Mining rights in Cretaceous Basin, James Bay Lowland by Order No. W.18/75, File: 7598 V. 5, dated March 10, 1975.
1975-1976	- Geophysical Surveys of lignite field and vicinity (Scintrex Surveys Ltd., 1975).
1977	- Three drill holes sunk east of Abitibi River in response to geophysical surveys to determine if lignite extended east of main field (Telford, 1979, Verma et al., 1978).
1978	- Eight drill holes sunk across southern expanse of Moose River Basin to determine extent of Mesozoic deposits (Telford and Verma, 1978 and 1979).
1981	- Ontario Energy Corporation granted an exemption under the Environmental Assessment Act to explore for lignite in the James Bay Basin (Ont. Min. Env. 1981).

49 m of overburden. There are between 96 and 106 million tons proven recoverable reserves (Table 1) and a total possible of up to 221 million tons in these fields. The feasibility study concluded that extraction of lignite and development of a 1,000 MW power plant at this site was practical and economical "of the same order of magnitude as that which would be available from alternative thermal power" (Onakawana Development Ltd. 1973).

Recent drilling and geophysical surveys carried out by the Ontario Geological Survey in 1975, 1977 and 1978 have helped to define more precisely the characteristics and extent of the Mesozoic lignite, silica sand, kaolin and refractory clay deposits of the Moose River Basin. The geophysical surveys and drilling programs and complete drill logs are discussed and presented by Rogers et al. (1975), Utard (1975), Scintrex Surveys Ltd. (1976), Telford and Verma (1978), Verma et al. (1978) and Guillet (1979). Vos (1975 and 1979) and Guillet (1979) also discuss the characteristics, extent and economic potential of the 4 main minerals composing the Mattagami Formation.

In July of 1981 the Ontario Energy Corporation was granted an exemption under the Environmental Assessment Act for "an exploration program to explore for mineral deposits, especially lignite, in the Cretaceous Basin in the James Bay Lowlands", (Ontario Ministry of Environment 1981, p. 27).

2.2.6 Other Minerals

Other extractive resources known to occur in the Hudson Bay Lowland include iron ores (magnetite and hematite), copper, sand and gravel and peat. Iron and copper ores have been found in the Sutton Ridges southwest of Cape Henrietta Maria (Figure 8). These ridges are part of a large Precambrian inlier which rises above the surrounding Paleozoic strata. They rise up to 120 m above the surrounding Lowland and are composed of Archean and Proterozoic igneous and sedimentary strata. Iron formations (hematite) are 3 to 30 m thick with metalic iron concentrations of 27 to 34% (Dowling 1912, Bostock 1971). Copper has been found only in trace amounts between Sutton and Hawley Lakes (Hawley 1926). Neither the iron nor the copper is presently economical to extract although Bostock (1971) notes the possibility of larger deposits (particularly magnetite) southeast of Hawley Lake (Table 1). Several small iron ore bodies in the form of siderite ($FeCO_3$) and limonite have also been reported in cavities in limestone on the Mattagami River at Long Rapids (Williams 1920, Sanford et al. 1968). This is a secondary replacement type of mineralization occuring in bodies less than 9 m thick and 15 m across. These ore bodies were considered insufficient to warrant much economic interest according to Sanford and Norris (1975). However, Skinner (1973b) and Shilts (1980b) note that high concentrations of siderite in glacial deposits in and outside the Lowland indicate that siderite reserves may be substantially larger than those presently known. Shilts (1980b) also notes the presence of high manganese concentrations associated with the siderite mineral in tills derived from carbonate rocks of the Hudson Bay Basin (Table 1).

Stratigraphically above the bedrock are Pleistocene deposits of till, sand, gravel and peat which are in turn overlain by postglacial peat (Martison 1953, Skinner 1973a and b). These deposits are very substantial but because of inaccessibility and low demand are not yet economical for exploitation.

Brown et al. (1967) report on an unsuccessful exploration for diamonds along the Abitibi River in 1962 by the Canadian Rock Company. The presence of diamonds in the southern James Bay Lowland has been suggested by the occurrence of kimberlite dykes on the Abitibi River and by the discovery of diamonds down-ice in till deposits of Wisconsin and Michigan (Table 1).

2.3 Summary and Gaps in Knowledge

The geology of the Hudson Platform is well understood on a regional basis and is the best known of the three main physical components of the Hudson Bay Lowland. However, relative to other geological provinces in Canada it remains the least known. Observations of outcrops are restricted to river banks and along the coast as exposures between rivers in the Lowland are virtually non-existent. In addition the peatland terrain is not conducive to summer travel for drilling purposes and thus costly transportation (helicopters) is required and most operations are restricted to winter periods. Thus there remains a great deal to be learned regarding local and sub-regional geolocial conditions and specific paleontological associations, especially from the Devonian and Silurian as noted previously. Of particular need is more information on the nature of the Paleozoic-Precambrian relationships, especially in the area of the Cape Henrietta Maria arch and in Hudson and James bays; stratigraphic succession and lithology beneath Hudson Bay in the thickest part of the platform; nature and occurrence of primary and secondary structural elements, especially with respect to potential oil and gas reservoirs; and the well preserved biohermal-interreefal facies of the Attawapiskat Formation which have undergone very little diageneses.

The Hudson Bay Lowland has a variety of different minerals but few proven resources. As yet, the high cost of exploration and development both in the Lowland and offshore in Hudson Bay, plus the availability of similar resources in more accessible areas have restricted the discovery of large reserves and the extraction of known reserves. Minerals with the largest proven reserves include limestone, gypsum, fire clays and lignite but only the latter has been seriously considered for exploitation. This could occur at any time. Reserves of oil and gas have been estimated to be greater than those in the Michigan Basin but no pools have been found. As of 1968 (Sanford et al.) only 25 wells had been drilled compared to many thousands in Michigan and southern Ontario, and thus the Lowland can be considered to be virtually untested. With the present demands for these resources it is extremely likely that new drilling operations could be undertaken in the Lowland and offshore. The most recent programs concentrated on the Hudson Bay Basin and these will likely be resumed at some later date. The most critical area of the Hudson Bay Lowland for exploration and development will likely be the Moose River Basin because of its large variety of known and possible resources (oil, gas, limestone, gypsum, lignite and fire clay), its proximity to major markets and its accessibility (by rail). It is difficult to put a time frame on these but except for oil, gas and lignite would not be within 10 to 20 years.

For the reader interested in more information the volume edited by Hood (1969) provides the single most complete overview of all the earth science research carried out in the Lowland to 1968. A good, concise review of the geology and paleohistory of the Hudson Platform is found in Stockwell et al. (1972, p.137-147). For more detail on individual stratigraphic formations, including a good geological map of the entire Lowland (scale 1:1,000,000), the best source is Sanford *et al*. (1968).

3. PLEISTOCENE EPOCH

3.1 Surficial Geology Review

3.1.1 Introduction

The Hudson Bay Lowland is very important to the interpretation of the Pleistocene because of its proximity to the central portion of the Laurentide glacier of the Wisconsin glaciation (Skinner 1973a and b). Glacial and nonglacial events recorded by deposits and landforms in this region should correlate with major glacial stadials and interstadials (periodic fluctuations of the ice margin caused by climatic changes) and interglacials as recognized elsewhere in northeastern North America. In addition, plant remains deposited during the last major interglacial (Sangamon) and in postglacial time in the Lowland reveal past climates and climatic changes that are important to Quaternary interpretations (Terasmae 1958).

The Pleistocene history of the Hudson Bay Lowland is complex. The focus for this chapter is on glacial and nonglacial Pleistocene deposits of the Hudson Bay Lowland and those immediately outside the Lowland which are most significant to the interpretation of events within the Lowland. Hence the voluminous literature on the characteristics and behaviour of the Laurentide ice sheet (Flint 1943 and 1947, Shilts et al. 1979, Shilts 1980a), on glacial lakes Barlow-Ojibway (Prest 1970a, Vincent and Hardy 1979) and on glacial lake Agassiz (Upham 1889, Mayer-Oakes 1967, Prest 1970b) will not be dealt with in detail.

3.1.2 Surficial Deposits and Glaciation

The earliest description of glacial deposits from the Lowland (Albany and Attawapiskat rivers) are those by Bell (1887) from the southern Lowland (Albany and Attawapiskat rivers). Other early descriptions were provided by Dowling (1904 and 1905) along the Ekwan River and Sutton and Hawley lakes; by Wilson (1906) from some of the tributaries of the Moose and Albany rivers; by McInnes (1906) along the Winisk River; by Baker (1911) on the Mattagami River; by Tyrrell (1916) in the northwest part of the Lowland along the Nelson, Hayes, Severn and Fawn rivers; and by Williams (1921) along the Albany river (Figure 9). Their descriptions consisted primarily of noting where, on these rivers, unconsolidated deposits occurred (in some cases they were also mapped - Tyrrell 1913) with brief descriptions of their major lithologies. Of most interest were interglacial peats ('lignites') and till deposits (boulder clays).

All the unconsolidated deposits lying above the Paleozoic limestones in the Lowland were considered as Pleistocene by these early writers. In 1920 however, J. Keele of the Geological Survey of Canada established a Mesozoic age for some of the lignites in the Moose River Basin. McLearn (1927) then carried out the first intensive study of the unconsolidated deposits in the southern Lowland and, with the help of paleobotanists (Auer 1927, and others), was able to distinguish between the Mesozoic clays, sands and lignites and the overlying Pleistocene sequences. The former were best displayed along the Mattagami River and the latter along the nearby Missinaibi River. This must have confused some of the early geologists because both rivers were well travelled, providing the main transportation link to the southern Lowland and Moose Factory.

The descriptions of the Pleistocene sequences by the early geological explorers often referred to the number of drift sequences, the basic lithologies in terms of glacial (boulder clay) versus nonglacial deposits (stratified sands and gravels and peat), occasionally with measured sections (Bell 1887, McInnes 1906, Dowling 1912, Tyrrell 1913, Williams 1921 and McLearn 1927). In addition some papers included lists of glacial straie orientations from within the Lowland (Figure 10) and the surrounding shield (Bell 1887, Upham 1889 and Tyrrell 1898 and 1913). This information was used by these authors to begin to interpret the glacial history of the Lowland. They recognized at least two or three major glacial episodes punctuated by at least one

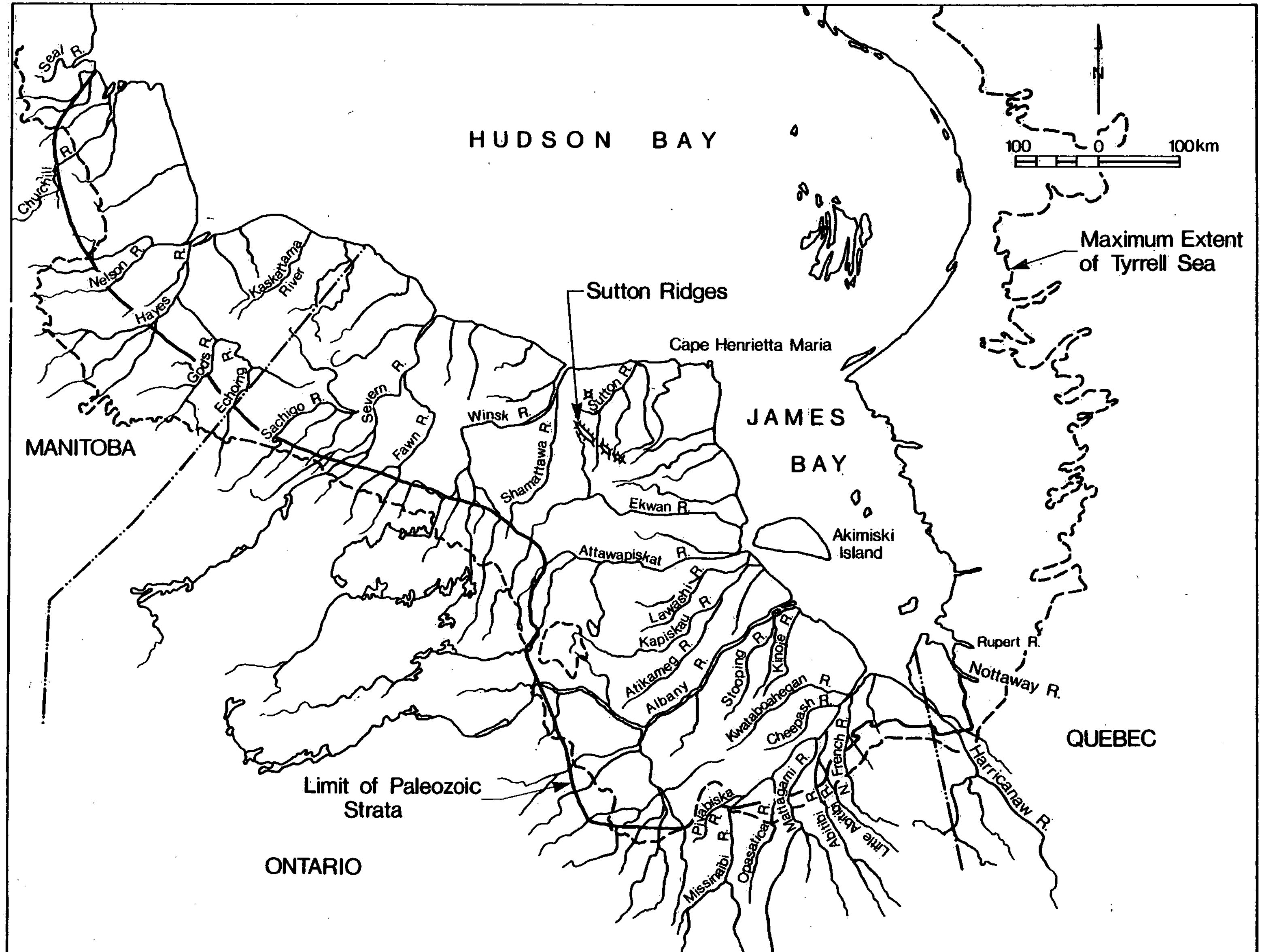

FIGURE 9. MAJOR RIVERS OF THE HUDSON BAY LOWLAND AND EXTENT OF POSTGLACIAL MARINE INUNDATION. (Tyrrell Sea – from the Glacial Map of Canada, Geol. Surv. Can. map 1253A)

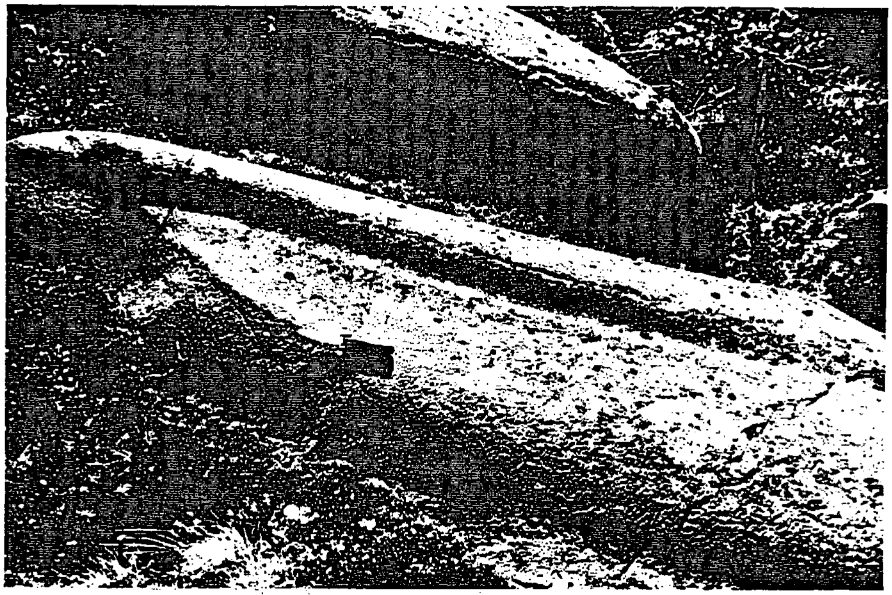

Figure 10: Glacial moulding and striations on bedrock of the Wachi Creek Precambrian inlier southeast of Winisk.

major interglacial period during which organic materials were deposited in an environment and climate similar to that occurring in the area at present (Auer 1927, McLearn 1927). The interpretation of those interglacial beds ('Missiniabi beds') by McLearn (1927) in fact are very close to the most recent interpretation by Skinner (1973a and b).

Geomorphic evidence, especially the occurrence of at least 3 distinct groupings of glacial straie orientations in the Lowland, and on the Canadian Shield surrounding the western Lowland, led Tyrrell (1898 and 1913) to suggest that three main glacial source areas were active during the last major glaciation (the Wisconsin). These glacial centres, each operating independently, were in Québec-Labrador, Keewatin (northwest Hudson Bay) and on the height of land between the Arctic and Atlantic drainage in Ontario. The latter was referred to as the Patrician Glacier. Although some of Tyrrell's interpretations are now considered unlikely, such as the existence of a Patrician accumulation and dispersion centre (see Prest 1970b and Shilts 1980a, p.4, Fig.3) and that one ice centre could advance at the same time another is retreating during the same glaciation, his descriptions and contributions are substantial. In particular he used geomorphic evidence to advance the continental glaciation theory at a time when many others still believed strongly in the iceberg theory as the main mode of erosion and deposition for glacial features (see Zaslow 1975, p. 164). He also interpreted the Wisconsin "Laurentide" ice sheet (as referred to by Flint 1943) as being composed of more than one major ice accumulation and dispersion centre.

During the 1940's and 1950's very little exploration took place in the Lowland. The emphasis in the literature at this time was to describe glacial and postglacial events in northeastern North America (i.e. the Laurentide glacier). Detailed studies of varve[2] chronologies (Antevs 1953 and 1955); preliminary radiocarbon dating of peats associated with major glacial landforms (Antevs 1955, Flint 1956); and pollen assemblages, representing forest succession and climate changes during late glacial and postglacial times (Antevs 1955, Potzger and Courtemanche 1956), formed the basis of glacial and deglacial interpretations by these and later authors (Prest 1970b). Some earlier interpretations based primarily on the descriptions of the geological explorers were provided by Coleman (1941) and Flint (1943 and 1947). The paper by Flint (1943) is especially significant because he attempts to dispell some earlier beliefs with respect to the formation and configuration of the Laurentide ice sheet. For example, he asserted that the Laurentide Glacier originated in Québec-Labrador and other centres, such as in Keewatin, were Late Wisconsin and of local importance only.

Although little was known at this time about the final deglaciation of the Lowland and Hudson Bay Region, these authors described Late Wisconsin events in central North America, especially the Great Lakes Region which had been studied intensely in the early 1900's. The result was a fairly detailed account of glacial retreat from the northeastern U.S., southern Ontario and

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2 Varves are a form of rythmite or couplet made up of a layer of silt and a layer of clay or silt of a different colour. A complete couplet represents the sedimentation of a one year period into a proglacial lake.

southern Québec. Proglacial lake histories in the Great Lakes Basin and in the claybelt areas of northern Ontario and Québec, as well as the history of the late glacial Cochrane advance just south of the Lowland had, in preliminary fashion, been established. Varve chronology and radiocarbon dating were employed to correlate and date events throughout eastern North America. The Cochrane readvance was estimated to have occurred between 10,150 and 11,300 years B.P. by Antevs (1953), and between 6,730 and 10,700 years B.P. by Flint (1956). Most authors agreed that glacial retreat in northern Ontario prior to the Cochrane and immediately after into Hudson Bay was very rapid. Flint (1956) was one of the first to suggest this was due to floating of the ice mass by marine inundation (following the Cochrane advance) and its subsequent isolation from the main accumulation area in Labrador. More recently, the date for final retreat of the ice into the southern Lowland accompanied by marine inundation (Tyrrell Sea - Figure 9) is put at about 7800 years B.P. (Terasmae and Hughes 1960b, Prest 1963). Not only was final retreat of the Cochrane ice front rapid, but Vincent and Hardy (1979) note that the Cochrane I and II advances must have been very rapid as well; in fact sufficiently rapid to affect the sedimentological character of varves in glacial lakes Barlow-Ojibway.

During the late 1950's through mid 1960's much of the emphasis in the literature was placed on the peat, sand, silt and clay deposits representing a non-glacial interval between glaciations in the southern Hudson Bay Lowland. Terasmae (1957, 1958) carried out detailed palynologic investigations on the peat beds outcropping on the Missinaibi River. He noted that radiocarbon dating places their age at greater than 40,000 years B.P. The pollen assemblages indicate a climate similar to today. The enclosing mineral sediments also indicate depositional environments similar to present, i.e. a lowland with bog and fen development near major river courses. Assuming certain rates of deposition, he estimated the duration of this nonglacial interval to be about 6000 years. On this evidence he concludes that the deposits were not interglacial (Sangamon) as believed by some previous authors but represented a major substage in the early Wisconsin glaciation. In a subsequent paper Terasmae and Hughes (1960a) coined the term 'Missinaibi beds' for these nonglacial sediments which are best displayed on the Missinaibi River. They placed the age of the deposit at greater than 53,000 radiocarbon years but still considered them to be interstadial. This date was based on preliminary radiocarbon dating by deVries (as referenced by Terasmae and Hughes 1960a). The authors described 3 river-bank sections of Quaternary deposits. In addition to the Missinaibi beds they identified 4 other units; 2 main basal units below the nonglacial beds and 1 till/drift above these beds overlain by recent marine clays.

Prest (1966) observed marine clays immediately underlying Missinaibi beds in the Abitibi River which indicated that Hudson Bay must have been ice free prior to their deposition. Because of this he concluded that the Missinaibi beds were interglacial, not interstadial. He later suggested they may yet prove to be interstadial because their flora represented a climate which was too cool to be Sangamon (Prest 1970a: pp. 687-690). The paper by Prest (1970a) also summarizes the history of studies on the Missinaibi beds providing 14 descriptions from various parts of the Lowland of nonglacial sequences now believed to be Missinaibi equivalents.

A number of investigations were carried out during the late 1950's and 1960's in areas surrounding the Hudson Bay Lowland. These are detailed Quaternary studies covering certain map sheets which have added a great deal to the interpretation of late glacial and postglacial events in northeastern North America. They include the central District of Keewatin, west of Hudson Bay (Fyles 1955); the southern District of Keewatin (Lee 1959); Red Lake-Lansdowne House area of northwestern Ontario (Prest 1963); Cochrane district south of the Hudson Bay Lowland in Ontario (Hughes 1961, 1965 and Boissonneau 1966); and northeastern Ontario/northwestern Québec south and southeast of the Lowland (Prest 1966). In addition Falconer *et al*. (1965a and b) proposed a tentative correlation of major moraine systems encircling Hudson Bay and Labrador. They suggest that these moraines represent the location of the Late Wisconsin ice margin 8000 to 9000 years ago. These would correspond to the outer edge of the Cochrane advance and are termed the "Cockburn Moraine System" of the "Cockburn Phase" by the authors (after the Cockburn Moraine of Baffin Island-Falconer *et al*. 1965b, p. 150).

The first detailed Quaternary investigations in the Hudson Bay Lowland since the work of McLearn (1927) took place in 1967 during 'Operation Winisk'.

B.G. Craig and B.C. McDonald of the Geological Survey of Canada examined river-bank sections on 11 rivers across the Lowland and incorporated data from earlier studies. Their prelminary findings were published in a short summary paper (Craig and McDonald 1967). McDonald (1969) later discussed glacial and interglacial deposits and interpretations of the Lowland and Craig (1969) discussed late glacial and postglacial history. These are significant because they represent the first attempt at describing the glacial and postglacial deposits with interpretations of their mode of formation for the whole Lowland. Also they added a great deal to what was known about that period. The authors were able to confirm the presence of interglacial deposits (Missinaibi beds) between tills throughout the Lowland, and noted the presence of lacustrine sediments immediately underlying Tyrrell Sea clays in the southeast and northwest portions of the Lowland (Craig and McDonald 1967). These indicate the presence of glacial lakes Barlow-Ojibway and Agassiz, respectively in outer parts of the Lowland. Craig (1969) elaborated on these findings and discussed the history of differential glacial retreat, proglacial lake drainage and pattern of marine incursion[3] (7900 years B.P.). He also examines the elevation of the marine limit and discusses isostatic uplift (next section). McDonald (1969) focuses on the Missinaibi beds which he concludes are interglacial. His primary evidence for this is the presence of marine sediments in the nonglacial sequence in at least 2 outcrops which were not known by Terasmae and Hughes (1960a). McDonald also discussed the Quaternary stratigraphy as revealed in 7 composite sections covering the Lowland. These show the presence of up to 3 basal tills overlain by Missinaibi beds, which are in turn overlain by 2 tills separated by lacustrine deposits. Proglacial lake deposits (absent in the central Lowland), Tyrrell Sea sediments and peat and/or alluvium comprise the uppermost deposits.

McDonald later (1971, as reported by Skinner 1973b) correlated the Missinaibi beds with the St. Pierre beds of the St. Lawrence Lowland which are interstadial, not interglacial. He seems to have reversed his earlier conclusion as did Prest (1970a)

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3 This incursion is known as the 'Tyrrell Sea', the name coined by Lee (1960) - refer to Section 3.2 and Figure 9.

although he noted that both beds could be interglacial. Skinner (1973a and b) more recently asserted that the Missinaibi beds are interglacial.

These papers (especially Skinner 1973b) are landmark papers on the Quaternary deposits and their interpretation in the southern Hudson Bay Lowland. Skinner carried out detailed studies of river-bank sections in the Moose River drainage basin and incorporated descriptions from earlier investigators including McLearn (1927), Terasmae and Hughes (1960a), McDonald (1969) and B.G. Craig (unpublished). Information from more than 130 sections on 10 rivers or dam diversions are included in his interpretations. He presents convincing arguments and provides the most detailed interpretations of the Quaternary deposits of the Lowland to date. Figures 11, 12, and 13 are taken from Skinner (1973a). They illustrate his terminology and paleoenvironmental interpretations of all the Quaternary units identified in the southern Lowland (Figure 11), with more detailed descriptions and interpretations for the Missinaibi Formation (Figure 12), and postglacial deposits (Figure 13). Of particular interest are his interpretations of the Missinaibi beds and the nature of the post-Wisconsin marine incursion into the southern Lowland. For the latter he postulated the occurrence of a saline underflow as marine waters and freshwater (proglacial lake) mixed forming a 'pebble-clay' deposit at the base of the Tyrrell Sea clay. Similar deposits in Québec have been ascribed to the drainage of glacial Lake Barlow-Ojibay into the Tyrrell Sea (Cowan 1980).

Skinner coined the term 'Bell Sea', after Robert Bell of the Geological Survey, for the marine incursion which occupied the area at the beginning of interglacial period marked by the Missinaibi beds (during the Sangamon Interglacial). He also showed the possible correlation between his upper Kipling till in the Lowland with the Cochrane till south of the Lowland (Figure 14). Prest (1970a) also correlated these tills but Skinner points out that there is still insufficient evidence. Skinner's conclusions are included in the annotation of his paper (Skinner 1973b).

Klassen and Netterville (1973) summarize their investigations of Quaternary deposits in the north-western part of the Lowland. They indicate that the deposits are generally similar to those in the southern

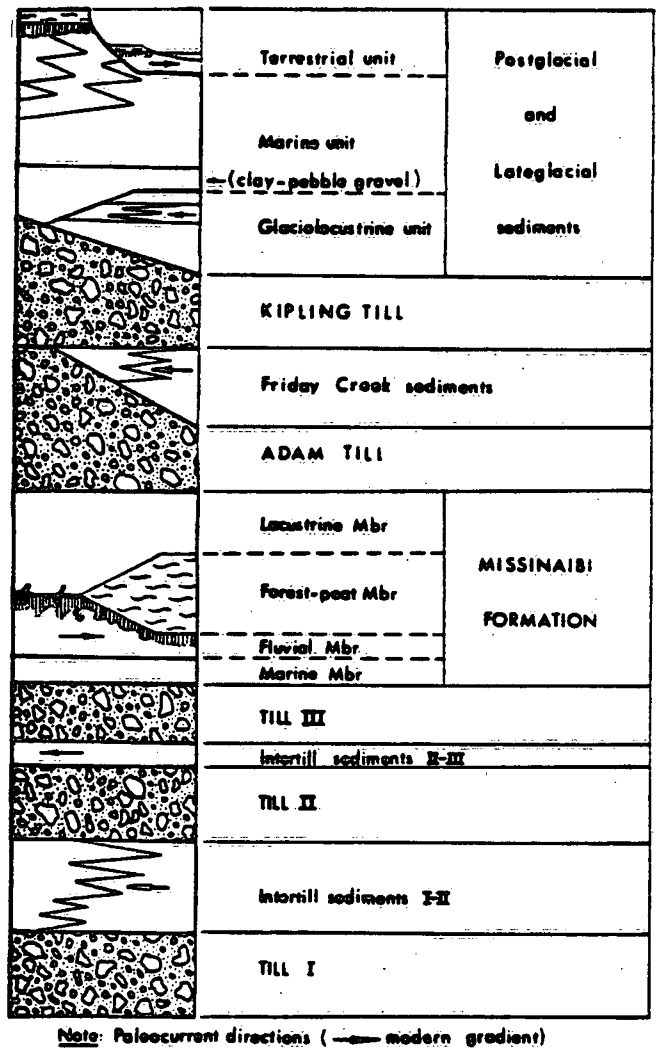

Figure 11: Composite Section of the Quaternary sequence (rock-stratigraphic units) of the Moose River Basin (from Skinner 1973a).

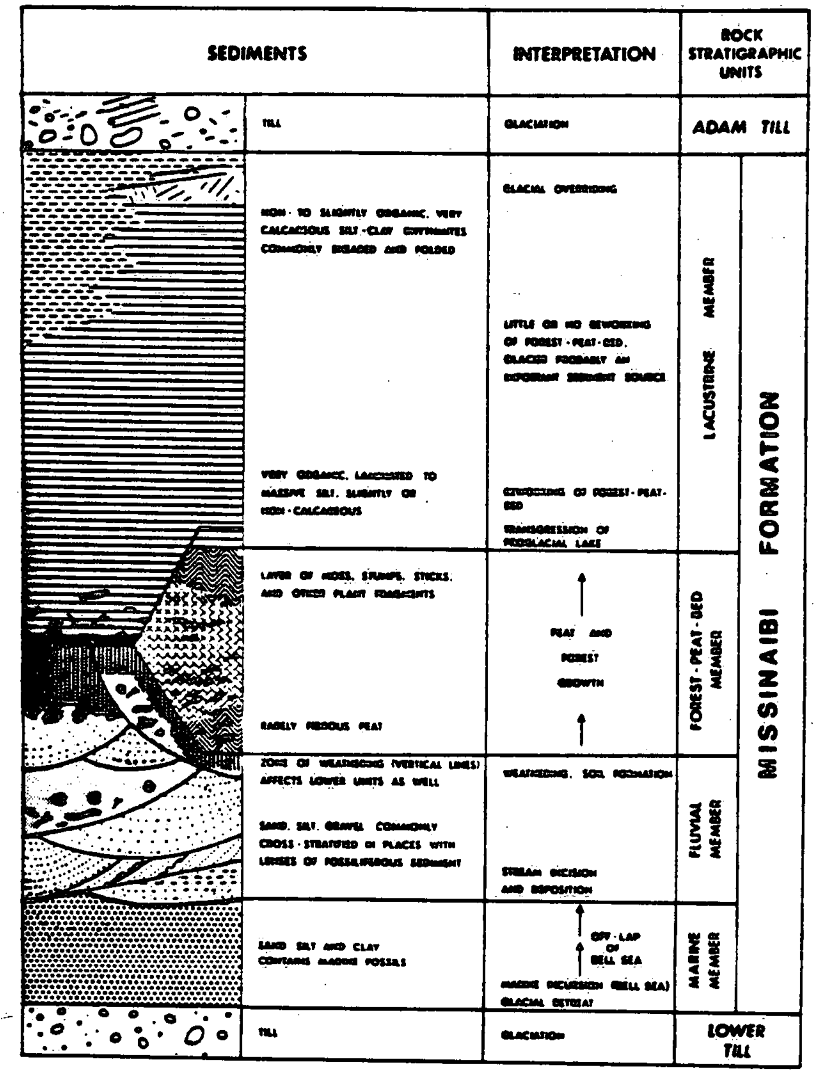

Figure 12: Detailed composite section of Missinaibi Formation (Missinaibi beds of Terasmae and Hughes 1960a, from Skinner 1973a).

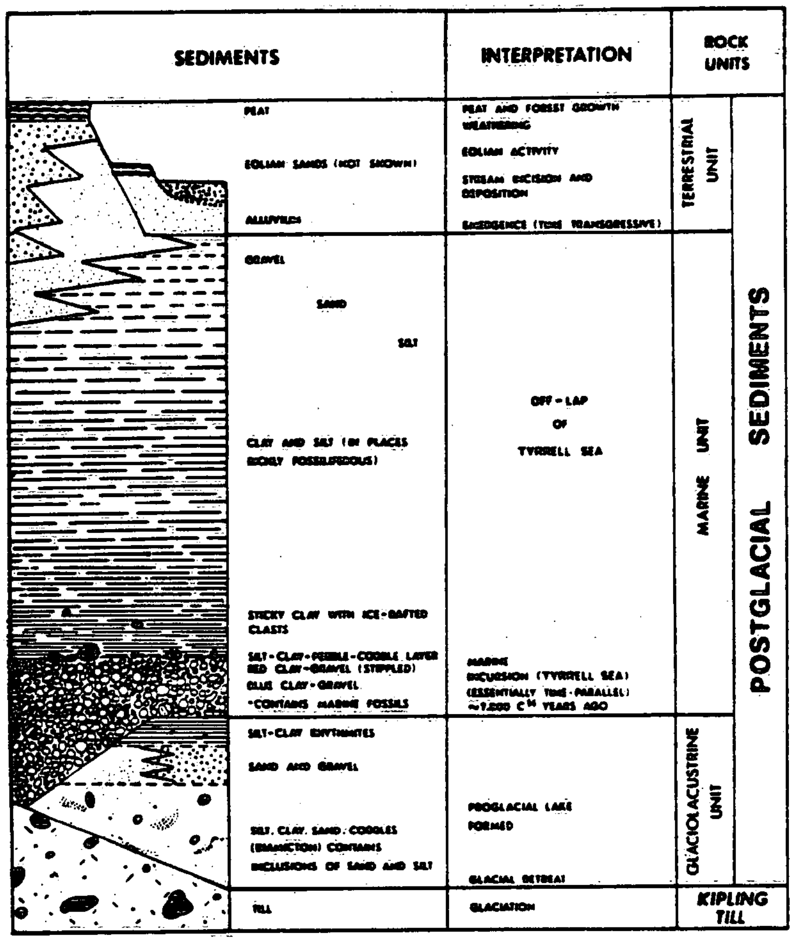

Figure 13: Detailed composite late glacial and postglacial section (from Skinner 1973a).

Figure 14: Adam Creek diversion channel on the Mattagami River. The channel banks are the type section for the Adam till. Also exposed here are the Friday Creek sediments and Kipling till overlain by alluvium.

Lowland which indicates a uniform, widespread Quaternary history of the whole Hudson Bay Lowland. Netterville has since completed an M.Sc. Thesis (1974) which describes the Quaternary deposits in a portion of the Manitoba Lowland (God's River Region). Klassen is currently preparing a Geological Survey of Canada publication on the results of their work in the northwest Lowland (W. Shilts, Geological Survey of Canada, personal communication).

The work of Skinner, McDonald, Craig, Klassen and Netterville (published and unpublished) have been reviewed in light of more recent findings. The results are published in a series of papers by Bill Shilts of the Geological Survey of Canada (Shilts et al. 1979, Shilts 1980a and in press). The more recent findings include analyses of till lithologies in the southwestern Lowland (see also Shilts 1980b), and amino acid dating of marine shells collected from various localities in the Lowland. Glacial dispersion patterns of red erratics northwest of Hudson Bay (Keewatin) and source-dispersion characteristics of three other distinct erratic lithologies are also considered in detail.

The most recent paper by Shilts (in press) is particularly complete, providing and excellent review of the literature relating the behaviour of the Laurentide ice sheet in the Hudson Bay region, and discussing his new evidence in combination with previous work and concepts. The major findings reported by Shilts are: (1) that the Laurentide ice sheet originated as two distinct ice accumulation centres, (2) that there was no stable, single core or dome of ice over Hudson Bay and (3) that Hudson Bay was open to marine waters at least twice during the Pleistocene. The first of these findings discounts traditional concepts of a single major Québec-Labrador ice centre, first postulated by Flint (1943 and 1947). In fact, Shilts supports Tyrrell's original concept of a Keewatin ice centre playing a major role throughout the Wisconsin (Tyrrell 1898). The third finding is based on new amino acid dating techniques. Amino acid ratios of marine shells collected from post-Missinaibi tills occur in four groupings which are tentatively assigned ages of around 135,000-106,000, 76,000, 35,000, and 8,500 years. This places the Missinaibi beds (Bell Sea) as interglacial in age. Shilts also attempts a stratigraphic reconstruction of the Lowland. It differs from Skinner (1973 a and b) primarily by showing three post-Missinaibi tills (rather than 2) for the entire Lowland which, in each case, incorporate marine detrius reworked from immediately preceding marine deposits. Marine deposits underlying the upper two tills are not found in any of the sections yet described from the Lowland.

The Tyrrell Sea inundation of the Lowland represents the transition from glacial (Pleistocene) conditions to postglacial conditions. Its widespread occurrence and plethora of depositional and erosional landforms in the Hudson Bay region has made this the object of much discussion. The Tyrrell Sea will be considered in more detail in the next section, in terms of the marine limit and isostatic rebound, but there are also some interesting interpretations of the pattern of marine inundation in concert with the nature of final deglaciation and break-up of the ice sheet in the region. Of particular note on this subject are the papers by Lee (1960), in which the term 'Tyrrell Sea' was first applied to the marine inundation, and Lee (1968), Andrews and Falconer (1969), Craig (1969), Prest

(1970a), Andrews and Barnett (1972), Skinner (1973b), Andrews and Peltier (1976), Vincent and Hardy (1979) and Cowan (1980). Most authors agree that the southern James Bay area was the first part of the Lowland to be submerged because this is where the oldest date on the marine limit has been obtained (about 7900 years B.P., Craig 1969). Prest (1970a) shows the marine incursion crossing the ice from Hudson Strait and entering the northwest part of the Lowland but this does not hold up to the present evidence. Glacial retreat into Hudson Bay from the Cochrane (Cockburn) terminal position must have been rapid with active calving of the ice front into the marine waters which entered from Hudson Strait. The nature of the final break-up of the ice sheet and the exact route of marine inundation is not known. Lee (1968) and Cowan (1980) use landform evidence east of James Bay to show the ice mass separated along a north-south line retreating into Labrador and toward the centre of Hudson Bay with marine waters following this line of separation. Craig (1969) notes the Tyrrell Sea entered the southern James Bay area from east-central or eastern Hudson Bay and Skinner (1973b) indicates it may have followed south along a line on the west side of James Bay as the ice broke-up over the topographically high Sutton Ridges Precambrian inliers. Prest (1970a) and Cowan (1980) suggest the whole ice sheet was floated by marine waters during the late Wisconsin which actually caused the ice to surge to the Cochrane advance position from well inside the Lowland. There is little evidence for this however, and it is more likely the ice broke-up concurrent with marine inundation. Andrews and Falconer (1969) and Andrews and Peltier (1976) use evidence from the Ottawa Islands in northeast Hudson Bay, especially glacial striations and radiocarbon dating from marine deposits, to suggest the ice collapsed downward, to the west of these islands because of calving in Hudson Strait. This permitted marine waters to cross the ice and enter the southern James Bay area. The presence of a single ice dome over Hudson Bay does not fit the recent findings of Shilts et al. (1979) and Shilts (1980 and in press), which suggest the presence of many small glacial centres around the bay. Andrews and Falconer (1969), Andrews and Barnett (1972) and Andrews and Peltier (1976) however, also note that final retreat was toward at least 6 deglacierization centres surrounding Hudson Bay. Vincent and Hardy (1979) show glacial lakes Barlow-Ojibway draining northward into the Tyrrell Sea between two ice frontal positions, each representing distinct deglacial centres. This is estimated at 7900 years B.P., during the maximum of the Cochrane II advance.

Dionne (1972) divided the Tyrrell Sea period into two stages. The lower Tyrrell ('Tyrrellien inferieur') represents the oldest phase to about 3000 years B.P., corresponding to the period of greatest rates of uplift. Slower uplift rates from 3000 years B.P. to the present define the upper Tyrrell ('Tyrrellien superieur').

Ballivy et al. (1971) report the result of geochemical and mineralogical analysis of Tyrrell Sea clays (silty clays) from a deposit near Rupert House, Québec. They have also analysed clays of glacial Lake Barlow-Ojibway from southeast of the Lowland and show the chemical and mineralogical differences of these two types of deposits. On the basis of these analyses they recognize Barlow-Ojibway deposits underlying Tyrrell Sea clays on the eastern edge of the Lowland.

In general the Quaternary deposits are well displayed along the major rivers and their main tributaries. The thickest and best exposures tend to occur in the upstream portion of these rivers, nearest the Lowland/Shield border where river dissection is most advanced. These deposits, though widespread in the Lowland (McDonald 1969, Klassen and Netterville 1973), are not everywhere represented and vary considerably in thickness even along individual rivers. In many places the rivers are flowing over bedrock with only alluvium and sometimes Tyrrell Sea clays present. Drilling between rivers in the Onakawana area and on the coast of James Bay have shown wide variations in thickness of Quaternary deposits (Dyer and Crozier 1933). Thickness varies from being totally absent in some river cuts and along parts of the coast where bedrock is exposed to in excess of 210 m in a buried preglacial valley of the Mattagami River (Hogg et al. 1953).

3.2 Glacio-Isostacy Review

3.2.1 Introduction

One of the processes that has interested geologists and geomorphologists from the time of Robert Bell and Joseph Tyrrell is the glacio-isostatic rebound taking place in the Hudson Bay Region. The evidence for uplift is abundant, including marine shells and beach ridges hundreds of feet above the present sea level, in places deposited almost continuously from the marine limit to the shores of Hudson and James bays (Bell 1880, Richards 1941, Lee 1959, Craig 1969, Figures 9 and 15). The physical evidence also includes marine clay deposits, especially in lowland areas (Bird 1954, Lee 1959, Figure 16); erosional bluffs and perched boulder fields along the east coasts of Hudson and James bays (Bell 1879a, Andrews 1968); marine terraces cut into eskers and drumlins in the Keewatin District of northwest Hudson Bay (Fyles 1955, Lee 1959); and perched deltas on the Ottawa Islands (Andrews and Falconer 1969) in northeast Hudson Bay. Other evidence is provided by historical records and surveys at Hudson Bay Company posts (Bell 1896, Tyrrell 1896, Hunter 1970) dating from the mid 1700's; archaeological remains of Inuit and Indian beach encampments (Bell 1896, Bird 1954, Andrews et al. 1971); and personal accounts by natives, other residents and explorers with respect to changes in the configuration of the coast and shallowing of river mouths and harbours within living memory (Bell 1896, Bird 1954).

The literature describing the effects and investigating the processes of isostatic rebound in the Hudson Bay Region, date periodically from 1877 to the present. The longest period without significant contributions on the subject was between 1900 and 1935 but otherwise every decade is represented since the 1870's. During this 100 year period the literature has evolved from the description of physical and social evidence for isostacy and the proofs (or disproofs) of its continuance (Bell 1877, 1879a and b, 1880, 1896; Tyrrell 1896, 1900; Low 1889; Johnston 1939; Cooke 1930, 1942; and Manning 1951); to the determination of former and present uplift rates and marine limits (Gutenberg 1941, 1954; Bird 1954; Lee 1960; Barnett 1966, 1970; Wagner 1967; Hunter 1970; and Simpson 1972) and finally to the application of the characteristics of rebound to elucidate details of processes and events such as glaciation - deglaciation (Lee 1960, Andrews 1969, Andrews and Falconer 1969, Craig 1969, Elson 1969), biogeography and vegetational colonization (Webber et al. 1970), characteristics of the earth's crust and subcrust and remaining uplift (Innes 1960; Andrews 1968, 1969; Innes et al. 1968; and Walcott 1970), archeology (Andrews et al. 1971) and paleoclimate (Fairbridge and Hillaire-Marcel 1977). Table 3 summarizes determinations of uplift rates, marine limits and

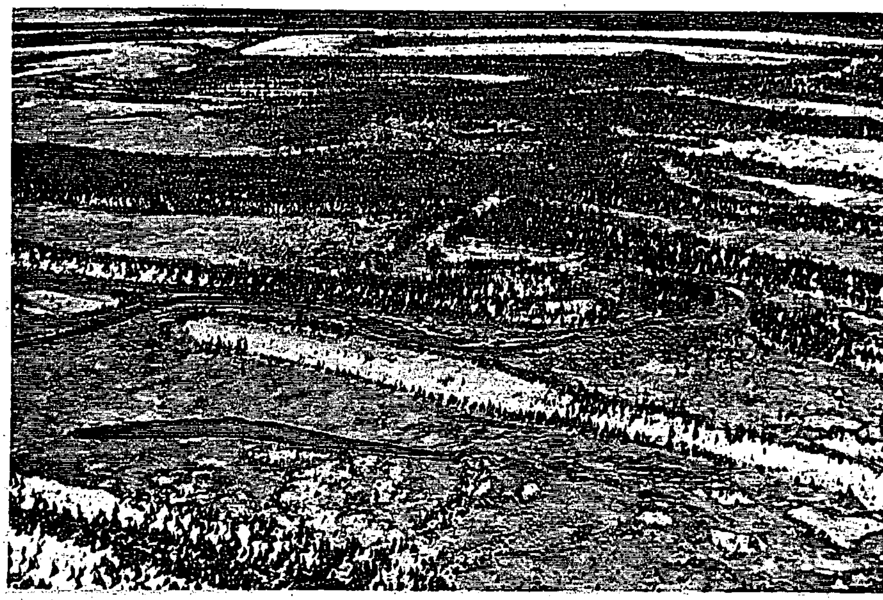

Figure 15: Raised beach ridges along portions of the south shore of Hudson Bay continue inland as recognizable forms for many 10's of km.

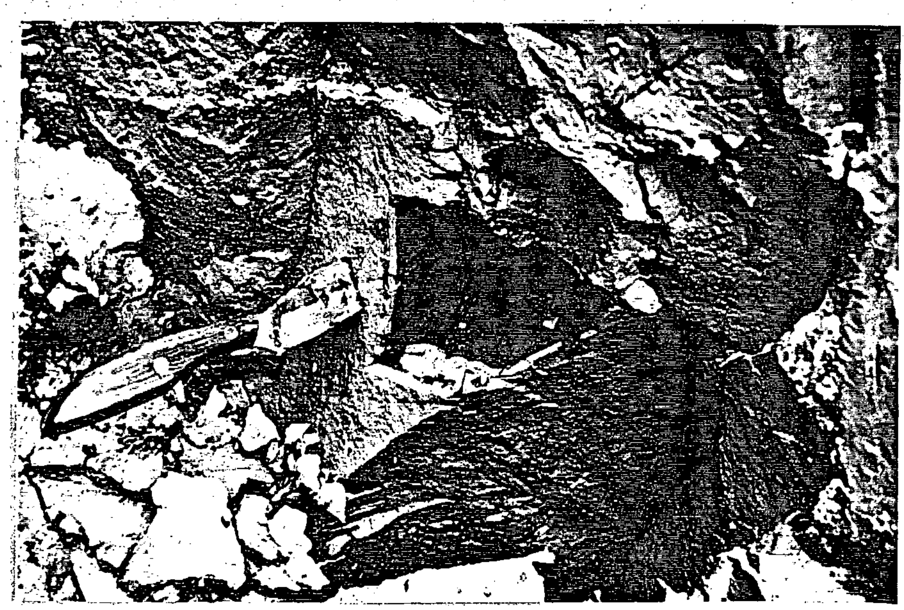

Figure 16: Compact Tyrrell Sea clayey-silts exposed in the base of a slump along the bank of the Harricanaw River. Note shell fragments (white specs) and dark, highly-reduced character of the clays beneath the oxidized surface (to right of knife).

TABLE 3 Emergence rates, marine limits and remaining uplift for the southern Hudson Bay Region determined by various authors between 1879 and the present.

AUTHOR(S)	LOCATION	UPLIFT/EMERGENCE RATE (as reported/ 100 yrs)	MARINE LIMIT(S) A.S.L.	REMAINING RECOVERY	METHOD OF DETERMINATION
Bell 1879a	east coast of James Bay	5-10 ft (1.5-3.0m)	≥ 300 ft (90m)		estimated rate of decay of spruce driftwood between sea level and 30 ft above.
Bell 1880	Churchill	7 ft (2.1m)	≥ 350 ft (105m)		historical records on Fort Prince of Wales and "other data".
Gutenberg 1941	Churchill	1-3m (3.3-10 ft) assumes 2m (6.5 ft)	--	800 ft (240m)	tide gauge records 1928 to 1939 and theoretical geophysics.
Bird 1954	Northwest Hudson Bay (Keewatin)	3 ft (.9m)	360-400 ft (110-120m)		archeological remains of Thule Eskimos 30 ft above sea level.
Gutenberg 1954	Churchill	1.05 $\pm$ 0.18m (3.3 ft)			re-evaluation of tide gauge data 1928-1951.
Innes 1960	Hudson Bay Region			800 ft (240 m)	theoretical estimate based on size of gravity anomaly over Hudson Bay and assuming sub-crustal densities of 3.3 gms/cm^3.
Lee 1960	Hudson Bay Region	20 ft (6.1m) decreasing to 1-3 ft (.3-.9m) at about 6500 yrs B.P.	800-900 ft east of Hudson Bay(240-275m) 400-600 ft west of Hudson Bay(120-185m)		estimate based on radiocarbon dates on shells, mainly from Quebec and northern Hudson Bay.
Barnett 1966	Churchill	2.4 ft (.7m)			tide gauge records 1940-1964.
Wagner 1967	a) Northern Hudson Bay	20 ft (6.1m) decreasing to 4.2 ft (1.3m) 6500 yrs B.P.			three age-elevation curves based on 20, 6 and 7 radiocarbon dates, respectively.
	b) Central Hudson Bay	16.5 ft (5m) decreasing to 3.8 ft (1.2m) 6500 yrs B.P.			
	c) Southern Hudson Bay	12.5 ft (3.8m) decreasing to 3.1 ft (.94m) 6500 yrs B.P.			

TABLE 3 (con t'd)

AUTHOR(S)	LOCATION	UPLIFT/EMERGENCE RATE (as reported/100 yrs)	MARINE LIMIT(S) A.S.L.	REMAINING RECOVERY	METHOD OF DETERMINATION
Andrews 1968	a) Churchill area b) Ottawa Islands (north-east Hudson Bay)			90m (300 ft) 100m (328 ft)	based on equation developed from 21 uplift curves determined using 89 radiocarbon dates.
Archer 1968	eastern Hudson Bay-Richmond Gulf		835-943 ft (255-290m)		aneroid barometer elevations of highest marine shell localities and ridges and lower limit of perched boulders.
Innes *et al.* 1968	Hudson Bay Region			180 m (590 ft)	theoretical estimate based on Free-Air gravity anomalies.
Andrews 1969	Hudson Bay Lowland a) Churchill b) Cape Henrietta Maria			90m (300 ft) 140m (460 ft)	based on equations derived from curves of postglacial uplift.
Andrews & Falconer 1969	northeastern Hudson Bay-Ottawa Islands	6m (20 ft) decreasing to .8m (2.6 ft) about 6000 yrs B.P.	158m ± 2.2m (518 ft ± 7.2 ft)		aneroid barometer elevations on perched boulder fields and radiocarbon dating of marine shells.
Craig 1969	Churchill area	22.5 ft (6.9m) 7000 yrs. B.P. decreasing to 5 ft (1.5m) between 3000 and 1000 yrs. B.P.	400-610 ft (120-190m)		age-elevation curve based on 6 radiocarbon determinations.
Andrews 1970	Hudson Bay Lowland	currently-.9m (2.9ft) to 1.3m (4.3 ft) 6000 yrs B.P. - 4m (13 ft) to 5m (16.4 ft) 8000 yrs. B.P. - 4m (13 ft) to 8m (26.2 ft)	158m (518 ft) near Churchill; 196m (643 ft) southwest of James Bay		age-elevation curves at 21 sites and theoretical estimates based on constant derived from these curves - not corrected for eustatic sea level rise.
Barnett 1970	Churchill	1.75 ft (.53m)			tidal records 1940-1968.

TABLE 3 (cont'd).

AUTHOR(S)	LOCATION	UPLIFT/EMERGENCE RATE (as reported/100 yrs)	MARINE LIMIT(S) A.S.L.	REMAINING RECOVERY	METHOD OF DETERMINATION
Hunter 1970	Fort Albany	.9m (29 ft) - 1.2m (3.9 ft)			historical records of Fort Albany area.
Walcott 1970	Hudson Bay Region			140m (460 ft) - 350m (1150 ft) (highest near Eskimo Pt., NW Hudson Bay)	estimate based on Free Air gravity anomalies assuming crustal densities of 3.3g/cm^3.
Webber *et al.* 1970	Cape Henrietta Maria	1.2m (3.9 ft)	350m (1150 ft) - 540m (1770 ft) (postulated)		levelling and 5 radiocarbon dates on marine shells (*Mytilus edulis*) and driftwood.
Simpson 1972	York Factory	3.12 ft (9.4m) to 4.29 ft (1.3m)		460 ft (140m)- 620 ft (186m)	C^{14} dating of driftwood and survey of Beacon Point in the Nelson-Hayes Estuary.
Skinner 1973b	James Bay Lowland (southern HBL)	since 6000 yrs B.P. - .6 to 1.0m (2 to 3.3 ft) prior to 6000 yrs B.P. - averages 8.0m (26 ft)	124m (410 ft)- 133m (440 ft)		C^{14} dating of marine shells and altimeter recording of elevations. [estimated by editor from graph-Figure 23].

remaining rebound made by various authors using a variety of techniques between 1879 and the present.

3.2.2 Pre-1967: The Evidence for Uplift

The first recorded reference to raised strandlines was by the explorer Luke Foxe in 1631 who attributed their formation to extraordinary tides (Warkentin 1964 as referenced in Kupsch 1967). Of the geological explorers Robert Bell of the Geological Survey of Canada was the first to recognize raised strandlines, beach ridges and marine shells in the area surrounding Hudson Bay. During the 1870's and 1880's Bell explored most of the major rivers and their tributaries in the Hudson Bay Lowland, the south and east coast of James Bay and the southwest and east coast of Hudson Bay. The first reference he made to raised marine features was in 1877 in a report describing his travels in southern James Bay (Rupert Bay) in 1875. Subsequent reports (Bell 1879a and b, 1880) describe raised marine features in other parts of the Lowland and the Hudson Bay Region. Bell (1877) considered the near-shore raised strandlines of southern James Bay as an indication of isostacy which Low (1889) later tried to explain by abnormally high tides. However even Low (1887) recognized isostacy as the cause for raised beach ridges he observed above Hudson Bay between Fort Severn and York Factory. In his reports of 1879(a) and 1880 Bell seems to have retracted somewhat and talks about the relative changes between land and sea-level. He notes that the ridges of eastern James and Hudson bays and the changes related to the history of old Fort Prince of Wales (Churchill) were a result of a "fall in the sea level" and, in the latter case, due to silting-up of portions of Hudson Bay; he does not refer to isostatic uplift. However sometime before 1895 he had become convinced that the land around Hudson Bay had been uplifted and was continuing to rise. In 1896 he published a short monograph giving numerous "proofs" that the land in this region was presently rising. This gave rise to a reply by Joseph Tyrrell in the same year that the evidence at old Fort Prince of Wales in fact suggested no uplift had taken place since 1741 in that area.

Tyrrell based much of his argument on the height of names chisseled into rock above sea level in Stoop's Cove, Churchill. One name was dated May 25, 1741 and was 7 feet above the estimated height of winter ice which is often still in the cove in late May. He concluded that Bell's estimate of 7 feet/100 years (Table 2, Bell 1880) of uplift for Churchill could not be accurate and "that the postglacial uplift of this portion of Hudson Bay has virtually ceased....the land has now reached a stable, or almost stable condition". He dismissed Bell's evidence as delusion. Tyrrell added further proof to his belief in 1900 quoting from a recently translated Danish explorer's description of Churchill harbour[4]. In 1939 W.A. Johnston re-measured the height of the names and found "no definite evidence of recent change of level of the coast relative to sea-level". As recently as 1942 H.C. Cooke, discussing a paper by Gutenberg (1941) dismissed Gutenberg's evidence of uplift based on tide-gauge records at Churchill and concurred with Tyrrell's concept of little or no on-going uplift in this area. He stated that if uplift were continuing at all it is only a "very few cm per century".

Bell (1879a, 1880) determined uplift rates for eastern James Bay and Churchill (Table 3) using the estimated rate of decay of spruce driftwood in raised beaches (Figures 17 and 18) and historical records.

Figure 17: Driftwood deposit on offshore side of a low gravel beach ridge on the James Bay coast, near the Albany River.

4 This was explorer Jens Munck who discovered the harbour in 1619 (Cumming 1969).

Figure 18: Driftwood log uplifted above the tidal zone and being incorporated into freshwater marsh deposits.

These were the first published estimates of the rate of uplift for the Hudson Bay Region. The first statistically or analytically determined uplift rates were made by Gutenberg in 1941. He used tide gauge data taken at Churchill Manitoba between 1928 and 1939. The data represented only a relatively short period and until 1940 the gauge was located in the mouth of the Churchill River behind a constriction to the open sea. Also, it was removed each winter because of ice conditions. These factors led Cooke (1942) to severely critize Gutenberg's estimated uplift. Gutenberg supported his calculations in a reply (see Cooke 1942) and in 1954 published an update using gauge data to 1951.

Unfortunately, he included the questionable pre-1940 data. His new estimate was substantially lower than his previous assumed uplift (Table 3). He also accused earlier authors of misinterpreting evidence of glacio-isostatic uplift in North America and for refusing to accept it as fact. He included Tyrrell in this and pointed out that his evidence was very questionable, (for example there was no proof ice was even in the harbour, let alone at its maximum height, when the names were chisseled), and in fact this evidence indicated a moderate uplift had taken place. Bird 1954 also referred briefly to the controversy between Tyrrell and Bell but Gutenberg's explanation of Tyrrell's 'evidence' seemed to put the issue at rest[5] (also, see Simpson 1972).

Churchill tide gauge data were further updated by Barnett in 1966 (1940 to 1964 data) and again in 1970 (1940-1968 data). His 1966 calculation was lower than Gutenberg's (2.4 feet/100 years compared to 3.3 feet/100 years - Table 3). Barnett's latest estimate was even lower at 1.75 feet/100 years (Barnett 1970).

Numerous marine shell collections were made from raised beach ridges in the late 1930's, 1940's and 1950's (for example Richards 1941, Fyles 1955, Lee 1959) surrounding Hudson Bay. Radiocarbon dates on these shells, especially those near the marine limit or highest recognized marine features and for which elevational information was known, greatly expanded the knowledge of isostatic recovery and the deglaciation history of the region. Lee (1960) provided the first overview of late glacial events and the extent of postglacial marine submergence around Hudson Bay. He coined the term "Tyrrell Sea" for this submergence and calculated emergence rates since deglaciation using age-elevation curves (Table 3).

Wagner (1967) also calculated emergence rates using age-elevation curves. She published 33 radiocarbon dates from shells, plant material and peat which she separated into north, central and southern Tyrrell Sea areas to calculate three sets of uplift

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5 Although Kupsch (1967), in a review paper, later questioned the reliability of the evidence for on-going uplift.

rates[6]. (Table 3).

3.2.3 Post-1967: The Application of Uplift Interpretations

Since 1967 the emphasis in the literature has been on the application and interpretation of known postglacial uplift for the prediction of uplift in other localities and to clarify other postglacial events. Andrews (1968) studied the form of 21 uplift curves from Arctic Canada, including one representing the Churchill area, to derive equations and constants defining the curves. He assumes marine inundation takes place contemporaneously with deglaciation and notes that although the age of the marine limit (and thus deglaciation) varies, the shape of the curves are similar. From this he derives his uplift constant ('A') from which one can determine uplift curves for any locale given only the age and elevation of the marine limit. His assumption is probably quite reasonable for the Hudson Bay Region where deglaciation was rapid (Andrews and Falconer 1969) and his estimates of uplift using the empirically derived constant seems to hold up well to field evidence (Andrews 1970). In addition he attempts to model remaining rebound in the Hudson Bay area by assuming that uplift will continue to behave as a simple exponential function (Andrews 1968, 1969). Andrews used the known uplift rates and rates derived from his equation for 58 localities in northeastern North America to contour average and present rates of uplift as well as uplift rates at 6000 andd 8000 years B.P. (Andrews 1970)[7]. His maps include the Hudson Bay Lowland (Table 3).

One of the most interesting applications of postglacial uplift data is toward the interpretation of glacial and deglaciation events. Lee (1960), using information on the age and extent of marine inundation and the rate of uplift in the Hudson Bay Region, was one of the first to discuss the early postglacial history of this area. Andrews (1969) concluded that Hudson Bay itself was an area of glacial convergence rather than

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6 Emergence and uplift are used interchangeably because most authors correct their uplift determination to account for eustatic sea-level rise and therefore are determining emergence from the sea.

7 Andrews does not correct his uplift rates for eustatic sea-level rise in this paper.

divergence during the Pleistocene based on uplift rates and residual rebound which were found to be the greatest southeast (Québec) and northwest (Keewatin) of the Bay. Radiocarbon dates, rate of uplift and geomorphic field evidence from the Ottawa Islands in northeast Hudson Bay provided valuable information for Andrews and Falconer (1969) and Andrews and Peltier (1976) to reconstruct the deglaciation of the Hudson Bay Region. They concluded from these data that deglaciation was catastrophic and marine inundation took place via Hudson Strait south along the collapsed centre of the ice sheet (west of the Ottawa Islands) to the southern and eastern Hudson Bay Lowland region. Craig (1969) also examined uplift rates, marine limits and geomorphic field evidence to discuss the deglaciation - marine incursion sequence around Hudson Bay.

3.3 Summary and Gaps in Knowledge

The southern portion of the Hudson Bay Lowland, especially the Moose River drainage basin has been studied thoroughly in terms of Quaternary stratigraphy, palynology and paleontology and the reconstruction of glacial, interglacial and postglacial events. McDonald (1969) and Skinner (1973a) suggest more stratigraphic studies are required in the central Lowland especially in the Kapiskau River and Severn River basins. Of particular interest would be the discovery and dating of interglacial peat deposits equivalent to the Missinaibi beds in these areas and of peat material in other nonglacial deposits between tills anywhere in the Lowland. Dating of the Friday Creek sediments (nonglacial) for example (Figure 11) would provide further elucidation of Wisconsin interstadials and possibly help correlate the Kipling and Cochrane tills. Other areas of possible study noted by Skinner (1973a) include studies of climatic change during the last interglacial as interpreted from the interglacial deposits, especially those containing the marine member, the number and occurrence of post-Missinaibi tills, directions of ice flow for each till sheet and the extent of pre-marine lacustrine beds. Shilts (1980a and in press) has provided new evidence in combination with earlier work, especially work carried out during the 1960's and 1970's, but he notes that a great deal is yet to be learned about the Quaternary history of the Hudson Bay Region (Shilts, in press).

Over the past 100 years various methods have been used to estimate emergence or uplift (Table 3). Postglacial uplift is represented by an exponentially decreasing function such that the rate of recovery was much faster immediately following deglaciation than at present. Even so, the present rates estimated for the Hudson Bay Region are among the highest in the world. This is a result of the proximity of at least two major late Wisconsin glacial accumulation centres; one immediately southeast of Hudson Bay in Québec and the other northwest of the bay in Keewatin District (Andrews 1969, 1970). Uplift rates tend to be highest, nearest the centre of these postulated accumulation areas (Andrews 1970). The most recent estimate of emergence for the Hudson Bay Lowland range from a low of .53 m/100 years at Churchill, Manitoba determined using tide gauge records (Barnett 1970), to a high of 1.2 m/100 years at Cape Henrietta Maria, estimated from radiocarbon dating (Webber et al. 1970). The estimates for Churchill, mid-way between the ice accumulation centres, vary between .5 and about 1.0 m/100 years (Gutenberg 1954, Andrews 1970, Barnett 1970) using different techniques. The highest rates occur near Cape Henrietta Maria and are estimated at 1.2 to 1.3 m/100 years (Andrews 1970, Webber et al. 1970). Bell (1879a) estimated a rate of emergence of 1.5 to 3 m/100 years (5-10 feet) for the east coast of James Bay. This is remarkably close to the accepted rate in this area which is somewhat surprising because he estimated the time of decay of spruce driftwood in sequences of raised ridges to determine this value. However he seems to have been a little on the high side for his estimate at Churchill (2.1 m/100 years). From Table 3 it appears that there is remarkable consistency in the estimates of uplift for southern Hudson Bay and James Bay given the number of techniques employed. The only trend apparent is a distinct decrease in the estimate of uplift at Churchill using tide gauge records as more recent data is added (Gutenberg 1941, 1954; Barnett 1966, 1970). Immediately following deglaciation uplift rates varied between 4 and 8 m/100 years (Lee 1960, Wagner 1967, Craig 1969, Andrews 1970).

Remaining uplift in the Hudson Bay area is estimated at between 90 and 240 m (Table 3). The highest values are based on Free-Air gravity anomaly values and theoretical crustal geophysics (Gutenberg 1941, Innes 1960, Innes et al. 1968). The lower values are those of Andrews whose estimates are based primarily on the shape of postglacial uplift curves (Andrews 1968, 1969). Again, the highest values are in the Cape Henrietta Maria-Cape Jones area.

A great deal has been learned about glacio-isostacy and the characteristics of marine submergence in the Hudson Bay Region. The Lowland is represented by numerous determinations of uplift at Churchill (Bell 1880; Gutenberg 1941, 1954; Andrews 1968, 1969, 1970; Barnett 1966, 1970 and Craig 1969), Cape Henrietta Maria (Andrews 1969, 1970; Webber et al. 1970) and southern James Bay (Andrews 1970, Hunter 1970). Certainly the general pattern of rebound and approximate rate of emergence can be estimated for any portion of the Lowland. What remains to be examined are perhaps a few more accurate determinations of uplift in the southern and central Lowland and the examination of geomorphic evidence within the region to better elucidate its submergence (deglaciation) history and any evidence of major still-stands. In addition Skinner (1973a) notes that detailed studies of the marine limit in the southern Hudson Bay Lowland can provide a good understanding of the deformation of a single strandline due to differential isostatic rebound.

4. RECENT EPOCH

4.1 Physiography Review

4.1.1 Introduction

The present knowledge of physiographic conditions in the Hudson Bay Lowland derives from studies made during two periods since 1875. Between 1875 and 1915 geologists from the Geological Survey of Canada and the Ontario Bureau of Mines explored all the major trunk streams and tributaries and much of the Hudson Bay and James Bay coasts by canoe. In the decade 1950 to 1960 several regional studies were undertaken in different parts of the Lowland for various purposes using aerial photographs and fixed-wing surveys. Since 1960 only three physiographc accounts have been published and these rely in whole or in part on the previous studies. This, at least in part, reflects a dominant trend in the earth and life sciences during the past 20 or more years toward more specific, quantitative analyses.

4.1.2 Review

As previously noted, the early explorations were made by geologists who described the bedrock geology as well as the general physiography, wildlife and timber for the first time. Their surveys were confined to the rivers but occasional references are made to the vast muskegs of the interior. These were primarily track surveys which not only provided physical descriptions but fixed prominent features such as lakes and tributaries by determining latitude and longitude. One of the most notable and well travelled of these explorers was Robert Bell (Geological Survey of Canada) who made track surveys along the Moose, Mattagami and Missinaibi rivers and the James Bay Coast in 1875 (Bell 1877), the Nelson and Hayes rivers in 1877 (Bell 1879b) and the Albany and Attawapiskat Rivers in 1886 (Bell 1887 and 1912, Figure 9). In 1886 A.P. Low explored the Severn and Berens rivers (Low 1887) and in 1887 and 1888 many of the islands and the south shore of James Bay (Low 1889). W.J. Wilson and Owen O'Sullivan explored portions of the Moose, Albany and Kapiskau rivers including some of their tributaries; the Atikameg, Otadaonanis, Stooping, Kwataboahegan and Atitibi rivers in 1901 or 1902 (Leroy 1903, Wilson 1906). Most of the Winisk River to its mouth was surveyed in 1902 or 1903 by William McInnes (McInnes 1906). D.B. Dowling explored the Sutton Ridges area of the Lowland including the Ekwan River, Sutton and Hawley lakes and the Swan and Washagami rivers in 1901 (Dowling 1904, 1905 and 1912). The Churchill River was explored by Tyrrell in 1890 and 1891 (Tyrrell 1890-91) and by Alcock in 1915 (Alcock 1916a and b). In addition to describing the rivers and lakes and their outcrops these geologists made the first fossil collections from Paleozoic, Mesozoic and Quaternary deposits; noted the character and magnitude of tides on James Bay and Hudson Bay; began correlating glacial and postglacial desposits including tills, interglacial stratified sands, gravels, peat, marine clays, and raised beach ridges; and provided the earliest interpretations of the Paleozoic, Mesozoic and Quaternary history of the Hudson Bay Lowland.

Prior to 1950 very little was known about the physiography of the interior portions of the Lowland. The peat deposits which comprise at least 80% of the landscape made access all but impossible at any time but the middle of winter (Figures 19 and 20). Between 1950 and 1960 at least 4 regional physiographic surveys which included descriptions of the interior peatlands were carried out. These relied heavily on the use of aerial photos, fixed-wing over-flights and, to a lesser degree, canoes.

The first of these was by Hanson and Smith (1950) who carried out an in-depth study of Canada geese populations nesting in the Lowland. These authors relied solely on canoe travel and a series of airplane flights between Moosonee and York Factory. Although primarily describing the habits and characteristics of the Canada Geese populations, the authors also described the major types of muskeg they observed and indicated the approximate occurrence of each type between rivers

Figure 19: The physiography of the Hudson Bay Lowland is characterized by expansive peatland complexes with patterns controlled by hydrology, minerotrophic status and other factors.

Figure 20: Mineral terrain in the Lowland consists primarily of river levees and raised beach ridges. This is an aerial view of a large raised beach complex surrounded by various kinds of peatland, south of the Albany River (also see Frontispiece).

along their flight paths. They identified 5 types of muskeg based primarily on the presence or absence of trees, lakes and streams (Hanson and Smith 1950).

In 1952 Coombs completed a thesis on the physiography of the Lowland. A summary of this was published 2 years later in a paper which has become a landmark description of the region (Coombs 1954). Coombs' work remains as the only published attempt at describing the physiography of the Hudson Bay Lowland as a complete region. He subdivided the Lowland into 4 zones based on oblique aerial photos taken in the 1930's and 1940's and on one or more fixed-wing surveys. He described the general physiography of each zone including amount of surface water, major forest types and tree species, surface patterns and their relations to muskeg and underlying mineral terrain, presence of raised beach ridges (Figures 15 and 20) and the coast of Hudson Bay and James Bay (Figure 21).

The third physiographic survey described the basin of the Severn River in the Canadian Shield and in the Lowland as part of a Ph.D. thesis by Moir (1958). It was primarily a disertation on the flora and the biogeography of the basin but the author provides excellent descriptions of the physiography. These were based on field studies carried out during the summers of 1951, 1952, 1953 and 1957 which included several fixed-wing surveys and a canoe trip down the Severn and Fawn rivers. In addition to describing the general landscape he also discusses its evolution relative to glaciation, deglaciation, marine inundation and isostatic recovery. Moir also published a short description of a series of raised beaches and their associated vegetation based on work from this thesis in 1954 (Moir 1954).

The last physiographic study of the Lowland to be carried out during this period was also in the form of a thesis. Dean (1959) conducted physiographic and vegetation mapping of the Albany map sheet using aerial photos with a minimum of ground truth. Most of the area covered is on the Shield but a large part of the Lowland in the Moose and Albany drainage basins is included. This study is the most detailed physiographic study carried out to date on any portion of the Lowland. Dean separated the Lowland into 2 physiographic regions which he subdivided into 17 'Landform Units' based on prominent patterns interpreted from 1:60,000 black and white aerial photos. His interpretations of glacial

Figure 21: Beach ridges, raised beach ridges and brackist marsh swales along the south coast of Hudson Bay.

events and peatland-substrate relationships are remarkable given the lack of detailed ground information and seem to hold up well to more recent studies (Cowell et al. 1978, Martini et al. 1980a, Figure 22).

The only other physiographic-based description covering a portion of the Lowland published during the 1950's was that of Beckel (1954). This is a very brief description of "major terrain types" of the Churchill Manitoba area. It is primarily a listing without mapping or geographic description.

Very little has been added to the literature since 1960 in terms of the regional physiography of the Lowland. In 1968 Robinson prepared a review paper on the geography of several regions surrounding Hudson Bay which summarized Coombs' (1954) descriptions for the Lowland Region. Hutton and Black (1975) prepared a physical and socio-economic regional synopsis of the arctic watershed in Ontario which includes much of the Lowland; however its physiography was dealt with only briefly. This contribution is most notable for its maps and illustrations depicting many aspects of the watershed. The most recent physiographic summary was

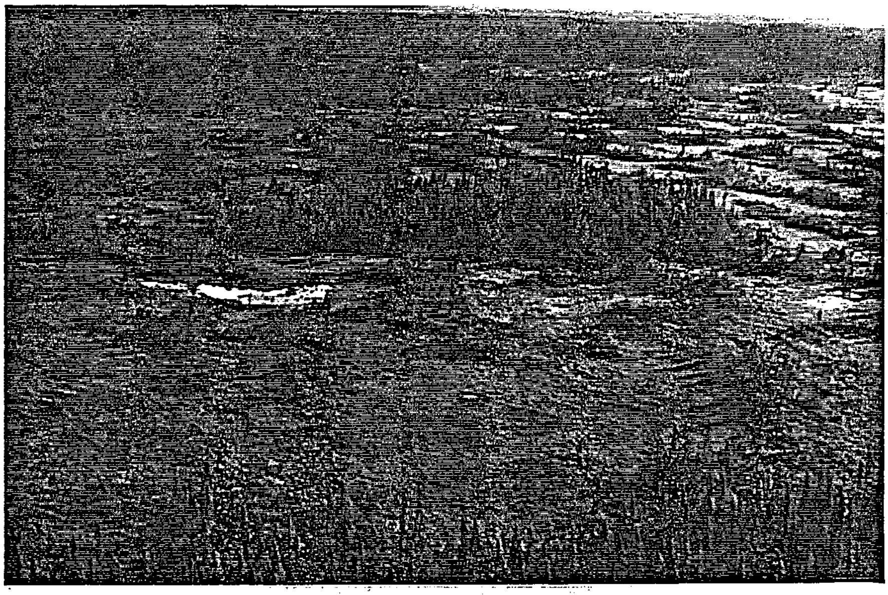

Figure 22: Black spruce island (centre) located in a string fen midway between the Moose and Albany rivers. The treed island occupies a slight rise in the underlying mineral soil.

prepared by Herrick (1977) in a report for Parks Canada on the Hudson Bay Lowland. The report is a theme analysis of landforms, drainage, geology, vegetation and wildlife of the region designed to characterize the Lowland and to recommend representative areas for preservation. The report is comprehensive as the author relied on published information, fixed-wing surveys and numerous communications with people familiar with parts of the Lowland. Unfortunately the author did not attempt to bring the various literature descriptions together using her field experience and hence the report is little more than an inventory.

4.2 Permafrost Review

4.2.1 Introduction

Permafrost investigations in the Hudson Bay Lowland can be traced back at least to Johnston (1930, as referenced in Beckel 1957) who determined a permafrost thickness of 35 m at Churchill, Manitoba. No further investigations were made until the 1950's when several studies including permafrost investigations were carried out between 1950 and 1957 (Beckel 1957, Charles 1959, Sjörs 1959, 1961 and 1963). The most recent series of permafrost studies began in 1965 (Brown 1968) with an attempt by the Division of Building Research of the National Research Council of Canada to determine the southern boundaries of the continuous and discontinuous permafrost zones.

4.2.2 Review

Only four studies have taken place which concentrate primarily on the distribution, characteristics and/or causes of permafrost. The papers by Beckel (1957), Brown (1968 and 1973), Zoltai and Tarnocai (1969) and Railton and Sparling (1973) present the results of specific permafrost investigations. The remainder describe permafrost occurrences and features as part of the ecology of the Lowland.

Beckel (1957) carried out an intensive monitoring program of active layer temperatures in the Churchill area in all seasons from 1951 to 1954. A variety of terrain types were monitored with permanent thermocouples which recorded at 2 or 3 levels within the active layer at 40 sites. This study provides some interesting quantitative information on the seasonal characteristics of soil temperatures including useful discussions of the controlling factors (i.e. air temperature, terrain and vegetation type, snow cover and so on).

Brown (1968) attempts to establish the boundaries of the permafrost zones in Ontario and Manitoba (also see Brown 1967). This is a fairly lengthy paper which includes a review of the physical, climatic and vegetational characteristics of the Lowland and the Canadian Shield in Ontario and Manitoba. His findings consist of noting the occurrence of sites he investigated that had permafrost and the relationship between permafrost and various ecological parameters (vegetation, terrain type, drainage and substrate type). These were also reviewed in a later, shorter paper (Brown 1973). Brown establishes the southern limits of the continuous, widespread and discontinuous permafrost zones in Ontario and Manitoba on the basis of this work. These limits were also adopted for the 'Permafrost Map of Canada' published jointly by the Geological Survey of Canada and the National Research Council (Brown 1967). Although Brown draws the southern limit of the continuous permafrost zone near the southern coast of Hudson Bay, he notes that there is no definite proof of permafrost in mineral terrain in Ontario. There has not been any drilling for permafrost and all the frozen ground he found in September, 1965 was confined to peatland areas, specifically in the form of palsas and peat plateaux (Figures 23 and 24). Brown (1968 and 1973) describes some of these peatland features and discusses their mechanism of formation and degradation.

The distribution and abundance of permafrost peat landforms were used by Zoltai and Tarnocai (1969) to define permafrost zones in Manitoba. The permafrost zones in the Lowland portion of the Province are similar to those defined by Brown (1967).

The last study focussing primarily on permafrost in the Lowland was by Railton and Sparling (1973) who describe an in-depth physical, botanical and microclimatological investigation of the formation and degradation of palsas. The study was carried out in July 1967 in the Hawley Lake area, where Sjörs (1961) earlier examined the ecology of the forest and peatlands, including palsas. Of particular interest is their finding of the low significance that changes in albedo[8], resulting from changes in vegetation and water level, play in the development and later degradation of the palsas. Instead, insulation by peat and vegetation was found to be one of the most significant factors affecting palsa growth with the natural destruction of this insulation causing degradation.

During the 1950's a number of people were actively studying the botany of portions of the Hudson Bay Lowland (see Sims *et al*. 1979). These studies included descriptions of the morphology, floristics and, in most cases, processes of formation and degradation of permafrost features. These people included J.C. Ritchie in Manitoba and I. Hustich and H. Sjörs in Ontario. The latter two were invited to study in Canada by the National Museum of Canada in order to share their botanical and peatland expertise in a study

8 The albedo is the percentage of incoming solar radiation which is reflected by any object at the earth's surface.

Figure 23: Incipient brown moss palsas (foreground and distance) in a fen swale west of Winisk.

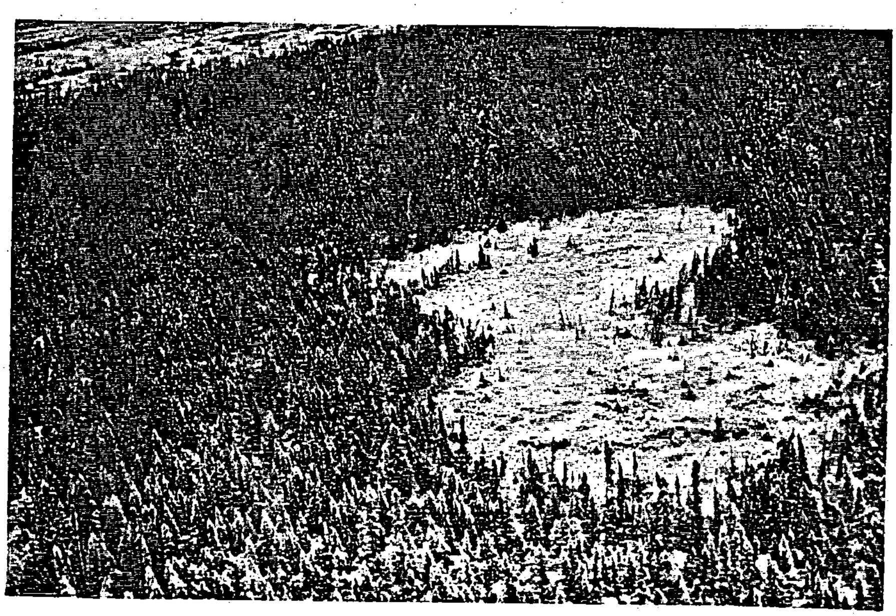

Figure 24: Melt or thaw scars within a large treed peat plateau south of Winisk.

of the Hudson Bay Lowland in 1956 (Hustich 1957 and Sjörs 1961). It is notewwothy that until this time there were very few studies of Canadian peatlands in contrast to extensive European, Finnish and Scandinavian studies (Sjörs 1963). In fact, much of the peatland terminology in use in Canada at present was introduced by Sjörs in his publications on the Hudson Bay Lowland (Sjörs 1959, 1961 and 1963).

Ritchie (1957 and 1960) discusses the floristics and morphology of 'palsa bogs' in northern Manitoba. He describes these features as characterizing specific vegetation zones as he attempts to establish the major vegetation zonation of northern Manitoba. His earlier paper (1957) considers 'mound topography' as a seral stage in the vegetational succession over time as controlled by uplift in the Churchill Estuary. His 1960 paper utilizes aerial photo interpretations to map more widespread vegetation zones including all of the Hudson Bay Lowland in Manitoba. He mapped two zones in the Lowland that had significant palsa formation. These are the two nearest the coast which he identifies as 'treeless bog' and 'Lowland complex'. He defined the term 'palsa bog' and describes their characteristic vegetation composition, but does not attempt to discuss their genesis or degradation.

In 1957, Hustich published a paper describing the physical and botanical characteristics of the Hudson Bay Lowland in general, tree species distribution, specific vegetation types and peatlands based on the literature as well as his own notes. He also briefly described palsas and 'black spruce islands' as permafrost features and suggested that the latter may have developed from palsas via colonization by black spruce (Picea mariana). His work on these features was primarily restricted to aerial viewing and he was obviously unsure of his ideas. Hustich considered permafrost to be restricted primarily to the occurrence of 'palsa bogs'.

Sjörs (1959, 1961 and 1963) was primarily interested in the relationships between peatland morphology and vegetation and the drainage and nutrient status of different peatlands. His 1959 paper is essentially a very brief review of his later two papers which were based on very detailed ecological studies in the Hawley Lake and Attawapiskat River areas, respectively. Sjörs was also very much interested in the permafrost features of each area which were represented by palsas at the former site and 'black spruce islands' at the latter. He described these features in some detail including partial coring, their floristics, morphology, occurrence and discusses their mechanism of formation and degradation. His discussion of black spruce islands in the 1963 paper is especially interesting and represents one of the most in-depth discussions on this topic (Figure 25). He indicates that those in the Attawapiskat area are probably relic although notes that no severe changes in climate have occurred since this area emerged from the Tyrrell Sea.

Ecological studies published more recently and including the permafrost factor are by Zoltai (1973), Kershaw (1976), Mills (1976 and Mills et al. 1976 - see Section 4.3) and Cowell et al. (1979).

The paper by Zoltai (1973) reviews peatland - permafrost relationships and discusses the mechanism of palsa and plateau growth and degradation. It is primarily a descriptive review based on field work carried out by the author in the Manitoba portion of the Lowland. Zoltai considered palsas and peat plateaux as part of the natural peatland dynamics or 'succession' in cold areas.

Kershaw (1976) primarily discusses salt marsh vegetation on Hudson Bay in Ontario, near the Manitoba Border. However, the paper includes some observations on ground ice found in the salt marsh and freshwater marshes in July. In August no permafrost was found within 1.5 m of the surface in the salt marsh, but was still near the surface in the freshwater marsh which has 12 to 27 cm of peat. It should be noted that the author determined the presence of permafrost by probing, not by coring.

The work of Mills (1976) and Mills et al. (1976) are described in the next section and will not be expanded here. Suffice is to say that the presence of permafrost including a qualitative indication of ice content and the measured depth of thaw are included as part of their ecological descriptions of Land Systems. Two of their map sheets include a portion of the Manitoba Lowland (Kettle Rapids and Hayes River map sheets).

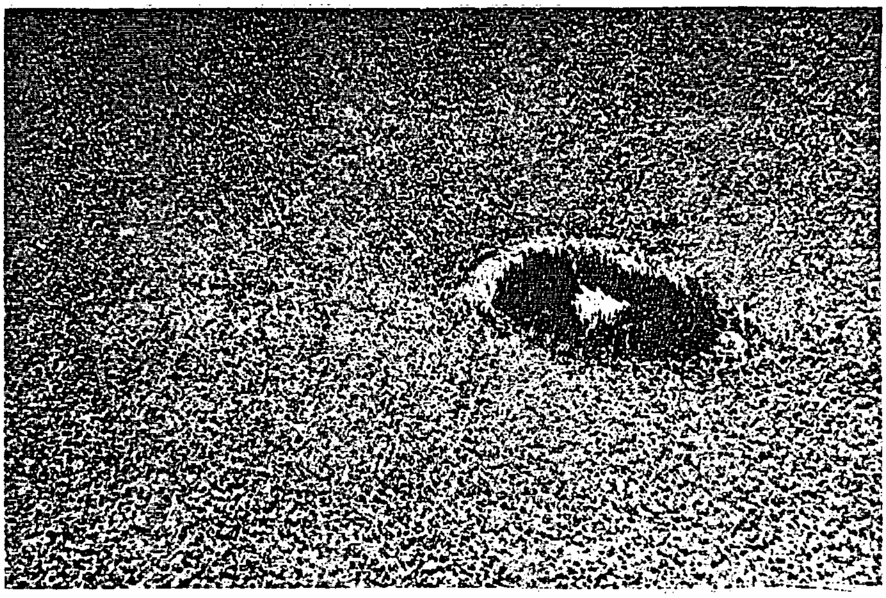

Figure 25: Black spruce island with melt hollow in centre, located within a treed fen in the lower Attawapiskat River area of the Lowland.

Cowell *et al.* (1978) report on the depth to frozen peat and thickness of frozen peat in particular wetland types in the Kinoje Lakes area on the southern boundary of discontinuous permafrost. Except for an incipient brown moss palsa, all their examples were likely seasonal frost. The usefulness of this paper is in its description of peatland - permafrost conditions on the southern edge of the discontinuous permafrost zone and the specific vegetation composition (dominant species) which act as the best insulators for frozen peat protection into the summer season. These would also be the first sites of permafrost aggradation under climatic cooling. The authors also carried out a transect study of a 'black spruce island', similar in shape to some described by Sjörs (1963). They found the presence of the island due to a rise in the mineral soil not to permafrost (Figure 22). This finding has important aerial photo interpretation implications, especially within the southern portions of the discontinuous permafrost zone.

4.3 Pedology Review

4.3.1 Introduction

In 1977 the Canada Soil Survey Committee, in cooperation with the Soil Research Institute of Agriculture Canada, published a report and inventory entitled, "Soils of Canada" (Clayton et al. 1977). The accompanying soil map (1:5,000,000) was compiled in 1972 and in combination with the inventory identifies the broad soil types of Canada including the Hudson Bay Lowland. Prior to 1969, however, there was little or no published material on the soils of this region.

There were only two papers describing soils of the Hudson Bay Lowland up to 1970. The most recent is a short paper which briefly describes chemical and physical properties of three frozen organic soils (Mesic and Fibric Organic Cryosols)[9] from peat landforms in the York Factory area of Manitoba (University of Manitoba, 1969). The other was published in 1917 (Johnston) and is entitled "Reconnaissance Soil Survey of the area along the Hudson Bay Railway". Rather than being a 'soil survey' the latter paper is primarily an inventory of surficial desposits (till, lacustrine clay, esker and beach sand and 'swamp'). The survey was carried out from The Pas, Manitoba to just inside the Lowland at Limestone Rapids. A more detailed soil survey along the railway was published in 1959 (Ehrlich et al.), but this was confined to the lacustrine deposits of Lake Agassiz; outside the Lowland.

Soil survey and pedological research in the Lowland has been greatly expanded since 1970. Within the past decade, all of the Lowland in Québec and large portions in Ontario and Manitoba have been covered by

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9 Soil classification terminology as per the Canadian Soil Survey Committee 1978.

reconnaissance surveys. These are not strictly soil surveys. The high cost of field work in the Lowland, necessitated by its inaccessibility has resulted in the adoption of a multidiciplinary study approach by those interested in the area. Thus information is collected on as many ecological parameters as possible, usually including; soils, vegetation, hydrology, landform, permafrost and others.

4.3.2 Québec.

The Québec portion of the Hudson Bay Lowland lies within the management region of the Baie James, Hydroelectric Development Project. Recognizing the significant environmental impacts on this region, the Société de dévelopement de la Baie James funded an ecological land classification[10] project which was undertaken by the Québec Region Lands Directorate of Environment Canada[11]. This resulted in the complete mapping of the region at 1:125,000 ('Land System' level - National Committee on Forest Land, 1969). Although the maps do not incorporate soil classification terminology, they describe the nature of constituent deposits (Jurdant et al. 1977). Detailed soil profile descriptions and samples (for chemical analyses) as well as vegetation and site descriptions were taken at numerous sites in the field (about 18 sites for the Lowland portion). These data are kept on file at the Lands Directorate office in St. Foy, Québec and are available for anyone interested (J.P. Ducruc, personnal communication).

In 1978 the Société d'Energie de la Baie James published an excellent, colourful summary of all the ecological studies carried out in the territore de la Baie James and du Nord du Québec for the Société de dévelopement de la Baie James since 1972.

4.3.3 Ontario

Soil Inventory and research forms an integral part of a multidisciplinary ecological study currently

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10 Formerly referred to as Biophysical Land Classification (National Committee Forest Land 1969).

11 The group carrying out these studies are known as SEER (Servie des Etudes Ecologiques Regionale).

being undertaken in Ontario's Hudson Bay Lowland. Environment Canada in conjunction with the Department of Land Resource Science, University of Guelph, Ontario are carrying out ecological surveys including process studies in pedology, sedimentology, vegetation ecology, geochemistry and wildlife ecology within the Lowland's coastal zone (Glooschenko and Martini 1978, Cowell et al. 1979). Preliminary descriptions and findings dealing with pedology, vegetation ecology, hydrology, geomorphology, sedimentology and geochemistry have been reported by Cowell et al. (1979), Glooschenko and Martini (1978), Martini and Protz (1978, 1979 and 1980), and Martini et al. (1978, 1979 and 1980b). This work commenced in 1976 and is expected to continue until 1981/82.

The coastal zone is defined by Cowell et al. 1979. It forms a zone of varying width extending to the edge of the mature, interior peatland complex and comprising the active coast plus the dominately minerotrophic wetlands of the most recently emerged portion of the Lowland. Within the southern part of this zone, the authors have inventoried soils (as well as landform and vegetation) in peatland and upland terrains and have attempted to correlate soil type (subgroup level) with the vegetation and physiognomic types in terms of time gradients perpendicular to the coast, as controlled by isostatic recovery (also Sims et al. in press, Wickware et al. 1981a). Soil profiles were described in detail for over 100 sites in the coastal zone south of the Albany River in 1977. These sites were selected on a random sample basis and provide a complete range of terrain types (Ecotypes). In addition, bulk samples of selected mineral soil profiles and water samples from wetland sites were taken for chemical analysis. These data are being kept on file at the Canada Centre for Inland Waters (Lands Directorate, Ontario Region) in Burlington, Ontario and will be published in report form at a later date. The work was continued in the Winisk area on Hudson Bay in 1978 and in 1979 was expanded to the Cape Henrietta Maria area (Wickware et al. 1980). An application of their work, involving the potential for peat utilization for energy has been published by Wickware et al. (1981a).

Martini and Protz (1978, 1979 and 1980) have looked at mineral soil profiles (and sedimentology) along transects in the active marine zone from the tidal flats (Rego Gleysols) through freshwater marshes (Orthic and Humic Gleysols) and beach ridges (Orthic Regosols) to older raised beach ridges (Humic Podzols). The written accounts cover the entire James Bay Coast and a portion of the Hudson Bay Coast in the Cape Henrietta Maria area. Detailed physical and chemical data for these profiles as well as brief written summaries of the soil characteristics are provided in these papers. The synopses from these reports are reproduced in the annotated bibliography. This work was continued in the Winisk and Fort Severn areas of the Hudson Bay coast in 1980.

In addition to these studies, there are two other papers which have been published dealing in part with soils in the Ontario portion of the Lowland. Rouse and Kershaw (1973) reported on the relationships among vegetation cover, evaporation and soil moisture. This study was part of a relatively small interdisciplinary study carried out on the Hudson Bay coast adjacent to East Pen Island near the Manitoba Border. At the other end of Ontario's Lowland, at Onakawana (south of Moosonee), the Ontario Ministry of Environment (Task Force Onakawana 1973) carried out a preliminary environmental and environmental impact study of the site of a proposed lignite mine and thermal generating station. The report briefly reviewed the physical, climatic, pedological and biological characteristics of the site and indicated potential impacts or problems. The authors briefly describe two characteristic soils of the area (a mesisol and gleysol).

4.3.4 Manitoba

Multidisciplinary environmental and ecological research into Manitoba's Hudson Bay Lowland has been carried out primarily under the direction of the Canada-Manitoba Soil Survey in cooperation with the University of Manitoba. Three such studies were carried out between 1969 and 1977. The first was a physical and historical research project of the York Factory area. This study commenced in 1969 and culminated in 1972 in the form of an unpublished Ph.D. thesis (Simpson 1972). The thesis briefly discussed soils (subgroup level) along a raised beach-swale transect on a peninsula in the estuary of the Nelson and Hayes rivers. Three types of organic soils studied as part of this project were reported on earlier (University of Manitoba 1969). In addition, C. Tarnocai published a paper in 1972 comparing the physical and chemical properties of two frozen organic soils, one of which was taken from a peat plateau in the York Factory area (also described in Zoltai and Tarnocai 1969). The other profile was from a palsa located in the discontinuous permafrost zone outside the Lowland. These soils were both classed as Cryic Mesisols.

In 1971, the York Factory studies were expanded to a broad reconnaissance survey of the Churchill portion of the Lowland as well as southern Keewatin district, N.W.T. and portions of the Canadian Shield in Manitoba. This resulted in a terrain study and map of the area (approx. scale 1:1,000,000) and included the description of approximately 25 profiles with chemical analyses for 6 profiles (Tarnocai 1974). These soils are predominately Crysols (organic and gleysolic), Regosols and Organic soils.

One of the most ambitious of biophysical (ecological) land classifications projects was begun in 1974 in Manitoba. This was known as the Northern Resource Information Program and was designed to cover over half of Manitoba including that province's share of the Hudson Bay Lowland at a mapping scale of 1:125,000 (Mills 1976, Mills et al. 1976). This project was being carried out by the Canada-Manitoba Soil Survey for the Manitoba Department of Renewable Resources and Transportation Services in order to provide basic information on soils, landforms, drainage, vegetation, wildlife, aquatic resources, permafrost and climate of a hitherto poorly known area which is currently undergoing developmental pressures. Unfortunately, the federal government withdrew its share of the funding in 1977 and the project had to be curtailed (G. Mills, personal communication). Two map sheets covering a portion of the Hudson Bay Lowland south and southwest of York Factory were completed and published (Mills et al. 1976). These maps (Kettle Rapids - 54D and Hayes River - 54C) display ecological 'Land Systems' (now referred to as Ecosections) which are annotated with symbols describing the various ecological components of the system. These are in turn keyed to an extended legend via the soil association which provides more detailed information on soil type, permafrost characteristics, surficial materials (texture), topography and dominant vegetation. According to Mills (1976) soil type plays a very strong role as an aid to extrapolate ground truth information for mapping purposes (80 to 90 sites per map sheet). The logistical and operational aspects of the study are discussed by Mills (1976). Although specific soil information is not provided on the maps, (only soil associations and dominant soil classes - subgroup level), detailed profile descriptions taken at ground sites are on file with the Canada-Manitoba Soil Survey, Department of Soil Science, University of Manitoba (Mills *et al*. 1976).

Mills (1975) also published a paper describing the physical and chemical characteristics of a unique soil sequence from a marine beach ridge just south of the Churchill River in the Lowland. The soil consisted of a Degraded Eutric Brunisol overlying a buried brunisolic paleosol. The two profiles have similar physical and chemical characteristics. Mills compares the two soils and briefly discusses their geochronology and the paleoecological and paleoclimatological implications of their occurrence.

The Canada-Manitoba Soil Survey is currently working on a soil map of Manitoba which utilizes much of the information gathered in the Northern Resources Information Program (G. Mills, personal communication). This map is being produced at a scale of 1:1,000,000 and is expected to be published sometime in the early 1980's.

4.4 Geomorphology and Coastal Sedimentology Review

Prior to 1954 geomorphological and coastal sedimentological research had not been conducted as such in the Hudson Bay Lowland. To that time only the physiographic descriptions of the early exploration geologists were available. However, of the early geologists, there were a few who provided more detail than others in terms of geomorphic descriptions or processes. Of particular note was Joseph B. Tyrrell (1890-91, 1916) who was one of the first to attempt to reconstruct the Pleistocene history of northern Manitoba and Ontario based on geomorphic evidence in the Lowland and on the surrounding Shield. In addition, J.M. Bell (1904) in a review of the economic resources of the Moose River Basin described "bizarre and grotesque cliffs", deep holes, "snow-white pillars", "majestic columns and deep narrow caverns", "a labrynth of wonderful natural bridges", and gypsum ponds, caves and springs of an area of gypsum karst near the headwaters of the French River. The karst occurs in folded gypsum which rises about 7-8m above the surface of the Lowland in an area known as Gypsum Mountain. The area was later briefly described by Guillet (1964) in a report on Gypsum in Ontario, which included a chemical analysis of the gypsum. The area is yet to be adequately studied in terms of karst geomorphological features and processes.

The rivers of the Lowland were the first access routes and a few of the early geologists provided estimates of their volume of flow as well as describing their physiography. McInnes in 1906 estimated the discharge of the Winisk River in early August, 48 km from the mouth, to be 25,000 ft^3/sec ($707m^3$/sec). Wilson (1906) estimated the flow of the Kapiskau River 40 mi from its mouth to be 566,000 ft^3/sec ($16,000m^3$/sec) (early July) and of the Abitibi River (just below the Frederickhouse River) to be 401,000 ft^3/sec ($11,350m^3$/sec - late September). In 1909 Dole and Stabler published a U.S. Geological Survey Water Supply Paper which briefly described the area surrounding Hudson Bay and provided the only published erosion rate ever estimated for the Lowland. They estimated the rate to be 28 tons/year/mile (15.7 tonnes/yr/km) but did not show what data they used to arrive at their figure.

Dowling (1912) uses geomorphic evidence to attempt to reconstruct the glacial and postglacial history of the Sutton Ridge - Cape Henrietta Maria portion of the Lowland. He provides one of the first discussions of postglacial landscape evolution in the Lowland particularly with respect to the development of the local drainage in relation to isostatic rebound and the retreat of the Tyrrell Sea.

The coastline of Hudson Bay and James Bay was described by numerous of the early exploration geologists. It was they who surveyed the major estuaries and described their relationships to the coastline. The coast of James Bay and some of the islands in the Bay were described by Bell (1877), Low (1889), Wilson (1906) and Dowling (1912). The Hudson Bay shore of the Lowland was described by Bell (1880, 1896), Low (1887), Tyrrell (1896, 1900) and O'Sullivan (1906, 1908a and b, 1912). Manning (1947, 1951), and Manning and Rae (1950), whilst carrying out formal surveys, made some of the first observations and measurements of tidal ranges for Hudson and James Bays. The tidal range, occurrence of high water and variations in mean water level of Hudson Bay and its major harbours, were examined in more detail by

Dohler (1968).

The paper by Moir (1954) marks the first published record of the geomorphological analyses of a particular landform or landscape in terms of the processes of development. In this short paper he examines a series of raised beach ridges east of Fort Severn and discusses the factors influencing their development. In his Ph.D. thesis (Moir 1958) he discusses beach ridge development more fully and notes the effect of peat accumulation masking their prominence inland. He also discusses the drainage development of the Fawn, Severn and Winisk rivers in relation to deglacation events. His thesis examines the biogeography of the Severn River Basin and thus he describes the landscape evolution in the basin, in both the Shield and Lowland portions, in some detail.

The first study in what can be termed 'wetland geomorphology' in the Lowland was the thesis presented by Dean in 1959. Although primarily an aerial photo survey of the Albany map sheet, Dean was able to discuss the geomorphic evolution of the Lowland portion of the area in terms of glacial events and postglacial peatland development. He discussed the character and evolution of the Albany, Kenogami and Moose Rivers and made some interpretations on the nature of the mineral substrate and its relationship to overlying peat materials. He also discussed some aspects of peatland drainage.

The most intensive and extensive geomorphic studies have occurred in the past 12 years. Figure 26 is a map of the Lowland showing the area of interest of these recent studies as well as a few of the earlier ones.

In 1968 Newbury finished his thesis on the Nelson River. This thesis is the most comprehensive analysis of subarctic river processes, expecially with respect to freeze-up and break-up, carried out to date. It deals with four major reaches of the Nelson River of which the lowest reach represents the Lowland portion.

Cumming (1969) describes and briefly discusses the development of all the trunk streams and their major tributaries in the Lowland. This paper is based on aerial and canoe traverses and although not very detailed, presents good summary descriptions of the major rivers (Figure 27). This is the last paper

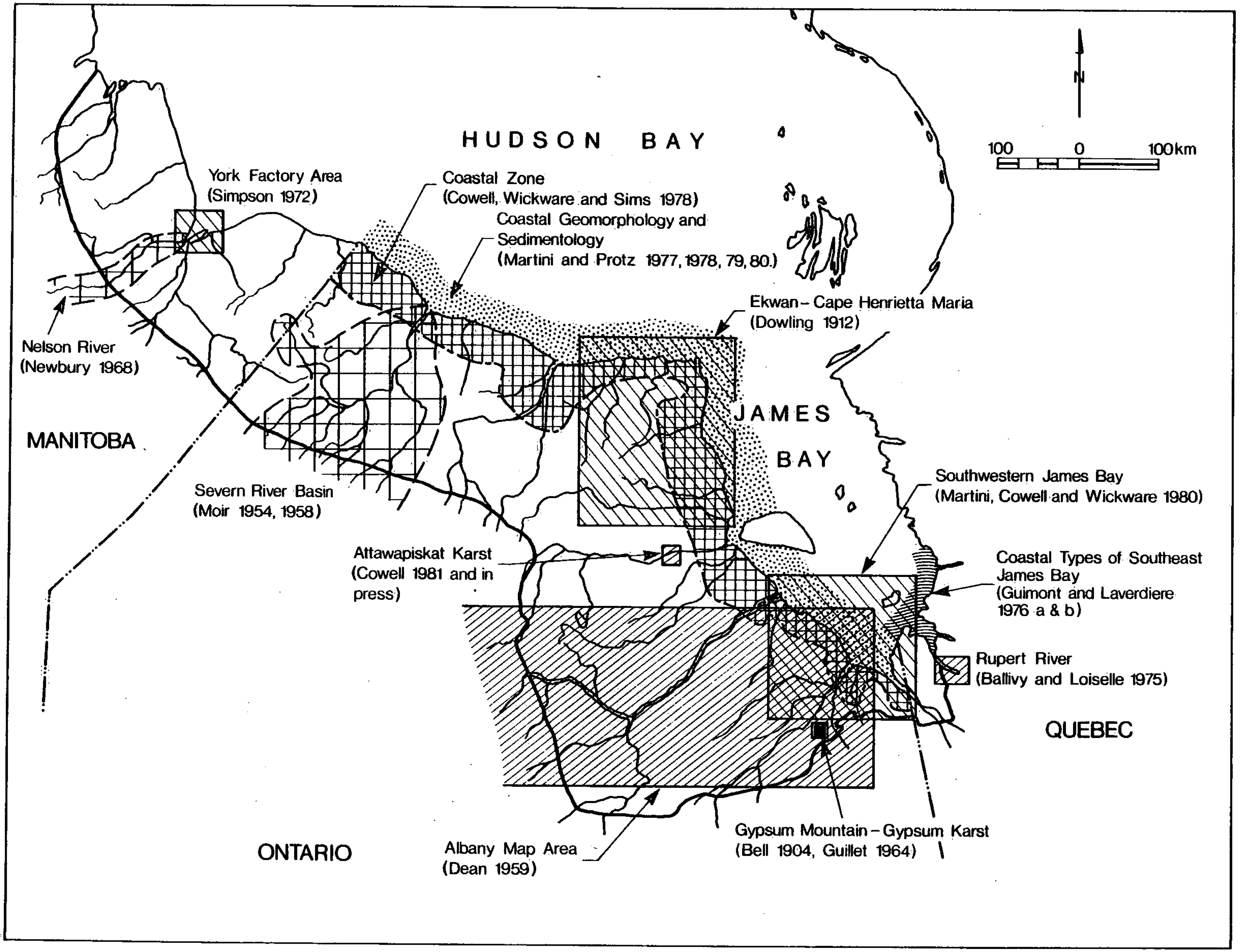

FIGURE 26. GEOMORPHOLOGICAL AND COASTAL SEDIMENTOLOGICAL STUDIES IN THE HUDSON BAY LOWLAND.

Figure 27: Aerial view near the mouth of the Winisk River, looking upstream, showing numerous islands and channels characteristic of the Lowland's major rivers.

published on the subject of the rivers of the Lowland.

More recently Ballivy et al. (1975) report on the geotechnical properties of marine and glaciolacustrine clays in the southeastern Lowland in relation to the development of rotational slides on river banks. Although based on work on the Rupert River their findings are applicable to most major rivers of the Lowland, especially the southern Lowland including the lower Harricanaw, Kesogami, Moose, Albany and Attawapiskat rivers, where such slides are common (Figure 28). Some of these slides are massive, containing many cubic meters of silt and clay, and characterizing long stretches of the rivers.

The most recent intensive geomorphic study in the Lowland is that of Cowell (1981, 1982). This is a study of karst landform development within a subarctic peatland landscape. It is a limestone karst on the Attawapiskat River which has formed, in part, in contact with peat materials (Figures 29 and 30). He coined the term 'organo-karst' for such an assemblage which had not

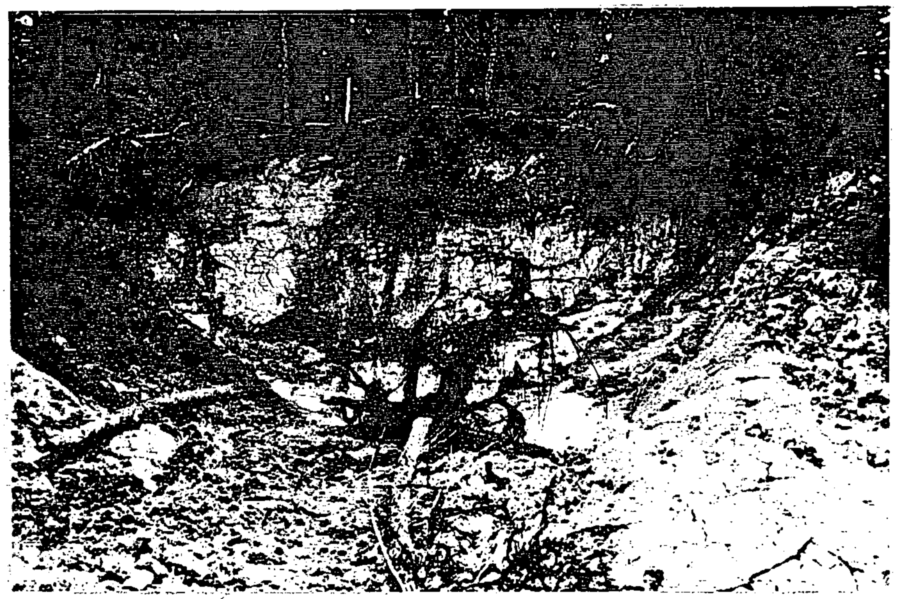

Figure 28: Large slump of alluvium and Tyrrell Sea clay in the bank of the Harricanaw River.

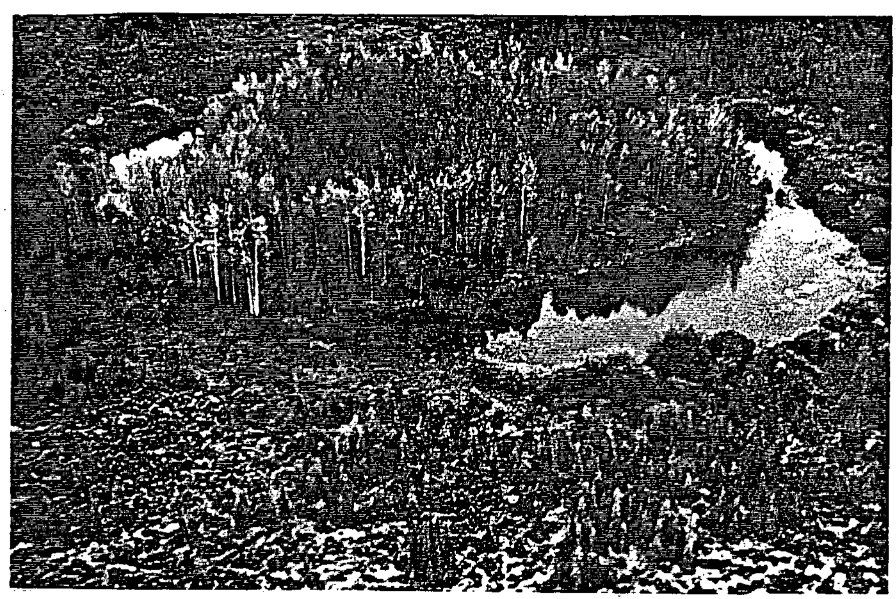

Figure 29: Flooded sinkholes surrounding a circular limestone reef knoll within a large bog area, near the Attawapiskat River.

Figure 30: Sinkhole at the end of a dry lake in the Attawapiskat Karst area.

previously been described in the literature.

Since 1972 there has been a great deal of interest in the coastal zone of the Hudson Bay Lowland, in all three provinces. Most of this centres on the immediate coast including the lower to upper tidal flats (Figure 31), supratidal zones, salt marshes (Figure 32), estuaries and beach ridges (Figure 33). There have also been studies in the near shore emergent coastal zone which includes raised beach ridges (Figure 15), freshwater marshes (Figure 18), river levees, fen swales, and the bog/fen complexes which continue into the interior lowlands (Figure 19).

Simpson (1972) completed a thesis which was based on a multidisciplinary study of the Nelson-Hayes Estuary in the area of York Factory, Manitoba. It was a geographical - geomorphological - pedological study of the tidal flats and near-shore raised beach ridges of the narrow peninsula between the mouths of the two rivers. The prime objective was to describe and explain the evolution of the point of land as it emerged, over time from Hudson Bay.

Figure 31: Upper tidal flats on the west coast of James Bay near the mouth of the Albany River.

Figure 32: Upper tidal flats and salt marsh along the Hudson Bay coast east of Winisk.

Figure 33: Gravel storm ridge on salt marsh on the James Bay coast near the mouth of the Moose River.

The Québec portion of the Lowland Coast has been studied by Guimont and Leverdière (1976a and b). Apparently an aerial photo study with little field support, their papers attempt to describe and classify the east James Bay coast from the Québec/Ontario border to north of Eastmain. Two of their 4 coastal types cover the Lowland portion which they refer to as 'annual moraine coast' and 'estuary coast and Rupert Bay coast'. These are based on gross coastal morphology. The authors also discuss some of the macro coastal processes in the region.

From 1977 through 1980 field work has been carried out in the coastal zone of the Ontario portion of the Lowland. Studies have concentrated on the active tidal flats and the near shore emergent part of the zone (Cowell et al. 1979, Figure 26). In addition to pedology and vegetation ecology studies, as noted in Section 4.3, work has included geomorphological descriptions of the landforms of the area and the evolution of the present peatland complex in terms of the isostatically rising land base (Cowell et al. 1979, Martini et al. 1980a, Wickware et al. 1981a and b). Soils, coastal sedimentology and coastal geomorphology have been systematically examined along all of the James Bay coast, and much of the Hudson Bay Coast as well as in the Attawapiskat Estuary and in Akimiski Strait (Martini and Protz 1977, 1978, 1979, 1980; Martini et al. 1978, 1979). These studies have formed part of a joint Environment Canada - University of Guelph research project. The reports by Martini and Protz and Martini et al. are lengthy contract reports which provide a great deal of description and preliminary chemical and physical analyses of soils and sediments. Descriptions and interpretations of data have recently been published in the more widely available literature (Martini 1981a and b, Martini et al. 1980b). The paper by Martini 1981b provides a concise overview of the morphology and sediments of the James Bay coast in Ontario. Martini (1981a) is the first comprehensive discussion and description of ice effects on the Ontario coast of James Bay. Martini et al. (1980b) summarizes soils, coastal sedimentation, marsh vegetation and wildlife studies along the James Bay coast.

4.5 Summary and Gaps in Knowledge

The general physiography of much of the Lowland has been described and it is possible to obtain a good impression of the region from these accounts. Unfortunately most of the early information is not in easily accessible form, having been published in limited-distribution annual reports, in theses or in manuscript reports. It would be useful to have this information brought together by someone familiar with the Lowland in an informative, critical manner. The Lowland is a unique region in Canada and a detailed study of the physiography of this region would be of value. Not necessarily a descriptive account but one that examines the evolution of the landscape and the interrelationships among peatland, mineral soil, drainage and vegetation physiognomy.

There are two important points with respect to permafrost in the Hudson Bay Lowland. Firstly, south and east of the Churchill area nearly all reported occurrences have been in peatlands. Secondly, there is some question as to the position of the southern boundary of the continuous permafrost zone. Outside of the Churchill area, permafrost investigations in the Hudson Bay Lowland have dealt solely with peat landforms; palsas, peat plateaux and black spruce islands. Although Brown (1968) referred to polygonal ground markings near Winisk and Kershaw (1976) reported a permafrost table in marshes in August near the Manitoba Border, there has been no conclusive evidence of permafrost in mineral soils, (tidal flats, beach ridges and levees), in the Hudson Bay Lowland outside of Churchill. This fact leads to the question of the presence of a continuous permafrost zone in Ontario. Brown (1967, 1968 and 1973) shows the southern limit of this zone paralleling the south coast of Hudson Bay. Railton and Sparling (1973) however, show this line passing just south of Churchill and ending at Hudson Bay. It continues in the northern extreme of Quebec. Brown (1973) acknowledges the lack of proof of the zone in Ontario and suggests that more work might change the boundaries. Recent field work by Environment Canada in the Winisk Area (Cowell et al. 1981) also seems to question the southern limit of permafrost. This is especially plausible because the southern limit of continuous permafrost follows the 17°F (-8.3°C) isotherm throughout the rest of Canada. Brown (1967) however, shows the line crossing this isotherm west of Churchill and approaching the 25°F (-3.8°C) isotherm at Cape Henrietta Maria. Clearly, the determination of the continuous permafrost zone in Manitoba and Ontario is the most pressing research required in the Hudson Bay Lowland on permafrost.

In addition, permafrost investigations are needed to determine the distributions and interrelationships of peat palsas, peat plateaux, black spruce islands and incipient or brown moss palsas. There is still much to be known about the mechanisms of formation and degradation of these features and particularly the characteristics of the mineral substrate and peat-mineral boundary. The Hudson Bay Lowland, as a predominantly peatland area, affords a complete assortment of permafrost - peatland features in one region and is relatively close to major research centres of central Canada.

Prior to 1969 there was essentially no pedological survey or research carried out in the Hudson Bay Lowlands. Since 1969 large portions of the Lowland in Québec, Ontario and Manitoba have undergone soil inventory descriptions and some research. These studies have, for the most part, been in conjunction with large-scale ecological land surveys. Because of these studies, the general nature and occurrence of organic and mineral soils of the Hudson Bay Lowland are beginning to emerge for the first time. However, there remains a great deal of pedological inventory and research to be carried out. Vast expanses of the interior Lowland of Ontario and south and southeast of York Factory in Manitoba have not been examined at all. The nature of the transition between dominantly organic soils and dominantly organic cryosols is not known. There is a tremendous opportunity to examine the development over time of organic soils, gleysols, podzols and brunisols as represented by sequences perpendicular to the coast, because of continual isostatic rebound. In particular, one can observe and measure processes involving oxidation/reduction (Rego Gleysols - Humic Gleysols), humic translocation (regosols - podzols on beach ridges), humification of peat materials (coastal marshes - coastal fens - interior bogs) and many more because of the time gradients provided by isostatic recovery. The Hudson Bay Lowland is one of the best regions in the world to study the characteristics, formation and processes of organic soils (and certain mineral soils) with and without the occurrence of permafrost.

Geomorphological studies of the coast and interior portions of the Lowland are also relatively new and there remains a great deal to learn. The Lowland is virgin territory in this regard due to problems of accessibility and perhaps because of some reluctance on the part of geomorphologists to explore such vast peatland areas. The Hudson Bay Lowland is a continually expanding coastal plain dominated by organic landforms and dynamic because of its youth and because of one of the fastest rates of isostatic recovery in the world. Geomorphological diversity is illustrated by active and raised beach ridges which are displayed in abundance of form and occurrence; rivers and their headwater tributaries which are actively dissecting the emerged plain; exposed limestone and gypsum outcrops which are experiencing dynamic but youthful stages of karstification; the constantly changing coastline of Hudson and James Bay where marine processes can be observed in the present and preserved in landforms throughout the Lowland, spanning the past 9000 years; and in the interior Lowland which shows evidence of marine modified glacial and glaciofluvial landforms such as drumlins, till plains, eskers and deltas. In addition, these landforms and processes occur in conjunction with the growth of organic deposits and landforms which influence and in turn are influenced by the former. The challenge is there for a whole new aspect of geomorphological research which might be termed "wetland geomorphology". The myriad of patterns and types of peatland landforms are intricately dependent on local and regional hydrological and nutrient conditions which are primarily controlled by the mineral substrate and the interaction of organic with other geomorphological processes. All aspects of this interaction as well as standard geomorphological conditions remain to be investigated in the Hudson Bay Lowland. All that is required is for the challenge to be accepted with the acknowledgement of the significance of this region with respect to altruistic and practical needs.

5. ANNOTATED BIBLIOGRAPHY

1. ALCOCK, F.J. 1916a. The Churchill River, Geog. Rev. 2:433- 448.

Keyword: Physiography

Location: Man. H.B.L. (Churchill River)

2. ALCOCK, F.J. 1916b. Lower Churchill River Region, Manitoba. Geol. Surv. Can., Summ. Rept. 1915:133-136.

Keywords: Stratigraphy, Physiography

Location: Man. H.B.L. (Churchill River)

3. ANDREWS, J.T. 1968. Postglacial rebound in Arctic Canada: Similarity and prediction of uplift curves. Can. J. Earth Sci. 5:39-47.

Andrews determined 21 uplift curves for the central and eastern Canadian Arctic using published radiocarbon dates. He used between 2 and 9 dates, with one date taken from near the marine limit to derive each curve. The Hudson Bay Lowland is represented by 1 curve drawn using 5 dates from the Churchill area. For each curve he derived a proportionality or decay constant which, although varying with time, tended to be similar for all 21 sites. This is reflected in the similarity of the form of the rebound curves. Andrews discusses the evidence for maximum marine inundation occurring immediately on deglaciation in Arctic Canada and concludes that this is a reasonable assumption. Thus it is possible to determine an accurate uplift curve for any locality in Arctic (and Subarctic) Canada given only (a) elevation of the marine limit and (b) a date for deglaciation of the site. This information can be used, to determine the decay constant and thus, using Andrews' equation, the amount of uplift at any time since deglaciation (and hence the uplift curve). Andrews also used the empirically derived curves to develop an equation to determine amount of uplift remaining beyond present. For the Ottawa Islands (central Hudson Bay area), Andrews predicts 100 m of uplift remaining. For the Hudson Bay Lowland (Churchill area) his values and reported uplift (Tables I and III) suggest there are about 90 m of uplift remaining.

Keywords: Isostacy, Marine Inundation, Deglaciation, Decay Constant, Radiocarbon Dates

Location: Man. H.B.L. (Churchill area), H.B.R.

4. ANDREWS, J.T. 1969. The pattern and interpretation of restrained, postglacial and residual rebound in the area of Hudson Bay. Geol. Surv. Can. Paper 68-53:49-62.

Andrews defines and discusses three types of rebound; restrained (occurs prior to deglaciation), postglacial (occurs during the following deglaciation) and residual (rebound still remaining). He discusses a few of the maps showing isolines on the elevation of the marine limit published prior to 1968. He then develops 2 maps, one showing isobases of relative uplift in the last 6000 years and the other showing isobases of residual rebound derived from equations. Both these maps indicate the greatest past and potential uplift occurring southeast of Hudson Bay and northwest of Hudson Bay with the Bay forming a saddle in-between. From this he concludes the bay itself was probably an area of convergence rather than divergence of ice during the Pleistocene. Residual rebound in the Hudson Bay Lowland is shown varying between 90 and 140 meters increasing toward the northeast (Cape Henrietta Maria). He places the age of deglaciation at 7800 to 8200 years ago. He notes that the calculation of restrained rebound is the most difficult to distinguish between glacio-isostatic recovery and rebound due to local or regional tectonic histories.

Keywords: Isostacy, Deglaciation, Marine Inundation, Glaciation, Radiocarbon Dates

Location: H.B.L., H.B.R.

5. ANDREWS, J.T. 1970. Present and postglacial rates of uplift for glaciated northern and eastern North America derived from postglacial uplift curves. Can. J. Earth Sci. 7(2):703-715.

Andrews has determined uplift rates for 58 localities in northeastern North America. He developed these rates using the equations and constants derived in his 1968 paper from 28 curves representing Arctic Canada. He discusses postglacial uplift over the past 10,000 years and shows small-scale contour maps of average and current rates of uplift as well as uplift rates at 6000 and 8000 years B.P. These determinations are based on the use of his 'A' constant which represents the amount of recovery in the first 1000 years after deglaciation. Because the form of the uplift curves are similar, uplift rates can be determined for any site, at any time since deglaciation using the A constant and knowing only the age and elevation of the local marine limit. Andrews uses field examples for a number of his sites to show that his calculated estimates are good approximations of uplift.

Rates of uplift for northeastern North America vary between .2 and 1.3 m/100 years at present; 1 to 5 m/100 years, 6000 years ago; and between 1 and 10 m/100 years, 8000 years ago. These calculations do not include corrections for eustatic sea level rises (.2 to .3 m/100 years). The highest rates occur at or near centres of former ice accumulation (northeastern James Bay area and Keewatin).

Keywords: Isostacy, Radiocarbon Dates, Glaciation, Deglaciation

Location: Northeastern North American including H.B.R.

6. ANDREWS, J.T. and G. FALCONER. 1969. Late glacial and postglacial history and emergence of the Ottawa Islands, Hudson Bay, N.W.T.: evidence on the deglaciation of Hudson Bay. Can. J. Earth Sci. 6(5):1263-76.

This paper deals with the deglaciation - marine inundation history of the Hudson Bay Region as evidenced by geomorphic features and radiocarbon dating of marine shells from the Ottawa Islands in northeastern Hudson Bay. The authors examine glacial striations, erratics, ground moraine, post glacial deltas, marine boulder fields and marine shell deposits on Gilmour and Perley islands. They have also obtained 9 radiocarbon dates from a range of elevations on Gilmour Island.

The evidence indicates a number of directions of ice flow across the islands which the authors interpret in terms of shifting ice fronts as marine waters invaded the region. Radiocarbon dates from the islands as well as dates from other parts of the region indicate marine inundation was via Hudson Strait and into central Hudson Bay west of the Ottawa Islands. This effectively cut the ice sheet in two as marine waters invaded into the deglaciated portions of the southern James Bay area. The final deglaciation of the region is believed to be back toward the postulated ice centres located northwest of Hudson Bay in Keewatin and southeast of Hudson Bay in the Richmond Gulf area. The authors have determined the marine limit to be near 158 m a.s.l. on the islands which emerged at a rate of 6 m/100 years between 7000 and 6000 years B.P. and are presently rebounding at a rate of about .8 m/100 years. The date for initial deglaciation of the Hudson Bay Region is placed at about 8000 years B.P. The authors conclude that deglaciation of Hudson Bay was catastrophic, occurring within a few hundred years.

Keywords: Deglaciation, Marine Inundation, Isostacy, Radiocarbon Dates, Surficial Geology, Glacial Straie, Marine Shells

Location: H.B.R. (Ottawa Islands N.W.T.)

7. ANDREWS, J.T., R. MCGHEE and L. MCKENZIE - POLLOCK. 1971. Comparison of elevations of archeological sites and calculated sea levels in Arctic Canada. Arctic 24 (3): 210-228.

Keywords: Isostacy, Archeology, Radiocarbon Dates

Location: H.B.R.

8. ANDREWS, J.T. and D.M. BARNETT. 1972. Analysis of strandline tilt directions in relation to ice centres and postglacial crustal deformation, Laurentide ice sheet. Geografiska Annaler. 54 Ser. A:1-11.

The authors discuss evidence for shifting ice centres from accumulation zones to glacial maximum to deglaciation. The intersection of strandline tilt directions and free air gravity anomalies suggest up to 6 accumulation and deglaciation zones. The loci of depresssion and hence uplift has shifted from the centre of the Laurentide maximum (over central Hudson Bay) to these 6 accumulation/deglaciation zones. The zones include the Foxe Basin, Northwest Hudson Bay (just north of Eskimo Pt.), west of central Hudson Bay, Southwest Cape Henrietta Maria (in James Bay), Southwest Québec and central Labrador-Ungava. It is not known for certain that uplift centres can shift but the evidence from Scandinavia suggests they can. More data, especially strandline tilt direction, are required to elucidate this problem further.

Keywords: Glaciation, Deglaciation, Strandlines, Pleistocene Chronology, Free Air Gravity Anomalies

Location: H.B.R.

9. ANDREWS, J.T. and W.R. PELTIER. 1976. Collapse of the Hudson Bay ice centre and glacio-isostatic rebound. Geology 4(2):73-76.

A short paper based on evidence from the Ottawa Islands (Andrews and Falconer 1969) and estimates of mantle viscosity in terms of predicted uplift. The evidence suggests a collapse of the ice sheet in central Hudson Bay (west of the Ottawa Islands) which is postulated to be the result of increased calving of the glacier outlet in Hudson Strait due to a rise in sea level between 12,000 and 10,000 years B.P. This resulted in the last retreat of the glacier to centres located over Keewatin and Labrador and subsequent marine inundation of the Hudson Bay Lowland.

Keywords: Deglaciation, Marine Inundation, Geophysics

Location: H.B.R.

10. ANTEVS, E. 1953. Geochronology of the Deglacial and Neothermal Ages. J. Geol. 61(3):195-230.

Antevs discusses the pattern and age of glacial retreat in eastern North America and Scandinavia. He attempts to correlate events and ages on the two continents from the Wisconsin maximum (27,000 to 29,000 years B.P.) to the last recorded advance and retreat at about 10,150 to 11,300 years B.P. In North America this last advance occurred in the 48 to 50°N latitude range and is referred to as the Cochrane advance. It is marked in the Cochrane area by the Nellie Lake outwash deposits and by the Cochrane terminal moraine. This advance preceded final retreat of the ice into Hudson Bay and final draining of glacial lake Barlow - Ojibway northward into the James Bay Lowland area (Tyrrell Sea). The chronologies were based primarily on radiocarbon dating and extensive varve analysis by the author and others in the early 1900's.

Keywords: Pleistocene Chronology, Deglaciation, Cochrane Readvance, Glacial Lake Barlow-Ojibway, Varves, Radiocarbon Dates

Location: H.B.R.

11. ANTEVS, E. 1955. Varve and radiocarbon chronologies appraised by pollen data. J. Geol. 63(5):459-499.

Antevs uses forest types identified by pollen assemblages in a bog in Québec to confirm the approximate deglaciation chronology he put forward in an earlier paper (Antevs 1953). This included a confirmation of the age of the Cochrane readvance in a time of general climatic cooling at 10,000 to 11,500 years B.P.

Keywords: Pleistocene Chronology, Deglaciation, Palynology, Forest Types, Varves, Cochrane Readvance, Radiocarbon Dates

Location: H.B.R.

12. ARCHER, D.R. 1968. The upper marine limit in the Litte Whale River area, New Québec. Arctic 21(3):153-160.

This paper reports on an altimeter survey of the upper marine limit at 21 sites on the southeast side of Hudson Bay in Québec. Measurements were taken at the lower limit of perched boulders which were interpreted to mark the upper limit of inundation. Results indicate a major centre of ice dispersal in the southern Hudson Bay - northern James Bay region during the Wisconsin. The marine limit in the study area was determined to be in the range 255-290 m a.s.l. (835-943 ft).

Keywords: Isostacy, Marine Limit, Glaciomarine Landforms, Wisconsin Glaciation.

Location: Northern Québec, H.B.R.

13. AUER, V. 1927. Botany of the interglacial peat beds of Moose River Basin. Geol. Surv. Can., Summ. Rept. 1926, pt. C:45-47.

Auer briefly describes pollen assemblages from samples taken by McLearn (1927) from 9 sections on the Soweska, Opasatika and Missinaibi rivers. He had difficulty separating pollen from the compact peat of the interglacial beds (Missinaibi Formation) and notes that his assemblages are not based on quantitative analyses. These are the same peats later examined quantitatively by Terasmae (1958). Auer briefly interpreted environmental conditions occurring during the deposition of peat (mostly deposited by water from surrounding bogs) and silts between glacial advances. He notes an abundance of spruce (*Picea sp.*), pine (*Pinus sp.*), mosses (*Hypnum sp.* and *Sphagnum sp.*), sedges (*Carex sp.*) and reeds. He concludes that "the conditions of interglacial time in this region were probably much like those of the present". Terasmae (1957, 1958) later reassigned these beds to a substage of the Wisconsin rather than interglacial.

Keywords: Palynology, Forest Composition, Pleistocene Stratigraphy, Glaciation, Interglacial Peat Beds, Missinaibi Formation

Location: Ont. H.B.L. (Missinaibi River)

14. AYRES, L.D., G. BENNETT and R.A. RILEY. 1969. Geology and mineral possibilities in northern Patricia District, Ontario. Ont. Dept. Mines, Misc. Paper 28:55 p.

Keyword: Economic Geology.

Location: Ont. H.B.L., Northern Ontario.

15. BAKER, M.B. 1911. Iron and lignite in the Mattagami Basin. Ont. Dept. Mines. XX (1):214-246.

This is a report on a canoe survey down the Mattagami River. The author describes and attempts to evaluate the mineral potential of lignite and iron ores (siderite). He describes the Paleozoic bedrock and fossils outcropping along the river. The entire overlying unconsolidated sequence is considered by the author to be Pleistocene although later investigations proved the lower clays, silts and lignites to be Mesozoic (Mattagami Formation). Baker assigned these silts and clays to a lower drift sequence and interpreted the lignites as being interglacial. He describes the river exposures and provides numerous photos of rapids and outcrops.

Keywords: Paleozoic Lithology and Paleontology, Mesozoic Lithology, Mattagami Formation, Precambrian Lithology, Iron Ores, Economic Geology.

Location: Ont. H.B.L. (Mattagami River).

16. BALLIVY, G., G. POULIOT and A. LOISELLE. 1971. Quelques charactéristiques géologiques et minéralogiques des dépôts d'argile du nord-ouest du Québec. Can. J. Earth Sci. 8(12):1525-41.

This paper presents a fairly detailed examination of the chemical and mineralogical properties of glacio-lacustrine and marine clays of the Hudson Bay Region. The authors sampled glacial lake Barlow-Ojibway clays near Mattagami, Quebec outside the Lowland and Tyrrell Sea clay near Prince Rupert, Québec on the eastern edge of the Lowland. The clays were similar in many of their properties but the marine deposits had consistently higher proportions of CaO and CO_2 (13% to 15% vs. 1% to 4%) but lower percentages of H_2O (2% to 3% vs. 3% to 5.3%) and clay content (35% vs. 60%). Thus it is relatively easy to separate the two deposits. On this basis they determined the presence of glacio-lacustrine deposits (clay, sand and gravel) beneath the Tyrrell Sea clays near Prince Rupert.

Lacustrine and marine clays in the area had clay mineralogical compositions dominated by illite with (in decreasing abundance) chlorite, vermiculite and kaolonite. The kaolinite is believed by the authors to be derived from glacial erosion of the Cretaceous Mattagami Formation which occurs in the Lowland to the west.

In addition the authors noted the presence of disturbed lacustrine sediments beneath an upper till on the Rupert River, 50 miles upstream from Rupert House. They assign these lacustrine sands and clays to Late Wisconsin, immediately prior to the Cochrane advance (represented by the till). This is significant because they may be correlative with the Friday Creek sediments of Skinner (1973b) which he suggested may be Late Wisconsin.

Keywords: Geochemistry, Quaternary Stratigraphy, Minerology, Lithology, Deglaciation, Mattagami Formation, Tyrrell Sea Deposits, Glacial Lake Barlow-Ojibway Deposits, Cochrane Readvance, Clay.

Location: Qué. H.B.L., H.B.R.

17. BALLIVY, G., A.A. LOISELLE and G. POULIOT. 1975. Quelques charactéristiques géotechniques des dépôts d'argile de baie James: les coulées d'argile de Fort Rupert, Québec. Can. Geotech. J. 12(4):498-509.

This paper describes the marine and glacio-lacustrine clays outcropping on the Rupert River. Descriptions and chemical and mineralogical results are the same as those described by Ballivy et al. (1971). This paper is primarily concerned with the geotechnical properties of the clays, especially the Tyrrell Sea clays relative to the development of rotational slides along the banks of the rivers. This is a useful study because such slides are common on the main rivers of the Lowland especially where alluvium overlies the marine clays.

They examine the water content, shear strength and, liquid and plastic limits of the clays and discuss the history and characteristics of 3 slides on the Rupert River. The slides occur in spring and fall which the authors attribute to a rising water table in the sediments due to rainfall or snowmelt. Drainage into the soil is facilitated by the presence of cracks in the overlying organic desposits which help to converge the drainage along the edge of the river. Water circulation in the clays is aided by the presence of horizontal silt beds.

Keywords: Erosion, Rotational River Bank Slides, Geotechnical Properties, Tyrrell Sea Clays.

Location: Qué. H.B.L. (Rupert River), H.B.R.

18. BARNETT, D.M. 1966. A re-examination and re-interpretation of tide guage data for Churchill, Manitoba. Can. J. Earth Sci. 3(1):77-88.

In this paper Barnett attempts to derive a rate of uplift for the Churchill area using a 25-year record of tide guage data (1940-64). He calculates uplift to be in the order of 2.4 ft/100 years (after allowing for a eustatic rise in sea level of 4.75 in/100 years) and rejects Gutenberg's (1941, 1954) calculation of between 1 and 3 m/100 years using tidal guage records for an earlier period (1928-39). Barnett points out the problems using tide guage data, especially for a harsh climate, and indicates the 1940-64 period records are more accurate than those prior to 1940. The earlier records are more suspect because the guages were not installed permanently and were not accurately levelled to a known bench mark or datum.

Barnett reviews a number of earlier papers dealing with isostacy to that time. He also notes several authors' conclusions that there is up to 800 ft. of uplift remaining but concludes as a 'general suggestion' that the remaining uplift is much less than this.

Keywords: Isostacy, Tidal Levels, Tide Guage Records

Location: Man. H.B.L. (Churchill)

19. BARNETT, D.M. 1970. An amendment and extension of tide guage data analysis for Churchill, Manitoba. Can. J. Earth Sci. 7: 626-627.

This is a follow-up to the earlier paper (Barnett 1966) in which an uplift rate of 2.4 ft/100 years was determined using tide guage records from Churchill, Manitoba. An error was found in the original regression which lowered the reported uplift rate. With "more rigorous statistical treatment" and the addition of 4 years record (1965-68) Barnett reports a revised rate of 1.75 ft/100 years.

Keywords: Isostacy, Tidal Levels.

Location: Man. H.B.L. (Churchill)

20. BECKEL, D.K.B. 1957. Studies on seasonal changes in the temperature gradient of the active layer of soil at Fort Churchill, Manitoba. Arctic 19(3):151-183 (includes numerous graphs and tables).

Beckel presents the results of a detailed study, carried out by the Defense Research Northern Laboratory, on active layer temperatures in all seasons over a four year period (1951 to 1954). Measurements were taken at 40 stations located in a variety of terrain types (raised beach ridges, sedge swales and pools) in the vicinity of Churchill. Copper-constantan thermocouples were installed at each site for the duration of the study and temperatures were recorded once every 2 to 5 weeks at the ground surface, near the permafrost table and, in some sites, at a depth of 12 inches (30 cm).

The paper summarizes the results for selected sites (including terrain type, frost depth, water level and temperature extremes) and discusses four sites in detail with soil profile data and graphs of temperature over time for the period of record. These four sites include two dry sites, one of which has been disturbed, and two wet sites. The author discusses measured soil temperatures in terms of terrain type, soil texture, depth of snow, solar radiation, air temperature, vegetation and peat thickness. Although many of his findings are well known (or assumed) today; such as the lag in soil temperature behind air temperature, the insulation qualities of deep snow cover, the effect of vegetation cover removal, etc., the paper provides quantitative evidence and is a useful reference for anyone interested in soil and permafrost processes of the southern Hudson Bay area.

Keywords: Permafrost, Active Layer, Terrain Types, Soils, Snow Depth, Vegetation, Peat Thickness, Solar Radiation, Raised Beach Ridges, Sedge Swales, Pools.

Location: Man. H.B.L. (Churchill)

21. BECKEL, D.K.B., C.E. LAW and B.R. IRVINE. 1954. Major terrain types of North American tundra nd boreal forest areas with examples from the Churchill Manitoba area. Defence Res. Board, Def. Res. Nor. Lab., Tech. Note 37: 5p. + photos.

This is a short paper describing 17 "terrain types" representing arctic and subarctic Canada. The intent was to formalize terminology and descriptions for military personnel reporting on arctic and subarctic regions. Examples were taken from various locations in northern Canada and photographs of each type are included. Descriptions are very brief and relate primarily to vegetation and ground surface morphology.

Arctic types represented in the Churchill area include: rough rock ridges; gravel, sand and/or shattered limestone ridges and hills; dry heath uplands; shattered limestone and clay; tussock or hummock muskeg; swamp; boulder strewn marine beaches; and lakes and ponds. Subarctic types include: rough rocky ridges; dry sandy ridges; white spruce forest; black spruce forest; willow and sedge marsh; recent burns; and lakes. Peat bog and grasslands were 2 subarctic types without Churchill examples.

Keywords: Physiography, Terrain Types.

Location: Man. H.B.L. (Churchill), northern Manitoba and Northwest Territories.

22. BELL, J.M. 1904. Economic resources of the Moose River Basin. Ont. Bur. Mines 13(1):135-179.

This paper gives a summary of the economic resources of the Moose River and its tributaries. Bell describes and maps outcrops of lignite, gypsum and iron (scale of map - 8 mi. to 1 in.). He also describes the gypsum karst features of the Moose River (below the Mattagami river) and of Gypsum Mountain located between the Abitibi and French Rivers. These include springs, sinkholes, caves, columns and natural bridges.

Keywords: Economic Geology, Paleozoic and Mesozoic Geology, Gypsum Karst, Karst Landforms.

Location: Ont. H.B.L. (Moose River)

23. BELL, R. 1872. Report on the country between Lake Superior and the Albany River. Geol. Surv. Can., Rept. Prog. 1971-72 pt 4:101-114.

This report deals mainly with the country south of the Lowland but follows the Albany River as far as its junction with the Kenogami River. The author describes yellowish limestone and coal (probably lignite) outcrops within the Lowland.

Keywords: Stratigraphy, Paleozoic and Mesozoic Geology, Physiography, Limestone, Lignite.

Location: Ont. H.B.L. (Albany River), Northern Ontario

24. BELL, R. 1877. Report on an exploration in 1875 between James Bay and lakes Superior and Huron. Geol. Surv. Can., Rept. Prog. 1875-76:294-342.

The author discusses the geology and physiography along certain rivers between the upper Great Lakes and James Bay. He reports on a track survey made from Lake Huron to Moose Factory via the Mattagami, Whitefish and Sturgeon rivers and return to Lake Superior via the Missinaibi and Michipicoten rivers. Bell also covered about 100 miles of shoreline in Ruperts Bay and is the first to discuss the possibility of isostatic rebound in this area.

Keywords: Paleozoic Geology and Paleontology, Physiography, Isostacy.

Location: Ont. H.B.L. (Moose River)

25. BELL, R. 1879a. Report on an exploration of the east coast of Hudson's Bay 1877. Geo. Surv. Can., Rept. Prog. 1877-78: pt C:1-37.

Bell describes some of the country between Lake Superior and Moose Factory as an update to his earlier report (Bell 1877). Most of the report describes the bedrock and surficial geology of the east side of James Bay and Hudson Bay, particularly the Eastmain coast of James Bay. He notes 'raised' beaches along this part of the coast up to 300 ft above sea level. He observed spruce driftwood in ridges up to 50 ft above the bay and estimated an uplift rate of 5-10 ft/100 years based on the rate of driftwood decay between lower and upper ridges. Bell did not at this time consider them to be evidence of uplift but refers to a 'fall in the sea-level'. He also records the orientation of 66 glacial straie, and generally describes the topography, soil, climate, timber, rivers and harbours, fish and mammals of this part of the coast. From Moose Factory he explored about two-thirds of the way up the east coast of Hudson Bay and James Bay.

Keywords: Bedrock Geology, Physiography, Isostacy, Surficial Geology, Raised Beach Ridges, Driftwood, Glacial Straie.

Location: Ont. H.B.L., Qué. H.B.L., east coast of Hudson and James Bay (mainly outside H.B.L.)

26. BELL, R. 1879b. Report on the country between Lake Winnipeg and Hudson Bay. Geol. Surv. Can., Rept. Prog. 1877-78: pt CC:1-31.

The geology and physiography along the Nelson and Hayes rivers are briefly described in this report. Bell made track surveys of these rivers and noted the effects of isostacy at their mouths (includes map of lower 90 miles of Nelson River at 4 mi to the inch). He also very briefly described marine and Pleistocene deposits in exposures at the mouth of the Nelson River and noted the effects ice in the spring.

Keywords: Paleozoic Geology, Physiography, Isostacy, Pleistocene Deposits.

Location: Man. H.B.L. (Nelson and Hayes Rivers)

27. BELL, R. 1880. Report on explorations on the Churchill and Nelson Rivers and around God's and Island Lakes. Geol. Surv. Can., Rept. Prog. 1878-79, pt C:72 p.

This report is based on track surveys carried out in 1878 and 1879 along the Churchill and Nelson Rivers. Bell provides his usual accounts of the bedrock and surficial geology and topography with notes on timber, mammals, birds, insects and climate for the lands along these rivers between Lake Winnipeg and Hudson Bay. He notes marine shells 60 mi from the mouth of the Churchill, 350 ft a.s.l. Based on 'circumstances connected with the history of old Fort Prince of Wales' Bell estimates a relative change in the level of sea and land to be about 7 ft/100 years. He attributes this to a general lowering of sea level and partly to the silting-up of portions of Hudson Bay, "interrupting the free flow of tides" and not necessarily to uplift of the land.

Keywords: Bedrock Geology, Physiography, Isostacy, Surficial Geology, Coastal Sedimentation.

Location: Man. H.B.L. (Churchill and Nelson Rivers)

28. BELL, R. 1883. Report on the geology of the basin of Moose River and adjacent country. Geol. Surv. Can., Rept. Prog. 1880-82, pt C:1-9.

This paper reports on the geology of the shield area and does not include any of the Lowland.

Keywords: Precambrian Geology.

Location: Northern Ontario

29. BELL, R. 1887. Report on an exploration on portions of the Attawapiskat and Albany rivers. Geol. Surv. Can., Rept. Prog. vol. 2, pt G:1-38.

This report is the same as Bell 1912 (see below).

Keywords: Paleozoci Stratigraphy, Quaternary Deposits, Physiography, Precambrian Geology, Surficial Geology, Coastal Morphology, Reefal Limestone.

Location: Ont. H.B.L. (Albany & Attawapiskat rivers).

30. BELL, R. 1896. Proofs of the rising of the land around Hudson Bay. Am. J. Sci., Ser. 4 vol. 1:219-228.

This is an interesting monograph which was presented as an address to the Geological Society of America in 1895. Bell briefly describes the east and west coasts of Hudson Bay and James Bay then proceeds to list the evidence which indicates the rising of the land. These include personal accounts over 20 years of exploration in the area and the accounts of natives, Hudson Bay Co. personnel and historical records of changes in the coastline, emergence of new islands, former islands becoming part of the shore and the shallowing of the river mouth channels. He also describes the raised terraces and beaches with decaying driftwood on eastern Hudson and James bays and describes old Eskimo beach camps now up to 70 ft above sea level. Marine shells have been collected by the author up to 500 ft above sea level. The author concludes that "proof of the rising of the land around Hudson Bay in postglacial times would be admitted by any geologist". This is a very interesting description which includes many historical facts dating from Henry Hudson's voyage.

Keywords: Isostacy, Coastal Morphology, History.

Location: H.B.R.

31. BELL, R. 1912. Report on an exploration of portions of the Attawapiskat and Albany rivers, Lonely Lake to James Bay. Rept. Ont. Bur. Mines 21:59-86.

This is a descriptive report of the geology along the

Albany and Attawapiskat rivers based on track surveys made in 1886. He described numerous Precambrian and Paleozoic outcrops along these rivers including the first description of the reefal Attawapiskat Formation. Bell briefly considers some aspects of the vegetation, wildlife and glacial desposits along the rivers and describes the James Bay coast between their mouths.

Keywords: Paleozoic Stratigraphy, Quaternary Deposits, Physiography, Precambrian Geology, Surficial Geology, Coastal Morphology, Reefal Limestone.

Location: Ont. H.B.L. (Albany & Attawapiskat rivers)

32. BIRD, J.B. 1954. Postglacial marine submergence in central Arctic Canada. Bull. Geol. Soc. Am. 65(5):457-464.

Bird discusses postglacial marine submergence in the vicinity of northern and northwestern Hudson Bay (Keewatin). He describes and shows photos of marine features, and estimates the marine limit at 360 to 400 feet in Keewatin and 550 to 650 ft on Southhampton and Coates islands. He concludes that the land in this area is still rising, based on accounts by natives of changes in the shore configuration and on the presences of archaeological sites up to 80 ft above the sea. Sites attributed to the Thule people are up to 30 ft above the sea and 1000 years old which suggests an uplift rate of 3 ft/100 yrs. He also refers to Gutenberg's (1941) estimate of 3-6 ft/100 yrs based on tide-guage records at Churchill and notes that the Canadian Hydrographic Service has "thrown doubt on the validity of the earliest records" (prior to 1940).

Keywords: Marine Inundation, Beach Ridges, Isostacy.

Location: Northwestern Hudson Bay (Keewatin)

33. BIRD, J.B. 1967. The Physiography of Artic Canada. Johns Hopkins Press, Baltimore Md.: Hudson Bay area pp.81-116.

Bird describes the physiography of the Hudson Bay Region and briefly discusses preglacial (Tertiary) drainage in the Region when the bay was above sea level. He includes a small scale map of the Tertiary drainage pattern which crossed the Lowland and present day Hudson Bay to empty into the sea in the vicinity of Hudson Strait.

Keywords: Physiography, Tertiary Drainage Patterns.

Location: H.B.R.

34. BOISSONNEAU, A.N. 1966. Glacial history of northeastern Ontario: I. The Cochrane-Hearst Area. Can. J. Earth Sci. 3(5):559-578.

The author describes the major glacial, glaciofluvial and glaciolacustrine landforms, and deposits of a large portion of the Canadian Shield immediately south of the Hudson Bay Lowland in Ontario. He also discusses the glacial chronology and sequence of events represented by the deposits. The Cochrane advance is described in terms of two advances over the area leaving a drumlinized clay till. He reports a minimum date of 6390 $\pm$ 350 years B.P. (taken from the literature) for the withdrawal of ice from the Cochrane area and notes that retreat into the James Bay area must have been rapid. Recent evidence suggests the Tyrrell Sea invaded southern James Bay around 7700 to 7900 years B.P. (Craig 1969).

Keywords: Surficial Geology, Glaciation, Deglaciation, Cochrane Readvance.

Location: Northern Ontario, South H.B.R.

35. BOSTOCK, H.H. 1969. Precambrian sedimentary rocks of the Hudson Bay Lowlands. Geol. Surv. Can., Paper 68-53:206-214.

Keywords: Precambrian Geology, Stratigraphy, Inliers.

Location: Ont. H.B.L. (Sutton Ridges).

36. BOSTOCK, H.H. 1971. Geological notes on Aquatuk River map-area, Ontario with emphasis on the Precambrian rocks. Geol. Surv. Can., Paper 70-42: 57 p.

This paper is based on data collected in 1967 for 'Operation Winisk' and also on aeromagnetic data. Bostock presents a good, detailed report on geology of the Precambrian inliers in the Hudson Bay Lowland between the Winisk River and James Bay (Sutton Ridges). This is the most complete geological description of these areas to date. He describes the various lithologies, their mineralogical composition (with photomicrographs), metamorphic history and economic potential. In addition, he provides regional stratigraphic and aeromagnetic interpretations. Included with the report are aeromagnetic maps and an aeromagnetic interpretation of the Precambrian rocks.

Keywords: Precambrian Geology, Stratigraphy, Inliers, Mineralogy, Aeromagnetic Survey, Economic Geology.

Location: Ont. H.B.L. (Sutton Ridges)

37. BROWN, D.D., G. BENNETT and P.T. GEORGE. 1967. The source of alluvial kimberlite indicator minerals in the James Bay Lowland. Ont. Dept. Mines, Misc. Paper 7:35p.

Diamonds have been found in facial deposits of Wisconsin and Michigan. Their provenance is unknown however the southern James Bay Lowland is the most promising source up-ice from these till deposits. This is due to the presence of kimberlite dykes on the Abitibi River, inside the Lowland. These dykes have mineral assemblages similar to diamond producing areas of South Africa. The authors report on the possibility of diamonds occurring in the southern James Bay region and describe the results of an exploration for diamonds over an 125 mi^2 area along the Abitibi River in 1962 by the Canadian Rock Company. No evidence of diamonds were found.

Keywords: Economic Geology, Mineralogy.

Location: Ont. H.B.L. (Abitibi and Moose River).

38. BROWN, R.J.E. 1967 (reprinted 1969). Permafrost Map of Canada. Div. Build. Res., Nat. Res. Council Can. Pub. # 9769, (also Geol. Surv. Can. Map 1246A).

Keywords: Permafrost, Permafrost Distribution, Permafrost Map.

Location: Canada.

39. BROWN, R.J.E. 1968. Permafrost investigations in northern Ontrario and northeastern Manitoba. Nat. Res. Council, Div. Build. Res. Tech. Paper 291:39 p. plus appendicies, figures, tables and photos.

Brown reports on permafrost investigations carried out during 1965 as part of a program by the Division of Building Research, National Research Council to determine the distribution of permafrost and location of its southern limit in Canada. The program lasted from 1962 until 1969 and resulted, at least in part, in the Permafrost map of Canada (Brown 1967). This paper described investigations in Ontario and Manitoba.

The distribution of permafrost was checked by means of a series of N-S helicopter-supported surveys which originated in Moosonee, Ontario and terminated in Thompson, Manitoba. Measurements of the depth to permafrost, permafrost thickness (where possible), ground ice characteristics, vegetation types (dominant species), thickness of living cover, peat thickness and type of substrate were made at 41 stops (23 had permafrost) of which about 24 were in the Hudson Bay Lowland (mainly the Ontario portion). This data is presented in a table and reviewed in the paper.

Brown outlines his findings in detail and discusses general characteristics of the occurrence and distribution of permafrost. In addition, he describes several air photo patterns, discusses permafrost indicators and discusses the mechanism of palsa and peat plateau formation (and degradation). He also briefly reviews the climate, geology, vegetation, soils, relief and drainage of northern Ontario and Manitoba (Lowland and Shield). It is especially well illustrated with 31 photographs and numerous maps and diagrams. This paper represents the most extensive permafrost research in the Lowland. Although limited in distribution, copies may be available from the Publications Section, Division of Building Research, National Research Council of Canada, Ottawa, Ontario.

Keywords: Permafrost, Peatland, Vegetation, Peat Thickness, Terrain Types, Palsas, Peat Plateaus, Soils, Drainage, Air Photo Interpretation.

Location: Ont. H.B.L.

40. BROWN, R.J.E. 1973. Permafrost-distribution and relation to environmental factors in the Hudson Bay Lowland. Proc. Symp. Physical Env. Hudson Bay Lowland (B.D. Kay editor), Guelph, Ontario: 35-68.

The author disucsses the occurrence and distribution of permafrost and permafrost features in the Hudson Bay Lowland. Most of the discussion deals with the distribution, characteristics and mode of origin of peat plateaus and palsas. He considers their origin to be similar and plateaus may in fact represent coalescent palsas which contradicts somewhat to the ideas of Zoltai (1973-see below). Brown considers drainage, snow cover and insulation by surface peat and living vegetation to be the main controls on permafrost features. He also notes that the existence of the continuous permafrost zone along the southern coast of Hudson Bay remains to be proven. There is as yet no proof of permafrost occurring in mineral soils in Ontario although up to 60 m of it has been recorded at Churchill, Manitoba. Paper includes photographs and vertical aerial photos.

Keywords: Permafrost, Peatland, Palsas, Peat Plateaus, Drainage, Snow Cover, Vegetation.

Location: H.B.L.

41. CANADIAN SOIL SURVEY COMMITTEE, Subcommittee on Soil Classification 1978. The Canadian system of soil classification. Can. Dept. Agr., Publ. 1646. Supply and Services Canada, Ottawa, Ont.:164 p.

This is the most recent publication in a series published by Agriculture Canada on the system of classifying Canadian soils. It replaces "The system of soil classification for Canada", publication 1455, published in 1970 and revised in 1974. The new publication provides the most up to date system for classifying soils including a new soil order (Cryosols) but the old manuals are still useful for their information on soil profile description terminology and their classes, limits, characteristics, and so on.

Keywords: Soil Classification, Soil Description.

Location: Not Applicable.

42. CHARLES, J.L. 1959. Permafrost aspects of Hudson Bay Railroad. J. Soil Mech. 85:125-135.

Charles summarizes the history of construction of the Hudson Bay Railroad outlining problems encountered with permafrost and design measures to overcome the problems. The railroad was constructed between 1910 and 1929. Although he doesn't provide much data on permafrost characteristics or processes he outlines its occurrence along the road. The entire section of railroad in the Lowland from Limestone River to Chruchill, Manitoba (257 km) was, according to Charles, underlain by permafrost. This may be questionable because all the drilling was carried out in winter. Some field checking seems to have been performed one summer but, depending on how early this was carried out, seasonal ice may still have been present. The paper is interesting primarily for its descriptions of railroad construction as carried out in a muskeg terrain in the early 1900's. The author provides four generalized drill profiles from different locations along the railroad (including Churchill and Kettle Rapids in the Lowland), and a cross-section through the Deer River showing the relatioship between 'permafrost', organic sediments, mineral sediments, lakes and the river.

Keywords: Permafrost, Physiography, History, Peatland, Drill Holes.

Location: Man. H.B.L. (Nelson river to Churchill), Northern Manitoba

43. CLAYTON, J.S., W.A. EHRLICH, D.B. CANN, J.H. DAY and I.B. MARSHALL. 1977. Soils of Canada. Res. Br., Can. Dept. Agr., Supply and Services Canada, Ottawa, Ont.: 2 volumes, 2 maps and glossary of terms in soil science.

Volume one is a background report which covers soil concepts including classification and physiography, geology, soil climate, vegetation and general soil type descriptions of Canada. Volume two is an inventory of soils in Canada which is organized on the basis of dominant soil order. These are keyed to the soil map (1:5,000,000 scale) using symbols which denote soil order and great groups and a reference number which refers to individually mapped areas. The inventory provides information for each individually mapped area including up to 3 dominant soil subgroups (40% area, 20% area and 10-20% area), the total area mapped, physiography, soil climate, landform, dominant texture, vegetation and land use, a geographic grid reference, source of information and reliability of source. The Hudson Bay Lowland is composed of 11 individually described areas. These are dominantly gleysolic and organic soils. The other map is a map of soil climates of Canada.

Keywords: Soil Classification, Soil Description, Soil Climate, Physiography.

Location: H.B.L., Canada

44. COLEMAN, A.P. 1941. The Last Million Years. A History of the Pleistocene in North America. U. of Toronto Press, Toronto, Ontario.

Keywords: Pleistocene History, Glaciation, Deglaciation.

Location: North America.

45. COOKE, H.C. 1930. Studies of the physiography of the Canadian Shield. II. Glacial depression and post-glacial uplift. Roy. Soc. Can., Trans. Ser. 3, vol. 24(4):51-87.

Keywords: Isostacy, Physiography.

Location: H.B.R.

46. COOKE, H.C. 1942. Is the land around Hudson Bay at present rising? Am. J. Sci. 240(2):144-146.

Cooke critizes Gutenberg's (1941) use of tide gauge data from Churchill to determine rates of uplift. Cooke notes that the gauge was located in the mouth of the Churchill River behind a constriction to the open sea. He also notes that the change in sea level was not regular over the 1928 to 1939 period but jumped in 1934 which might indicate an error in placement since the guage was removed each year. On this basis he rejects Gutenberg's estimate of uplift for the area (2m/100 years) and concurs with Tyrrell (1896) that there is little or no ongoing uplift in the area. He concludes that "if there is uplift at all, it must be of the order of a very few cm per century".

Gutenberg replies (p. 147-149) that the sudden break does not amount to 1 ft, that the effect of the constriction is negligible and that the average of 13 years rules out river flow effects. He then rejects Tyrrell's evidence (Tyrrell 1896) as based on too many assumptions.

Keywords: Isostacy, Tide Gauge Data.

Location: Man. H.B.L. (Churchill)

47. COOMBS, D.B. 1952. The Hudson Bay Lowland. A geographical study. unpub. M.Sc. Thesis, McGill Univ., Montréal, Québec:227 p.

Keywords: Physiography, Peatland, Muskeg, Vegetation, Physiogarphic Patterns, Permafrost.

Location: H.B.L.

48. COOMBS, D.B. 1954. The physiographic subdivisions of the Hudson Bay Lowlands south of 60 degrees north. Geog. Bull. 6:1-16.

This paper is taken from a thesis by Coombs in 1951 at McGill University. It represents one of the first descriptions of the physiography of the whole Lowland.

As such it is a landmark paper for its basic descriptions and regional geography. However, there are some misleading concepts with regard to the development of the Lowland in relation to isostatic rebound, retreat of the Wisconsinian glaciers and the occurrence of permafrost. Coombs describes four major physiographic subdivisions including a 'Dry Zone', a Muskeg and Small Lake Zone, a Marine Clay Zone and a Coastal Zone. His descriptions of each are good but there is some problem with their distribution, especially among the latter three. His concept of the 'Dry Zone' is also misleading because he attribuites extensive tree cover in the zone (40% of the zone) to dry land. In fact much of this area consists of conifer swamps and Larix-black spruce fens. The Muskeg and Small Lake Zone consist of the 2 subtypes referred to as Smallpox and Pothole Muskeg, respectively by Hanson and Smith (1950). In these areas open water varies from 3 to 50% of the surface area and dry land makes up less than 10%. The Marine Clay Zone is the northernmost zone where surface patterns are influenced by the marine clay substrate. The fourth zone, the Coastal Zone forms the treeless area along Hudson Bay and the area of tidal flats and storm beaches of James Bay. Coombs defines the boundaries of the Hudson Bay Lowland by the extent of Paleozoic strata.

Keywords: Physiography, Peatland, Muskeg, Vegetation, Physiographic Patterns, Permafrost.

Location: H.B.L.

49. COWAN, W.R. 1980. Hudson Bay field meeting. Geosci. Can. 7(1):36-37.

This short summary describes a field trip to the east coast of James and Hudson bays. Although outside the Lowland, some of the landforms examined affect interpretations of late glacial events in the Hudson Bay Region. Of particular note is the Harricanaw Interlobate Moraine, formerly mapped as an esker, believed to mark the final separation of the Wisconsinian ice mass. This would follow the interpretation of Lee (1968) w.r.t. the approximate location of the separation but Andrews (1969) and Skinner (1973b) place it to the west of James Bay. Also the leaders of the field trip (Claude Hillaire-Marcel and Jean-Serge Vincent) accept Prest's (1970a) idea of glacier surges, caused by calving in glacial lake Ojibway and in the northern sea, leading to the Cochrane advance. A unit of mixed sand, gravel and clay occurs between Lake Ojibway and Tyrrell Sea clays in this area which is interpreted as marking the sudden drainage of Lake Ojibway into the Tyrrell Sea. Similar deposits in southern James Bay Lowland were interpreted by Skinner (1973b) as the result of saline density currents resulting from mixing of salt and freshwater (Lake Ojibway).

Keywords: Deglaciation, Marine Inundation, Tyrrell Sea, Cochrane Readvance, Harricanaw Interlobate Moraine, Glacial Lake Ojibway, Surficial Geology.

Location: H.B.R. (southern and eastern)

50. COWELL, D.W. 1981. Subarctic karst geomorphology and the development of organo-karst landforms in the Hudson Bay Lowland, Ontario. Proc. 8th Int. Cong. Speleol., Bowling Green Ky., July 1981:13-15.

"The Hudson Bay Lowland is an area of unconfined peatland underlain by Paleozoic strata. Silurian limestone outcrops 90 km west of James Bay along the Attawapiskat River. It is also found on either side of the river in the form of glacially-scoured biohermal reef knobs, within an otherwise continuous organic cover. Circumneutral to acid organic groundwaters are in contact with the limestone reefs and the peatland plain is consequently undergoing active karstification. Prominent sinkholes surround the reefs and are expanding at the expense of the peatland. Three distinct karst morphologies have evolved depending on the height of the reefs relative to the peat surface. The result is an extensive organo-karst complex.

Paralleling each bank of the river is a zone of fluvio-karst characterized by sinkholes and active ponors. Karren forms are poorly represented because of the local lithology but good examples of pit karren and rillen karren have been observed." - ABSTRACT

Keywords: Karst Geomorphology, Sinkholes, Karren, Organo-Karst, Biohermal Reefs, Peatland, Fluvio-Karst, Attawapiskat Formation.

Location: Ont. H.B.L. (Attawapiskat River)

51. COWELL, D.W. 1982. Karst hydrogeology within a subarctic peatland, Attawapiskat River, Hudson Bay Lowland, Ontario. Proc. V.T. Stringfield Symp. Karst Hyd., Atlanta, Ga. Nov. 1980, J. Hyd. May 1982.

"The Hudson Bay Lowland is a largely unconfined peatland underlain by predominately carbonate strata of the Paleozoic Hudson Platform. The Attawapiskat River has cut through 30 m of mid-Silurian bioclastic limestone centered approximately 90 km west of James Bay. Limestone cliffs of 12 to 15 m provide local relief along the river but inland the terrain is flat, covered by 1.5 m or more of peat. The area was deglaciated 8000 to 9000 years B.P. and emerged from the marine Tyrrell Sea approximately 4400 B.P. Since that time 2 karst hydrogeological zones have become established. These are a fluvio-karst zone in the exposed limestone paralleling the river and an organo-karst zone inland. They occupy approximately 16% and 13% of the study area, respectively. The remainder is peatland. The fluvio-karst is characterized by disappearing lakes and streams with sinkholes. The organo-karst is a complex of glaciated biohermal rock knobs surrounded by peatland. The contact between the organic mantle and limestone is marked by prominent sinkholes which drain the adjacent peatland. Three distinct karst morphologies have evolved depending on the height of the reef knolls relative to the peat surface. Karst drainage in the fluvio-karst zone is likely entirely vadose feeding springs at or in the Attawapiskat River. In the organo-karst zone sinkholes probably cause cones of depression within the groundwater tables which occurs in the peat material above the floor of the sinkholes."-ABSTRACT

Keywords: Karst Geomorphology, Sinkholes, Organo-Karst, Peatland, Attawapiskat Formation, Fluvio-Karst, Hydrogeology, Biohermal Reefs.

Location: Ont. H.B.L. (Attawapiskat River)

52. COWELL, D.W., J.K. JEGLUM and J.C. MERRIMAN. 1978. Preservation of seasonal frost in peatlands, Kinoje Lakes, southern Hudson Bay Lowland. Proc. 3rd Int. Conf. Perm. Edmonton, Alberta:453-459.

The results in this paper represent part of a helicopter-supported ecological survey of peatlands at the southern boundary of the discontinuous permafrost zone. The authors present detailed information of the occurrence of seasonal frost in a variety of wetland types (treed bog, open bog, swamp, treed fen, marsh and open fen). The data includes depth of peat, depth of frost and thickness of frozen peat, location of groundwater table and dominant species. Although a significant number of the total sites had frozen peat (19 of 52) all but one, an incipient or brown moss palsa, were seasonal, melting prior to the next winter. The palsa was slightly raised above the surrounding fen and had no living vegetation. It was covered by decaying brown moss (Scorpidium scorpioides) which provided sufficient insulation for permafrost to develop in this southern climate.

The authors also presented a transect of a black spruce island which indicated the island was a product of a rise in the mineral soil and not due to permafrost. They concluded that permafrost was not a casual factor for 'black spruce islands' in the Kinoje Lakes area and that both microtopography and permafrost may play a role in locating and generating islands further north (cf. Sjörs 1963). They also concluded that treed bogs and open bogs would be among the first sites of permafrost aggradation if the climate became cooler.

Keywords: Permafrost, Seasonal Ice, Vegetation,

Physiography, Peatlands, Peat, Palsas, Black Spruce Island.

Location: Ont. H.B.L. (Kinoje Lakes)

53. COWELL, D.W., G.M. WICKWARE and R.A. SIMS. 1979. Ecological Land Classification of the Hudson Bay Lowland Coastal Zone, Ontario. Proc. Can. Com. Ecol. Land Class., Ecol. Land Class. Ser. #7, Lands Directorate, Environment Canada: 165-176.

This paper outlines a hierarchical ecological land classification being conducted in the coastal zone of Ontario's Hudson Bay Lowland by the Federal Department of the Environment. The Coastal zone is defined as "that part of the Lowland which is characterized by a distinctive hydrologic, vegetative, and physiographic regime bordered on one side by waters of the Hudson and James Bays, and on the other by the mature peatland complex of the Hudson Bay Lowland". The study is described as ongoing but ground truthing and mapping have been completed for 4000 km^2 of the coastal zone from the Québec border to the Albany River.

Mapping is being carried out at three levels; Land Region (1:1,000,000), Land District (1:500,000) and Land System (1:100,000). Map polygons at the Land system level represent ecological units based on landform, hydrology and vegetation. Each system is annotated with symbols relating to minerals and organic landform types, texture and peat depth, water type and vegetation physiognomy.

The authors briefly summarize characteristics of Land Regions, Districts, and Systems and include tables comparing physiography, hydrology, and physiognomy (Land District level) and physiognomic type, characteristic vegetation and soil class (Land System level). They present some preliminary findings in terms of the distribution and composition of Land Systems; in particular how the systems (and component Land Types) vary with distance from the coast due to isostatic rebound.

Detailed site-specific information on landforms, water, soils and vegetation have been collectd by the authors at 154 sites during 1977 in the southern James Bay area. This data plus soil and water chemistry analyses will be reported on at a later date in the form of an ecological classification report. Soil data will be made available from the Lands Directorate, Canada Centre for Inland Waters, Box 5050, Burlington, Ontario, L7R 4A6.

Keywords: Ecological Classification, Pedology, Vegetation, Landform, Hydrology, Peatland, Raised Beach Ridges, Coastal Zone, Survey Methodolgy.

Location: Ont. H.B.L. (coastal zone - Southern James Bay)

54. COWELL, D.W., G.M. WICKWARE and R.A. SIMS. 1981-abstract only. The occurrence of permafrost in organic and mineral landforms in Ontario's Hudson Bay Lowland. Presented at Hudson/James Bay Symp., U. Guelph, Ontario. April 1981.

"The location of the southern boundary of continuous permafrost relative to the southwest coast of Hudson Bay varies according to different authors. Recent work in the Winisk and Cape Henrietta Maria areas of Ontario suggest permafrost may in fact be more discontinuous than previously thought.

"In the Winisk area, observations in near-coastal wetlands suggest only sporadic occurrence of ice at depths of 1-2 meters in organic and mineral soils. Permafrost was generally absent in beach ridges located within 6 km of the coast and brown moss palsas were the only organic permafrost landform in fen swales. Further inland, various permafrost features such as peat palsas and plateaus were commonly observed particularly in saturated fen complexes. These observations suggest slow development of permafrost over several hundred years following emergence of the landbase from beneath the waters of Hudson Bay. In the Cape Henrietta Maria area, although ice was encountered more frequently, it was still found discontinuously in the upper 1 meter of the soil profile.

"Permafrost landforms in organic soils occur throughout the Hudson Bay Lowland in the form of brown moss palsas, palsa bogs, lichen-heath palsas, polygon fens, peat plateaus, and stone palsas. Brown moss palsas have been observed as far south as the Harricanaw River south of James Bay. Polygon fen, palsa bogs, lichen-heath palsas and stone palsas are found mainly along Hudson Bay. Peat plateaus, often with circular collapsed cores ('Black Spruce Islands') are found throughout the Lowland north of the Kapiskau River. They are the most common permafrost landform in the central portion of the Lowland. Frozen mineral soils have been observed in some river levees and beach ridges south of Hudson Bay". - ABSTRAC

Keywords: Permafrost, Palsas, Peat Plateaus, Peatland, Raised Beach Ridges, Polygon Fen.

Location: Ont. H.B.L. (Moose River to Winisk)

55. CRAIG, B.G. 1969. Late Glacial and Postglacial History of the Hudson Bay Region. Geol. Surv. Can., Paper 68-53:63-77.

The author examines the available geomorphic evidence (primarily landforms surrounding the Region), altitudes of highest recorded marine features, early postglacial radiocarbon dates (i.e. nearest to marine limit) and other dates from within the Tyrrell Sea area in order to interpret the late glacial and early postglacial history of the Hudson Bay Region. He divides the region into 5 major zones based on the direction of glacial retreat and used radiocarbon dates from marine shells to describe the history of marine incursion into each zone.

The late glacial events include differential retreat in the 5 zones with major proglacial lakes in the southern James Bay and Churchill areas. Marine incursion began about 7900 years B.P. entering along east-central or eastern Hudson Bay from the Hudson Strait. The marine waters followed the ice front south, replacing the proglacial lake in the southern Hudson Bay Lowland, then northwest and north into Keewatin. Differences in the elevation of the marine limit in the Region (highest near Churchill, southern James Bay and east of Hudson Bay) are ascribed to differential uplift, presence of proglacial lakes and time of flooding. Graig provides an uplift curve, constructed using 6 radiocarbon dates from Mytilus edulis shells, representing uplift between 3000 and 1000 years B.P. for the Churchill area of 5 ft/100 years. He also presents lists of 24 radiocarbon dates from the region and shows the location of 17 marine shell localities studied in the Hudson Bay Lowland.

Keywords: Isostacy, Deglaciation, Marine Inundation, Raised Beach Ridges, Landforms, Radiocarbon Dates, Proglacial Lakes, Marine Shells.

Location: H.B.L., H.B.R.

56. CRAIG, B.G. and B.C. MCDONALD. 1967. Quarternary geology, Operation Winisk, Hudson Bay Lowland (32, 42, 43, 44, 53, 54). Geol. Surv. Can., Rept. Act. Paper 68-1A: 161-162.

This paper presents a short review of the results of the first major geological investigation, including Pleistocene stratigraphy, of the Hudson Bay Lowland ('Operation Winisk'). Essentially the authors confirm the presence of the interglacial Missinaibi beds throughout the Lowland with two till sequences above. In the southeast and northwest they found freshwater lacustrine sediments above the tills and overlain by marine Tyrrell Sea deposits. In the central part of the Lowland these lacustrine deposits were absent. They note that retreat of the ice was not synchroneous throughout the Lowland but probably retreated from the southeast portion first, permitting early inundation of this area by the Tyrrell Sea. More detailed accounts were later presented by Craig (1969) and McDonald (1969).

Keywords: Pleistocene Stratigraphy, Glacial Chronology, Marine Inundation, Interglacial Deposits, Missinaibi Beds, Till, Lacustrine Deposits, Tyrrell Sea.

Location: H.B.L.

57. CUMMING, L.M. 1969. Rivers of the Hudson Bay Lowland. Geol. Surv. Can., Paper 68-53:144-169.

This paper is the result of canoe and aerial surveys across much of the Lowland during the geological Survey of Canada's 'Operation Winisk' in 1967. The author reviews concepts of preglacial drainage in the Hudson Bay - north central North America area and discusses the factors controlling the present river courses. He discusses the drainage areas of the major river systems crossing the Lowland, some of their exploration history, incidences of probable river capture or deflections, and utilization for transportation and hydroelectric power. He briefly describes the characteristics, patterns and bed material (bedrock vs unconsolidated) of all the major trunk streams and many of their tributaries. Rivers described or referred to include the North and South Knife, Herriot Creek, Churchill, Nelson, Angling, Hayes, Gods, Kaskattama, Anabuska, Kettle, Niskibi, Swern, Sachige, Fawn, Winisk, Shammattawa, Asheweig, Washagami, Little Ekwan, Ekwan, Kinusheo, Attawapiskat, Muketei, Kapiskau, Atikameg, Albany, Kenogami, Little Current, Drowning, Kabinakagami, Squirrel, Kwataboahegan, Moose, Missinaibi, Mattaganni, Abitibi and Harricanaw.

The author notes that the major controls on channel pattern are the distribution of Paleozoic and Precambrian formations jointing (especially in upstream portions), and the preglacial history of the Lowland.

Keywords: River Morphology, Physiography, Drainage, River Pattern, Preglacial Drainage, Landscape Evolution.

Location: H.B.L.

58. CUMMING, L.M. 1971. Ordovician strata of the Hudson Bay Lowlands in Northern Manitoba. Geol. Assn. Can., Spec. Paper #9:189-197.

Keywords: Ordovician Strata, Paleozoic Geology, Paleontology.

Location: Man. H.B.L.

59. CUMMING, L.M. 1975. Ordovician strata of the Hudson Bay Lowlands. Geol. Surv. Can., Paper 74-28:92 p.

This report is based on field work in 1967 for 'Operation Winisk'. It summarizes the Ordovician stratigraphy and paleohistory of the Hudson Bay Lowland and describes many individual outcrops in detail. Cumming describes regional and outcrop lithology, depositional environment, lead-zinc mineralization, oil and gas possibilities, formational nomenclature and inter-regional correlations. He describes over 140 outcrops ('stations') and several bore holes from the Ordovician in the Lowland. In these descriptions he includes lithology, thickness of exposed sections and fossil lists. He also locates each station and provides maps of outcrop occurrence and extent of outcrop of the Ordovician strata. The report is well illustrated with maps, cross-sections and photographs and has a good bibliography.

Keywords: Ordovician Stratigraphy, Paleontology, Paleozoic Geology, Economic Geology, Ordovician Lithology, Formational Nomenclature.

Location: H.B.L.

60. DEAN, W.G. 1959. Physiography and vegetation of the Albany River map area, northern Ontario an aerial photograph reconnaissance. Unpub. Ph.D. Thesis, McGill University, Montréal: 391 p.

This thesis is based on aerial photo interpretations (1:60,000, B & W) of a large area, with a minimum of ground truth, similar to that conducted by Hare in

Labrador-Ungava. It covers the 1:500,000 Albany map sheet which extends from latitude 48° to 52° and longitude 80° to 88°. The greatest portion of the area is on the shield but about one third of the map sheet is in the Hudson Bay Lowland (in the Moose-Albany area).

Dean divided the map sheet into 5 physiographic regions; 2 of which were in the Lowland - 'Lowland Border Plains' and 'James Bay Coastal Plain'. These were in turn subdivided into 17 'Landform Units' based on interpreted and observed glacial and marine deposits and on peatland development. He also produced a vegetation and landform map for the Albany area at a scale of 1:500,000. Dean reviewed literature dealing with climate, vegetation, geology, geomorphology and early exploration and discusses aspects of vegetation, physiography, drainage and landscape evolution based on his interpretation. His discussions of drainage and muskeg development and physiography in the Lowland portion represents a great deal of original work and presents a number of interesting points. This work in fact can be considered a rare study in wetland geomorphology which unfortunately has not been expanded upon. Certain of his points can be questioned, such as his ideas regarding flowage of muskeg, but overall it is a valuable study which should serve to stimulate interest in wetland patterns and how they relate to drainage and underlying landforms. His physiographic map is the only map that shows the distribibition of mineral soils (mainly beach ridges) for a large portion of the Lowland.

Keywords: Physiography, Landscape Evolution, Raised Beach Ridges, Marine Inundation, Peatland, Drainage, Deglaciation, Surficial Geology, Vegetation, Wetland Geomorphology, Muskeg, Landforms.

Location: Ont. H.B.L. (Moose and Albany River Basins).

61. DIONNE, J.C. 1972. La demonination des mers du postglaciaire au Québec. Cahiérs Géog. Québec 16:483-487.

Dionne briefly discusses the major postglacial seas of

Québec including the Champlain, Laflamme, Iberville, Goldthwait and Tyrrell seas in terms of their dates of occurrence, naming and location. He separates the Tyrrell Sea episode into 2 phases on the basis of rate of isostatic recovery. The first phase he termed the lower Tyrrell ("Tyrrellien inferieur") which lasted from 7000 to 3000 years B.P. representing the time of highest uplift rates. The upper Tyrrell ("Tyrellien superieur") began 3000 years ago and continues to the present.

Keywords: Marine Inundation, Tyrrell Sea.

Location: H.B.R.

62. DOHLER, G.C. 1968. Tides and tidal currents in Hudson Bay. Env. Can., Inland Waters Br., Reprint Ser. 105:11-19.

"This paper discusses the rhythm of the tides in varying degree along the entire shoreline of Hudson Bay and in every one of its harbours. Tables and maps are provided indicating tidal pattern for Churchill and Port Harrison, the occurrence of high water, tidal differences and variations in mean water level of the bay." - WATDOC

Keywords: Tides, Tidal Range, Coastal Processes.

Location: Man. H.B.L., H.B.R.

63. DOLE, R.B. and H. STABLER. 1909. Papers on the conservation of water resources. U.S. Geol. Surv., Water Supply Paper 234: Hudson Bay area p. 78-93.

This paper provides an estimated erosion rate for rivers of the Hudson Bay Lowland (28 tons/yr/mile). The accuracy of this estimate is unknown as no further research in quantitative fluvial geomorphology (other than flow rates) has been carried out in the lowlands.

Keywords: Fluvial Erosion.

Location: H.B.L.

64. DOWLING, D.B. 1904. Report on exploration of Ekwan River, Sutton Mill Lakes and part of the west coast of James Bay. Geol. Surv. Can., Ann Rept. 14 pt. F:11-60.

This report is based on a survey carried out in 1901 (see Dowling 1912).

Keywords: Physiograpchy, Coastal Morphology, Marine Inundation.

Location: Ont. H.B.L. (James Bay Coast).

65. DOWLING, D.B. 1905. The west side of James Bay, Canada. Geol. Surv. Can., Ann. Rept. 14 pt. A:107-115.

This report is based on a survey carried out in 1901 (see Dowling 1912).

Keywords: Physiography, Precambrian Geology, Paleozoic Geology and Paleontology, Surficial Geology, Inliers, Quaternary Paleontology and Paleohistory.

Location: Ont. H.B.L. (Ekwan River, Sutton Ridges).

66. DOWLING, D.B. 1912. Report on a survey of the Ekwan River and a route through Sutton Mill Lakes northward. Ont. Bur. Mines 21 (2):139-169.

This is a fairly comprehensive report describing the geology, physiography, timber, fossils and wildlife of the James Bay coast from the Moose River to Cape Henrietta Maria, the Ekwan River and the Sutton-Hawley lakes area of the Lowland. It is based on a survey carried out in 1901 which was also described in earlier reports (Dowling 1904 and 1905). It is an interesting account in which the author attempts to reconstruct some of the glacial and post-glacial events in the area, especially with respect to the development of the local drainage in relation to isostatic rebound and the retreat of the Tyrrell Sea. Most of the discussion and description concerns geological outcrops, fossils and till deposits along the Ekwan River and in the Sutton Ridge area. Dowling examines the ironstones outcropping above Sutton Lake and provides the results of analyses of 3 samples. In addition, he describes the tides on James Bay and reports on soundings he made in Sutton and Hawley lakes. There is also an appendix listing the Silurian fossils collected, as identified by J.F. Whiteaves.

Keywords: Physiography, Precambrian Geology, Paleozoic Geology and Paleontology, Surficial Geology, Quaternary Paleontology and Paleohistory, Inliers, Economic Geology, Coastal Morphology, Marine Inundation.

Location: Ont. H.B.L. (Ekwan River, Sutton Ridges and James Bay Coast)

67. DYER, W.S. 1928. The Mesozoic clay deposits of the Mattagami and Missinaibi rivers, northern Ontario. Bull. Can. Inst. Mining Met. 196:989-1001.

Keywords: Economic Geology, Mesozoic Stratigraphy, Mattagami Formation, Lignite.

Location: Ont. H.B.L. (Moose River area)

68. DYER, W.S. 1930a. Limestones of the Moose River and Albany River Basins. Ont. Dept. Mines, Ann. Rept. 38 (1929) pt. 4:31-33.

Dyer briefly discusses the economic potential of the limestones of the Moose River basin and gives 16 chemical analyses (as $CaCO_3$ and $MgCO_3$).

Keywords: Economic Geology, Paleozoic Stratigraphy, Limestone, Chemical Composition.

Location: Ont. H.B.L. (Moose and Albany rivers)

69. DYER, W.S. 1930b. Paleozoic geology of the Albany river and certain of its tributaries. Ont. Dept. Mines, Ann. Rept.38 (1929) pt. 4:47-60.

Dyer presents a general description of the area then concentrates on the stratigraphy and paleontology. He defines three Paleozoic formations based on river outcrops and briefly discusses the economic possibilities in this area. He also presents a sketch map showing the location and type of outcrops studied. This is one of the first detailed accounts and attempts at mapping the stratigraphy of any part of the Lowland.

Keywords: Paleozoic Stratigraphy, Paleontology, Physiography, Economic Geology, Limestone.

Location: Ont. H.B.L. (Albany River).

70. DYER, W.S. 1931. Stratigraphy and structural geology of the Moose River Basin, northern Ontario. Trans. Roy. Soc. Can., Ser. 3 sec. IV vol. 25:85-99.

Keywords: Stratigraphy, Paleozoic Geology, Structural Geology.

Location: Ont. H.B.L. (Moose to Albany rivers area)

71. DYER, W.S. 1932. Stratigraphy and oil and gas possibilities of Moose River Basin. in Oil and Gas of Eastern Canada. G.S. Hume (ed.). Geol. Surv. Can. Econ. Ser. No. 9:89-103.

Keywords: Stratigraphy, Economic Geology.

Location: Ont. H.B.L. (Moose River Basin).

72. DYER, W.S. and R.J. MONTGOMERY. 1930. Semi-commercial tests on northern Ontario fire clays. Ont. Dept. Mines, Ann. Rept. 38 (1929) pt. 4:19-21.

Fire clays (of the Cretaceous Mattagami Formation) sampled along the Mattagami River, 7 miles below Long Portage, were tested by 5 firms to determine the refractory properties of the clays. Results indicated excellent refractory properties. The clays were tested in the manufacture of bricks, pottery, sanitary porcelain, baking dishes, fire brick, locomotive tile and flue linings.

Keywords: Economic Geology, Mesozoic Clays, Mattagami Formation, Refractory Properties.

Location: Ont. H.B.L. (Mattagami River).

73. DYER, W.S. and A.R. CROZIER. 1933. Lignite and refractory clay deposits of the Onakawana Lignite field. Ont. Dept. Mines, Ann. Rept. 42 pt. 3:46-78.

This is primarily a report on the quality and extent of Mesozoic lignites and clays in the Onakawana field. Included are maps of the surface elevation of the lignite deposits. The overlying Quaternary deposits were found to vary between 30 to 300 ft. in thickness.

Keywords: Mesozoci Lithology, Economic Geology,r Surficial Geology, Onakawana, Lignite, Mattagami Formation.

Location: Ont. H.B.L. (Moose River Basin)

74. EHRLICH, W.A., L.E. PRATT, J.A. BARR and F.P. LECLAIRE. 1959. Soil survey of a cross-section through the Upper Nelson River Basin along the Hudson Bay Railway in northern Manitoba. Man. Soil Surv., Soils Rept. 10:48 p.

This is a fairly detailed report on the pedology of the lacustrine clays along the Hudson Bay Railway, as identified by Johnston (1917). The area of the survey is entirely outside of the Hudson Bay Lowland (maps and tables).

Keywords: Physiography, Soils, Glaciolacustrine Clays.

Location: Northern Manitoba.

75. ELSON, J.A. 1969. Late Quarternary marine submergence of Québec. Rev. Geog., Montreal 23(3):247-258.

Briefly reviews information on the Tyrrell Sea in Québec including date of inundation (7000 to 8000 yrs B.P.) marine limits (450 to 850 ft.), deposits, rate of uplift and eustacy. Elson shows a graph of uplift and suggests an uplift rate of up to 9 m/100 yrs between 7000 and 8000 yrs ago and 30 to 90 cm/100 yrs during the last 3000 years. These figures were approximated from interpretations of Lee (1960).

Keywords: Tyrrell Sea, Marine Inundation, Isostacy, Eustacy.

Location: Qué. H.B.L., H.B.R. (eastern Hudson Bay)

76. FAIRBRIDGE, R.W. and CLAUDE HILLAIRE-MARCEL. 1977. An 8000-yr paleoclimatic record of the 'Double-Hole' 45-yr solar cycle. Nature 268:413-416.

Based on raised beach ridge surveys in northern Québec, outside the Lowland.

Keywords: Isostacy, Marine Inundation, Raised Beach Ridges, Radiocarbon Dates, Beach Ridge Formation, Paleoclimate, Solar Cycles.

Location: H.B.R. (eastern Hudson Bay)

77. FALCONER, G., J.T. ANDREWS and J.D. IVES. 1965a. Late-Wisconsin end moraines in northern Canada. Sci. 147:608-610.

Field investigations, aerial photo interpretations and literature studies indicate a major system of end moraines encircling Hudson Bay - Labrador. The authors plotted these (up to 2240 km of moraines) on a small-scale map of northeastern North America and propose them to represent the Late Wisconsin ice margin centered over Foxe Basin and Hudson Bay between 8000 and 9500 years ago. This would equate the Cockburn moraines of Baffin Island with the Cochrane moraine of northern Ontario and moraines of Keewatin, Melville Peninsula and Labrador-Ungava. The last two, plus portions of those on Baffin Island, are not shown on the Glacial Map of Canada. The age of the system is based on 5 dates on shells and other material deposited in association with, or after the deposition of the moraine.

Keywords: Surficial Geology, Deglaciation, Radiocarbon Dates, End Moraines, Cochrane Readvance.

Location: H.B.R.

78. FALCONER, G., J.D. IVES, O.H. LOKEN and J.T. ANDREWS. 1965b. Major end

moraines in Eastern and Central Arctic, Canada. Geog. Bull. 7(2):137-153.

This is similar to Falconer et al. 1965a but provides more detail. The authors propose the name 'Cockburn Moraine System' to encompass all the moraines correlative with the late Winconsin ice front 8000 to 9000 years ago. These include the Cochrane, Sandy Lake - Albany River (Agutua), Lake Athabaska - Cree Lake, McAlpine, Melville Peninsula and Cockburn (eastern Baffin Island) moraines. They also propose the term 'Cockburn Phase' to describe the readvance phase of the ice front at this time.

Keywords: Pleistocene Chronology, Deglaciation, Surficial Geology, End Moraines, Cochrane Readvance' Radiocarbon Dates.

Location: H.B.R.

79. FLINT, R.F. 1943. Growth of the North American ice sheet during the Wisconsin Age. Geol. Soc. Am. Bull. 54:325-362.

This is a landmark paper describing the origin and behaviour of the Laurentide ice sheet in northeastern North America. Of particular significance to the Hudson Bay Lowland is Flint's assertion that the Laurentide Glacier originated soley in Québec-Labrador. He relegated the Keewatin and Patrician glaciers as "of local and temporal importance" only, having developed late in Wisconsin. He reached these conclusions after examining the evidence of the early geological explorers, including Tyrrell, Bell and Low; based on contemporary paleoclimatic theories; and by making comparisons with the Scandinavian ice sheet.

Keywords: Glaciation, Laurentide Ice Sheet, Deglaciation, Patrician Glacier.

Loation: Northeastern North America, H.B.R.

80. FLINT, R.F. 1947. <u>Glacial Geology and Pleistocene Epoch</u>. John Wiley and Sons, N.Y.

Keywords: Quaternary Geology, Pleistocene Chronology, Radiocarbon Dates.

Location: H.B.R.

81. FLINT, R.F. 1956. New radiocarbon dates and late Pleistocene stratigraphy. Am. J. Sci. 254(5):265-287.

The author discusses the late glacial chronology of central and eastern North America including the Hudson Bay Region. The discussion is based on over 80 radiocarbon dates of which 3 are from the southern portion of the Lowland in Ontario and one from a bog south of Cochrane. He notes that the Cochrane readvance is not well enough established to assign it as a stratigraphic stage or substage. He does not indicate an age for this advance but it would fall between 6730 years B.P. and 10,700 B.P. (Valders maximum) which is younger than Antevs' date (Antevs 1953). Flint also briefly discusses the deglaciation of Hudson Bay and is one of the first authors to indicate that the ice in Hudson Bay may have been floated and cut-off from the accumulation area in Labrador over a very short time period. The radiocarbon date on shells taken from the Opasatika River in the southern Lowland was 17,000 years which was noted as being far too old to date the marine incursion later termed the Tyrrell Sea. This sample was probably a mixture of interstadial-interglacial and modern or Tyrrell Sea shells (W.W. Shilts - personal communciations).

Keywords: Radiocarbon Dates, Pleistocene Chronology, Deglaciation, Cochrane Readvance, Marine Inundation.

Location: Ont. H.B.L. (southern), H.B.R.

82. FLOWER, R.H. 1968. Silurian Cephalopods of James Bay Lowland, with a revision of the family Narthecoceratidae. Geol. Surv. Can., Bull. 164:88 p. plus 34 plates.

This report is a listing of systematic descriptions of cephalopods collected by various geologists of the Geological Survey and the Québec Department of Natural Resources. It includes photos of most of the specimens.

Keywords: Silurian Paleontology.

Location: Qué. H.B.L., Ont. H.B.L.

83. FYLES, J.G. 1955. Pleistocene Features in Geological Notes on Central District of Keewatin, N.W.T. G.M. Wright. Geol. Surv. Can., Paper 55-17:3-4.

This is a short description of glacial straie, drumlins, abandoned shorelines, eskers and drumlinoid ridges west of Hudson Bay. He identified proglacial lake beaches and the outline of the marine limit in this area at 480 - 500 ft a.s.l.

Keywords: Glacial Landforms, Marine Inundation.

Location: Keewatin (west coast of Hudson Bay)

84. GILMORE, R.E. 1929. Lignite coal from Blacksmith Rapids, Abitibi River. Ont. Dept. Mines, Ann. Rept. 38 Pt. IV:34-40.

Keywords: Mesozoic Geology, Lignite, Economic Geology.

Location: Ont. H.B.L. (Abitibi River)

85. GLOOSCHENKO, W.A. and I.P. MARTINI. 1978. Hudson Bay Lowland baseline study. Proc. Symp. Tech. Envir. Socioecon. and Regulatory Aspects Coastal Zone Manag. Am. Soc. Civ. Eng., San Francisco, California:663-679.

This paper outlines an environmental study being carried out in the coastal zone of the Ontario portion of the Hudson Bay Lowland. Process studies in sedimentology, geochemistry, pedology, vegetation ecology and wildlife ecology are being conducted over the 1130 km of tidal flats in Hudson Bay and James Bay by the Canada Department of the Environment and by the Department of Land Resource science at the University of Guelph (Ontario). The study objective is to establish baseline values of the natural environment.

The authors discuss aspects of geology and geomorphology, sediments, soils, climate, vegetation, wildlife and socioeconomics of the Lowland's coastal zone. They also discuss some preliminary findings with respect to morphology, coastal processes and salt marsh ecology at North Point on James Bay. The paper does not provide much detail but serves to introduce some of the major sedimentological and ecological characteristics and processes of the environment.

Keywords: Salt Marsh, Ecology, Soils, Vegetation, Coastal Sedimentology, Coastal Geomorphology, Wildlife, Socioeconomics, Baseline Studies.

Location: Ont. H.B.L. (southern James Bay coastal zone)

86. GRANT, A.C. 1969. Some aspects of the bedrock geology of Hudson Bay as interpreted from continuous seismic reflection profiles. Geol. Surv. Can., Paper 68-53:136-143.

The structure of the Paleozoic bedrock beneath Hudson Bay is revealed in a series of seismic transects radiating outward from the centre of the bay.

Keywords: Geophysics, Paleozoic Geology.

Location: H.B.R.

87. GUILLET, G.R. 1964. Gypsum in Ontario. Ont. Dept. Mines, Ind. Min. Rept. 18:59-62.

The author describes the area known as Gypsum Mountain and discusses the natural karst features of the outcrop quoting from the earlier report by J.M. Bell (1904). He notes the location of Gypsum Mountain and refers to karst topography in the surrounding muskeg as well. He also describes the gypsum and provides 2 chemical analyses.

Keywords: Paleozoic Lithology, Gypsum Karst, Muskeg, Economic Geology, Chemical Composition, Gypsum.

Location: Ont. H.B.L. (French - Abitibi rivers)

88. GUILLET, G.R. 1979. Fossil Fuel Program, Moose River Basin drilling project, District of Cochrane. Ont. Geol. Surv., Open File Rept. 5276:121 p. with tables and photos.

The report discusses the logistics and preliminary results of the drilling program directed by the Ontario Geological Survey in the southern portion of the Moose River Basin (see Telford and Verma 1978). The report includes complete drill logs and discusses the general geology of the basin, stratigraphic analysis and correlation of the Quaternary, Mesozoic and Paleozoic strata, preliminary laboratory testing results and economic geology of the lignite, kaolin, silica sand and refractory clay deposits. Eight holes were drilled an average of 8 to 14 km apart. All penetrated to the base of the Mesozoic and 3 penetrated the Paleozoic strata.

The drilling results confirmed the presence of depositional phases in the Mattagami Formation and discovered previously unrecorded lignite seams up to 6 m in thickness. The emphasis in the report is placed on describing the stratigraphy and sedimentation and attempts at correlating within the Mattagami Formation across the basin as well as determining the economic potential of the mineral resource.

Keywords: Mesozoic Stratigraphy, Mesozoic Lithology, Economic Geology, Paleozoic Geology, Surficial Geology, Lignite, Kaolin, Silica Sand, Clay, Bore Holes, Mattagami Formation.

Location: Ont. H.B.L. (Moose River Basin, Missinaibi to Abitibi rivers)

89. GUIMONT, P. and C. LAVERDIERE. 1976a. Le littoral du sud-est de la Baie de James et de l'estuaire de l'Eastmain: le milieu physique. Soc. Devel. Baie James:133 p.

This is a report of a two week ground survey and air photo study of th Québec coast of James Bay from the Ontario - Québec border to Nouveau - Comptoir, north of Eastmain. The report offers a brief review of what is known on the geology and geomorphology of the coast, and describes several features of the coast and of the estuary of the Eastmain River. A preliminary classification of the coast is offered. Some of the interpretations of coastal features are not very well supported and further study is required (see below).

Keywords: Coastal Morphology, Coastal Zone, Landforms. Coastal Classification, Estuary, Aerial Photo Interpretation.

Location: Qué. H.B.L., Northern Québec (east coast of James Bay).

90. GUIMONT, P. and C. LAVERDIERE. 1976b. Le types de côtes du sud-est de la Baie de James. Proc. James Bay Env. Symp. 1976, Env. Can. Soc. Dével. Baie James and Doc. D'Energie Baie James:175-201.

"The south-eastern littorals of James Bay presents a morphology, as shown in its tracing, closely related to the last ice age, and to the former presence of the Tyrrell Sea; James Bay is but the reduced pattern of that sea.

"Annual moraine coasts: From Québec-Ontario border to Rupert Bay, a coast of large crests or spurs is formed from a series of annual moraines perpendicular to the shore and to the direction of the glacial retreat. The strong glacial erosion has moved the blocks of the shores, formed of rough pavements.

"Estuary coast and Rupert Bay coast: The size of Rupert Bay justified treating it as a specific entity. Attached to argillaceous and extremely flat inland, it is an estuary coast with vast littorals where sea-water penetrates into large mud flats; these vast accumulation areas extend inland and become salt meadows. Countless erratic blocks, that came from the North-West by means of glacier ice, cling to the foreland punctuating the foreshores of the east coast. It is only at the estuary of rivers running into the bay that some type of littoral erosion can be observed.

"Coast with large bays: The bays, from the mouth of the Rupert Bay to Vieux-Comptoir, are formed of large re-entrants widely opened to the sea, subtended in arcs between numerous headlands that become, offshore, numerous islands. The head of the bays are generally occupied by mud flats and sometimes by sandy foreshores where glacial erosion has left erratic blocks and hollow cavities in salt meadows.

"Coast formed of scattered headland and re-entrants: Beyond Vieuz-Comptoir, the coast becomes higher and more complex. That type of coast is formed of numerous headlands and re-entrants close to one another. With its islands and peninsulas prolonging the headlands into the sea, the littoral presents a crumbling aspect. There are as many rocky and morainic headlands as low flat areas sometimes submerged by the sea. Such a morphology characterizes a coastal youth still strongly related to the last ice age." - ABSTRACT

This paper is taken from a longer report by the same authors (1976a). Although no methodology or background is reported in this paper the descriptions are interesting and useful. The Lowland coast includes the

authors' "annual moraine coast" and "estuary coast and Rupert Bay coast". The other two coastal types occur north of the Lowland on the east side of James Bay. In addition to describing the coasts, they discuss the macro-coastal processes in terms of dominant winds, currents and sediments and the role played by the morphology of the emerging land base (see above).

Keywords: Coastal Morphology, Coastal Zone, Landforms, Coastal Classification, Estuary, Aerial Photo Interpretation.

Location: Qué. H.B.L., Northern Québec (east coast of James Bay)

91. GUSSOW, W.C. 1953a. Silurian Reefs of James Bay Lowland, Ontario. Bull. Am. Assoc. Petrol. Geol. 37(10):2422-24.

This short paper is based on the early descriptions of R. Bell of the limestone reefs along the Attawapiskat River near the mouth of the river. Bell had not recognized these as reefs. Gussow reviews these features because of their possible relationship to the presence of hydrocarbons. He also mentions similar outcrops on the Severn River.

Keywords: Economic Geology, Silurian Lithology, Biohermal Reefs, Limestone, Hydrocarbon.

Location: Ont. H.B.L. (Atawapiskat River)

92. GUSSOW, W.C. 1953b. Southern part of James Bay Lowland, Ontario. Bull. Am. Assoc.

Petrol. Geol. 37(10):2425-26.

A short note indicating an interest by Shell Oil in oil exploration of the James Bay Lowland and a mapping and drilling program supervised by Gussow and N.W. Martison.

Keywords: Economic Geology, Drilling, Hydrocarbons.

Location: Ont. H.B.L. (Moose River Basin)

93. GUTENBERG, B. 1941. Changes in sea level, postglacial uplift, and mobility of the earth's interior. Bull. Geol. Soc. Am. 52:721-772.

Gutenberg uses data from tide gauges and gauges on the Great Lakes up to 1938 to examine eustacy and isostacy in Fennoscandia and North America. Most of his discussion of North America deals with changes in Great Lakes levels based on gauge data between 1965 and 1939. He uses these data to discuss postglacial uplift in the Great Lakes Region. He notes that all uplift curves have their centre in the Hudson Bay region and then examines recently acquired tide gauge data from Churchill Manitoba, for the period 1928-1939 (excluding winters). This limited data suggests uplift in the area to be currently between 1 and 3 m/100 years, closer to 2 m/100 years. Gutenberg briefly reviews the controversy between Bell (1896) and Tyrrell (1896) as to whether or not the land is currently rising and notes that Tyrrell's evidence against a 7 ft/100 year uplift would probably allow a 2 or 3 ft/100 year uplift, however, he doesn't resolve this with his estimate of 2 m/100 years and instead dismisses Tyrrell's evidence. The reliability of such a short, discontinuous tide gauge record is not sufficiently questioned by the author. Also the data is questionable because the gauge was located in the mouth of the Churchill River behind a constriction.

Keywords: Isostacy, Geophysics, Tide Gauge Records, Eustacy.

Location: Man. H.B.L. (Churchill), H.B.R., Northeastern North America

94. GUTENBERG, B. 1954. Postglacial uplift in the Great Lakes region. Arch. Meteorol. Geophys. Bioklimatol. Ser. A, B and 7:243-251.

This is an update of the author's 1941 paper using more recent tide gauge data. He discusses the Great Lakes region, Fennoscandia and the Hudson Bay Region noting a lack of acceptance of the postglacial uplift theory for North America. He blames this on misinterpretation of the data including Tyrrell's (1896) estimate of the height of sea ice in Churchill Harbour relative to the height at which names were carved in rock above the ice in the mid-1700's. Gutenberg's final conclusion is "that the data reported by Tyrrell and Johnston and others indicate a moderate uplift, as it is to be expected at a point rather far from the probable centre of former glaciation".

His re-evaluation of the tide gauge data from Churchill (1929 to 1951) for only July, August and September indicate average uplift of 1.05 + 0.18 m/100 yrs. However, the problem of early data based on gauges located in the harbour is still present.

Keywords: Isostacy, Tide Gauge Records

Location: Man. H.B.L. (Churchill), H.B.R., Northeastern North America

95. HAMBLIN, A.P. 1979. Petrography of Mesozoic and Pleistocene sands in the Moose River Basin. in Mesozoic geology and mineral potential of the Moose River Basin, District of Cochrane. P.G. Telford and H.M. Verma (editors). Ont. Geol. Surv., Open File Rept.:94-153.

This paper report on in-depth petrographic studies of sands from drill holes in the Moose River Basin. Properties of colour, sorting, roundness, sphericity, purity, grain size, organic and carbonate content, granule lithology, calcite- dolomite ratios and heavy mineral assemblages are examined in order to separate sedimentary units. The author includes descriptive summaries of the drill hole sediments, heavy mineral analyses and carbonate analyses and is able to distinguish four main sedimentary units; 2 Pleistocene and 2 Mesozoic. The Pleistocene units represent a glacial and interglacial stage and the distinction of the Mesozoic is between the Jurassic Mistuskwia Beds (see Telford et al. 1975). and the Cretaceous Mattagami Formation.

Keywords: Mesozoic Lithology, Pleistocene Lithology, Petrography, Sand, Drill Holes, Mattagami Formation

Location: Ont. H.B.L. (Moose River Basin)

96. HANSON, H.C. and R.H. SMITH. 1950. Canada Geese of the Mississippi Flyway with special reference to an Illinois flock. Bull. Ill Nat. Hist. Surv. 25(3):67-210.

This report emphasizes the characteristics, ranges, behaviour, productivity and so on of the Canada Geese populations which breed in the Hudson - James Bay area, especially within the Lowland. In describing the nesting habitats of the geese, the authors present the first regional overview of much of the Lowland with respect to the physical character of its peatland (muskeg). Hanson and Smith identify 5 muskeg types based on appearance and on the presence or absence of trees, lakes or streams. These are well timbered Muskeg, Open Muskeg, Lake-Land Muskeg, Pothole Muskeg (Small Lake muskeg of Coombs 1954) and "Smallpox" Muskeg (Muskeg zone of Coombs 1954). The authors outline the distribution of these types by noting their occurrence between major rivers as observed on a series of flights between Moosonee and York Factory.

Keywords: Physiography, Peatland, Muskeg, Canada Geese.

Location: Ont. H.B.L. and Man. H.B.L. (Moose River to Nelson River)

97. HAWLEY, J.E. 1926. Geology and economic possibilities of Sutton Lake area, District of Patricia. Ont. Dept. Mines, Ann. Rept. 34 Pt. 7:56 p.

Keywords: Precambrian Geology, Economic Geology, Physiography.

Location: Ont. H.B.L. (Sutton - Hawley lakes)

98. HAWORTH, S.E., D.W. COWELL and R.A. SIMS. 1978. Bibliography of published and unpublished literature on the Hudson Bay Lowland. Can. For. Serv. Sault Ste. Marie, Ont., Inf. Rept. 0-X-273:270 p.

Approximately 1900 titles, representing the majority of sociological and scientific information reported on the Hudson Bay Lowland, are listed under 19 subject categories.

Keywords: Bibliography

Location: H.B.L.

99. HERRICK, R. 1977. Natural theme analysis of Natural Region 27 - the Hudson - James Bay lowlands. Contract #77-4, Parks Canada, Ottawa:156 p.

This report describes the geology, physiography, drainage, climate, vegetation and wildlife of "Natural Region 27" which is predominantly defined by the Hudson Bay Lowland. This is one of 39 Terrestrial regions in Canada (9 marine) defined by Parks Canada to assess and identify "Natural Areas of Canadian Significance" for preservation. The author has assimilated a great deal of information on the region including published and unpublished reports, personal communication with scientists and laymen familiar with the area and from a series of overflights across much of the Lowland.

The report is essentially and inventory and this is reflected in the writing. There is little or no integration between topics or "themes", or even in some cases within topics, and other than photographs there is not much evidence of input based on the author's flights. Following a listing of all landforms, flora, fauna and cultural and climatic theme representation known to occur in the Lowland, the author recommends the area along the Attawapiskat River, including Akimiski Island in James Bay, as a Natural Area of Canadian significance.

The description of the bedrock geology, glacial features, deglaciation, rivers and lakes, physiography and landforms are, for the most part, fairly general and brief. They provide a useful synopsis of the features and character of the Lowland and the author indicates a few areas where more information is needed. The physiographic descriptions for the Lowland are summarized from Coombs (1954).

Keywords: Physiography, Drainage, Beach Ridges, Paleozoic and Precambrian Geology, Tidal Flats and Raised Beach Ridges, Coastal Morphology, Peatland, Muskeg, Vegetation, Wildlife.

Location: H.B.L.

100. HOBSON, G.D. 1969. Seismic refraction results from the Hudson Bay Region. Geol. Surv. Can., Paper 68-53:227-246.

This paper presents an analysis of both onshore (Hudson

Bay Lowland in Ontario and Manitoba) and offshore seismic profiles indicating the structure and thickness of Paleozoic strata in the Hudson Platform.

Keywords: Geophysics, Paleozoic Geology, Seismic.

Location: Ont. H.B.L., Man. H.B.L., H.B.R.

101. HODGKINSON, J. 1969. Reconnaissance seismic and magnetometer surveys in Hudson Bay, Canada. Geol. Surv. Can., Paper 68-53:247-269.

Keywords: Geophysics, Paleozoic Geology.

Location: H.B.R.

102. HOGG, N., J. SATTERLY and A.E. WILSON. 1953. Drilling in the James Bay Lowland: Part I - Drilling by the Ontario Department of Mines. Ont. Dept. Mines, Ann. Rept. 61 Pt. 6:115-140.

This is a report on drilling operations carried out by the Ontario Department of Mines in association with the geological mapping program supervised by N.W. Martison (1953 - same report).

Three drill holes were drilled through the Quaternary and Paleozoic sediments to the Precambrian basement in the southern James Bay Lowland (Campbell Lake, Jaab Lake and Puskwuche Point). The authors describe the logistics and provide detailed well logs indicating depth, lithology and paleontology. The well depths ranged from 1129 feet to 1810 feet of which Quaternary deposits varied from 18 feet (Puskwuche Pt.) through 147 feet (Jaab Lakes, to an unexpected 700 feet (Campbell Lake). The report includes well logs.

Keywords: Quaternary Stratigraphy and Lithology, Surficial Geology, Paleozoic Stratigraphy and

Lithology, Paleontology, Economic Geology, Drill Holes.

Location: Ont. H.B.L. (Moose River Basin)

103. HOOD, P.J. (editor). 1969. Earth Science Symposium on Hudson Bay. Geol. Surv. Can., Paper 68-53:386 p.

This is a special publication by the Geological Survey of a Symposium on Hudson Bay held in 1968 in Ottawa. It summarizes much of what is known about the geology, glacial and postglacial history, oceanography and crustal geophysics of Hudson Bay and surrounding regions. The Lowland is well represented in this volume. Information on the geology and glacial history of the Lowland can be considered up to date as very little field work has been carried out since it was published.

Keywords: Paleozoic and Quaternary Stratigraphy, Paleontology, Pleistocene Chronology, Isostacy, Geophysics, Economic Geology, Precambrian Geology Paleozoic Geology, Surficial Geology, Mesozoic Geology.

Location: H.B.R.

104. HOOD, P., M. BOWER and E.A. GODBY. 1969. Magnetic surveys in Hudson Bay. Geol. Surv. Can., Paper 68-53:272-291.

This is a report aeromagnetic surveys carried out in the Hudson Bay Basin (including part of the Lowland) during 1965 The authors discuss the thickness of sedimentary rocks and the possibility of finding oil in these strata.

Keywords: Geophysics, Economic Geology, Paleozoic Geology.

Location. H.B.R.

105. HUGHES, O.L. 1961. Preliminary report on borings though Pleistocene desposits, Cochrane District, Ontario. Geol. Surv. Can., Paper 61-16:5 p.

The borings were made south of the Lowland in Ontario but are significant because 2 of the 3 bore holes described include deposits recognized as Cochrane sediments. These are divided into 2 units, a lower silty clay till and upper varved silt and clay.

Keywords: Surficial Geology, Deglaciation, Cochrane Readvance, Till, Varves.

Location: Northern Ontario, H.B.R. (southern)

106. HUGHES, O.L. 1965. Surficial geology of part of the Cochrane District, Ontario, Canada. in International studies on the Quaternary. H.E. Wright, Jr. and D.G. Frey (editors). Geol. Soc. Am., Special Paper 84:535-565.

Keywords: Surficial Geology, Cochrane Readvance, Deglaciation, Till, Moraine, Varves.

Location: Northern Ontario, H.B.R. (southern)

107. HUNTER, G. 1970. Postglacial uplift at Fort Albany, James Bay. Can. J. Earth Sci. 7(2):547-548.

This is a short note which supports the rate of uplift determined by Webber et al. (1970) at Cape Henrietta Maria (1.2 m/100 yrs). Hunter obtained an estimate of uplift at Fort Albany of .9 to 1.2 m/100 yrs based on historical records and surveys dating to the late 1700's.

Keywords: Isostacy, Historical.

Location: Ont. H.B.L. (Fort Albany)

108. HUSTICH, I. 1957. On the phytogeography of the subarctic Hudson Bay Lowland. Helsingfors-Helsinki, Acta Geogr. 16(1):1-48.

Hustich made several flights over the Ontario portion of the Lowland during the summer of 1956. These included stops at Moosonee, Mammamattawa (Albany River) and Fort Severn. This paper deals primarily with the vegetation and tree species distribution in the Lowland but includes a description of bog types and an overview of the physiography based on the literature and his own observations. He also provides estimates on the rate of peat accumulation (1.3 mm/year at Severn 0.8 to 1.3 mm/year near the Moose River) and briefly discusses 'palsa bogs', which he considers to "mark the area with real permafrost", and 'black spruce islands'. He did not acually study these features on the ground but theorized the latter may have developed by black spruce colonization of earlier palsas which had "dried out". Sjörs (1963 - see below) discusses these islands in more detail based on actual field investigations. The paper is well illustrtated with photographs and maps, including tree species distribution maps.

Keywords: Vegetation, Peatland, Muskeg, Permafrost, Physiography, Black Spruce Islands, Palsas.

Location: Ont. H.B.L.

109. HUTTON, C.L.A. and W.A. BLACK. 1975. Ontario Arctic Watershed. Env. Can., Lands Directorate, Ottawa: 107 p.

This publication presents a broad but useful review of the climate, physiography, agriculture, mining, communications and social characteristics of the Hudson and James Bays watersheds in Ontario (including Lowland and Shield). It consists mainly of maps with only general text. There are about 1 1/2 pages discussing the physiography of the Lowland (mainly drainage).

Keywords: Physiography, Drainage, Climate, Socioeconomics.

Location: Ont. H.B.L.

110. INNES, M.J.S. 1960. Gravity and isostacy in northern Ontario and Manitoba. Publ. Dom. Abs. XXI (6), Can. Dept. Mines Tech. Surv., Ottawa: 261-338.

This report primarily details gravity studies carried out in the central Canadian Shield and southern Hudson Bay Lowland. The gravity anomalies, although having large local variations, tend to become more negative northward toward the centre of Hudson Bay. Innes interprets this as most likely due "to lack of compensation following the disappearance of glacial loads". He is careful to point out, however, that it is not completely accepted that "the distribution of negative gravity fields can be correlated with centres of previous glaciation". Assuming the displacement is entirely glacio- isostatic and assuming sub-crustal densities of 3.3 gm/cm^3, Innes estimates a further crustal uplift in the Hudson Bay area of 800 ft. This agrees with Gutenberg's (1941) estimate for Churchill "based on scanty data".

Keywords: Geophysics, Isostacy.

Location: H.B.L. (southern), Northern Ontario

111. INNES, M.J.S., A.K. GOODACRE, J.A. WESTON and J.R. WEBER. 1968. Gravity and isostacy in the Hudson Bay Region. in Science, History and Hudson Bay. C.S. Beals and D.A. Shenstone (editors). Dept. Energy

Mines Res., Queens Printer, Ottawa vol. 2:703-728.

This paper is primarily a review of the geophysical characteristics of the crust-mantle boundary in the Hudson Bay Region. The authors briefly discuss aspects of the glacio-isostatic rebound in the area and show the Free Air gravity anomalies. These anomalies are attributed to short term glacio-isostatic depression and longer term tectonic movements. The authors estimate up to 180 m of uplift remains to occur in the region before equilibrium is attained.

Keywords: Geophysics, Isostacy.

Location: H.B.R.

112. ISBISTER, A.K. 1855. On the geology of the Hudson's Bay Territories, and portions of the Arctic and northwestern regions of America. Geol. Soc. London, Quart. J. 11:497-520. also Am. J. Sci. Ser. 2 vol. 21, 1856:313-338.

Keywords: Geology, Physiography.

Location: Man. H.B.L., H.B.R.

113. JOHNSON, R.D. 1971. Petroleum of Hudson Bay Basin studies. Oilweek May 10:pp. 40,43,52.

This is a short paper discussing drilling programs in Hudson Bay and briefly considers the geology of the Hudson Bay Basin.

Keywords: Economic Geology, Hydrocarbons.

Location: H.B.R. (southwestern Hudson Bay)

114. JOHNSON, R.D. and S.J. NELSON. 1969. Sogepet-Aquitaine Kaskattama Province No. 1 well, Hudson Bay Lowland, Manitoba. Geol. Surv. Can., Paper 68-53:215-226.

This is a farily detailed account of the logistics, problems and results of drilling in the Manitoba Lowland on the coast of Hudson Bay (one well sunk completely through the Paleozoic sequence).

Keywords: Economic Geology, Hydrocarbons, Paleozoic Geology.

Location: Man. H.B.L. (Kaskattama River)

115. JOHNSTON, W.A. 1917. Reconnaissance soil survey of the area along the Hudson Bay Railway. Geol. Surv. Can., Summ. Rept. pt. D:25-36.

This is a summary report on a field reconnaissance of terrain types along the Hudson Bay Railway. It was carried out prior to the change in terminus of the line from Port Nelson to Churchill. The survey is restricted to a narrow belt along the rail line, from the Pas to Limestone River (in the western portion of the Lowland). It is primarily a descriptive account of the climate, topography, timber, Pleistocene Geology and sediments along the road bed. The author classifies soils in terms of the nature of the deposits; i.e. boulder clay (till), lacustrine clay, esker and beach sand and swamp (organic). He discusses these 'soils' with respect to their surface morphology, drainage, composition, agricultural potential and occurrence. There are no maps or illustrations in the report and it is not of much pedological value.

Keywords: Physiography, Surficial Geology, Lacustrine Clay, Muskeg, Soil Drainage, Climate, Raised Beach Ridges, Eskers, Sand.

Location: Man. H.B.L., Northern Manitoba

116. JOHNSTON, W.A. 1939. Recent changes of the land relative to sea level. Am. J. Sci. 237:94-98.

Johnston remeasured the elevations of names cut into the rock above Sloops Cove at Churchill. They were first measured by Tyrrell (1896) in 1893 (who concluded that littl or no uplift had taken place in the intervening 150 years (1741 to 1893) because they were within 7 ft of the upper level of winter ice in the cove. Johnston's measurements were essentially the same as Tyrrell's (assuming ice surface 15 feet above mean tide) and thus he agrees with Tyrrell's conclusion as to the "absence of any definite evidence of recent change of level of the coast relative to sea level". He also briefly discusses the uplift in the Great Lakes Region and conludes that "condition governing uplift are different in the two regions".

Keyword: Isostacy.

Location: Man. H.B.L. (Churchill)

117. JURDANT, M., J.L. BELAIR, V. GERARDIN and J.P. DUCRUC. 1977. L'inventaire du capital-nature. Serv. Etud. Ecol. Rég., Dir. Rég. Terres, Env. Can., Ser. Class. Ecol. Terr. 2:202 p.

This report is a comprehensive review of the methodology, classification framework and mapping of the ecological land survey of the James Bay Territory carried out by the Service des Etudes Ecologiques Régionales (S.E.E.R) of the Québec Region Lands Directorate in conjunction with the Societé de Dévelopment de la Baie James. This work included all of the Québec portion of the Lowland as well as the drainage areas of the Rupert, Eastmain, La Grande and Grande Rivere de la Baleine Rivers. The report is well illustrated with numerous figures, ground, oblique aerial and vertical aerial photos and colour maps. The maps are examples of the complete range of classification and interpretation (derived) mapping carried out by S.E.E.R. This is an excellent compendium which can easily be used as a guide to their maps and classifications of the James Bay Terriroty.

Keywords: Ecological Classification, Soils, Vegetation, Hydrology, Survey Methodology, Peatland, Mapping.

Location: Qué. H.B.L., North-Central Québec

118. KEELE, J. 1920. Mesozoic clays in northern Ontario. Geol. Surv. Can., Summ. Rept. 1919, Pt. G:13-21.

This paper is primarily concerned with economic possibilities of the Mesozoic clays occurring on the Mattagami and Missinaibi rivers. Keele provides chemical analyses of the clays and considers their correlation and origin. He was the first to establish the age of this material; they were formerly believed to be Pleistocene.

Keywords: Economic Geology, Mesozoic Lithology, Mattagami Formation, Paleontology, Chemical Analyses, Clay.

Location: Ont. H.B.L. (Mattagami and Missinaibi rivers)

119. KERSHAW, K.A. 1976. The vegetational zonation of the East Pen Island salt marshes, Hudson Bay. Can. J. Bot. 54 (land 2):5-13.

This paper is primarily a discussion of salt marsh vegetation on the Hudson Bay coast near the Manitoba Border. The author also reports on the depth to permafrost in the salt and freshwater marshes. Probing indicated permafrost at 20 to 30 cm in July and 35 to 45 cm in late August in the upper marshes. During July, permafrost occurred as far into the tidal flats as the limit of continuous vegetation but in August was not within 1.5 m of the surface (detection limit) in the salt marsh. It was found in the freshwater marshes during August and the author observed permafrost hummock features (brown moss or incipient palsas ? - editor) in this marsh. Kershaw considers the presence of permafrost inland of the marshes essential in keeping the coastal marshes wet because of impermeability and resulting runoff. However, coastal marshes in southern James Bay, where permafrost does not occur (except in incipient palsas), are also wet. Although seasonal ice probably aids increased runoff in spring in both areas, the overall wetness is most likely due to the high regional watertable which is due to the low gradient in the Lowland and the proximity of the sea (in the case of the coastal marshes).

Keywords: Vegetation, Permafrost, Wetland, Tidal Flats.

Location: Ont. H.B.L. (East Pen Island)

120. KLASSEN, R.W. and J.A. NETTERVILLE. 1973. Quaternary Geology inventory, lower Nelson River Basin. Rept. Activities April - Oct. 1972, Geol. Surv. Can., Paper 73-1 Pt. A:204-205.

This is a short paper describing a mapping and interpretation project of glacial land more recent organic deposits on the Shield and in part of the Lowland along the Hayes, Nelson and Gods rivers in Manitoba. They have recognized glacial deposits similar to those in the James Bay part of the Lowland indicating a widespread unifrom glacial history of the whole Lowland.

Keywords: Pleistocene Chronology, Physiography, Quaternary Stratigraphy, Surficial Deposits.

Location: Man. H.B.L. (Nelson, Hayes and Gods rivers), Northern Manitoba

121. KUPSCH, W.O. 1967. Postglacial uplift - a review. Proc. 1966 Cong. Env. Studies Glacial Lakes Agassiz Region, W.J. Mayer-Oakes (editor), U. of Man. Press:155-185.

This paper reviews a number of earlier papers dealing with postglacial uplift in different parts of the world and the geophysics of uplift. The author discusses the Hudson Bay Region in terms of the evidence of isostacy as presented by the early explorers (Bell and Tyrrell) and by the limited tide gauge data used by Gutenberg (1941). He refers to the dispute between Tyrrell and Bell as to whether the land was still rising and questions the accuracy of Gutenberg's data (Bell 1879, 1880 and 1896, Tyrrell 1896 and Gutenberg 1941). From this Kupsch points out the unreliability of the evidenc for continuing uplift and notes that past uplift may not be due solely to former glacial loading.

Keywords: Isostacy, Geophysics, Tide Gauge Records.

Location: H.B.R.

122. LANNING, J. 1926. The gypsum deposits of the Moose River. Can. Mining J. 47:1172-74.

This paper is an economic evaluation of the gymsum which outcrops near Moose River Crossing. Lanning discusses the possible mining of this material by a company which staked claims to it in 1911. He gives a misleading description of the scenery and climate in this area ... "beautiful, peaceful, milder than the shield to the south".

Keywords: Economic Geology, Gypsum, Paleozoic Geology, Mining.

Location: Ont. H.B.L. (Moose River)

123. LEE, H.A. 1959. Surficial geology of southern District of Keewatin and the Keewatin ice divide, N.W.T. Geol. Surv. Can., Bull. 51:1-42.

Lee describes and maps the surficial geology of southern Keewatin along the west coast of Hudson Bay and discusses late glacial events in regards to the Keewatin ice divide.

Keywords: Surficial Geology, Glaciation, Deglaciation, Marine Inundation, Till, Drumlins, Eskers, Raised Beach Ridges, Pleistocene Chronology.

Location: Keewatin (west coast of Hudson Bay), H.B.R.

124. LEE, H.A. 1960. Late glacial and post glacial Hudson Bay Sea episode. Sci. 131:1609-1611.

This is a short article but rather significant because it is one of the first to bring together available evidence on late glacial events and the extent of postglacial marine submergence of the land surrounding Hudson Bay. Evidence from geological and archeological studies and from radiocarbon dates taken from the Hudson Bay area (mostly outside the Lowland) are used to approximate the extent and age of the maximum marine inundation which is named the 'Tyrrell Sea' for the first time in the literature. Radiocarbon dates and stratigraphical evidence were obtained by the author during the 1950's and by O.L. Hughes of the Geological Survey of Canada. Maximum submergence is estimated at 400 to 600 ft a.s.l. west of the Bay and 800 to 900 ft a.s.l. east of the Bay during the period 7000 to 8000 years ago. Uplift rates are estimated from the radiocarbon dates to have been about 20 ft/100 yrs initially followed by rates of 1 to 3 ft/100 yrs.

Keywords: Marine Inundation, Radiocarbon Dating, Isostacy, Deglaciation, Surficial Geology, Landforms, Tyrrell Sea.

Location: H.B.R.

125. LEE, H.A. 1968. Quaternary Geology in Science, History and Hudson Bay. C.S. Beals and D.A. Shenstone (editors). Dept. Energy Mines Res., Queens Printer, Ottawa: 503-543.

Lee presents a good summary of general Quaternary events which took place in the Hudson Bay Region. He briefly discusses glacial chronology, aspects of deglaciation including freshwater glacial lakes, marine inundation (Tyrrell Sea) and postglacial landform development (includin organic terrain). He also discusses some of the major glacial and postglacial landforms of the region (generally outside the Lowland) such as the De Geer moraines of Québec and Keewatin. He provides his own interpretation of late glacial events in order to explain some of the unique landform assemblages. For example, the drumlin/De Geer moraine complexes east of James Bay suggest the ice sheet may have broken in two along a north-south axis east of the Bay during the late stages of deglaciation.

The paper reflects the general lack of information on glacial landforms and events of the Hudson Bay Lowland, although Lee briefly discusses the Pleistocene sequences including the interglacial peats described by McLearn (1927), Terasmae (1958) and Terasmae and Hughes (1960).

Keywords: Pleistocene Chronology, Isostacy, Landforms, Marine Inundation, Tyrrell Sea, De Geer Moraines, Drumlins, Glaciation, Deglaciation, Glaciolacustrine, Missinaibi Formation.

Location: H.B.R.

126. LEROY, O.E. 1903. Reconnaissance surveys of four rivers southwest of James Bay. Geol. Surv. Can., Summ. Rept. 1902, Ann. Rept. 1902-1903 Pt. A:237.

Keyword: Physiography.

Location: Ont. H.B.L. (Moose - Albany rivers area)

127. LOW, A.P. 1887. Preliminary report on an exploration of country between Lake Winnipeg and Hudson Bay. Geol. Surv. Can., Ann. Rept. 1886, vol. 2 Pt. F:1-24. also Ont. Bur. Mines, vol. 21 Pt. 2.

This paper is a descriptive account of reconnaissance surveys carried out in 1886 along the Berens River from Lake Winnipeg to a branch of the Severn River, then to Fort Severn and on to York Factory along the coast. He describes the timber, geography, botany, fish and geology along this route and also includes notes on isostacy.

Keywords: Physiography, Isostacy, Paleozoic Geology.

Location: Ont. H.B.L. (Severn River), Man. H.B.L. (Ontario to York Factory), Northern Manitoba

128. LOW, A.P. 1889. Report on exploratioins in James Bay and country east of Hudson Bay drained by the Great Whale and Clearwater rivers 1887 and 1888. Geol. Surv. Can., Ann. Rept. 1887-1888, vol. 3 Pt. J:94 p.

Low describes many of the islands in the southern part of James Bay, including Akimiski ('Agoomski') Island, as well as the shoreline of Hannah and Rupert Bays. He attempts to discount R. Bell's concept of isostacy in this area, attributing raised beaches and driftwood to occassional abnormally high tides.

Keywords: Isostacy, Physiography, Coastal Morphology, Raised Beach Ridges, Driftwood.

Location: Ont. H.B.L., Qué. H.BL. (southern James Bay)

129. LOW, A.P. 1899. Hudson Bay. Geol. Surv. Can., Summ. Rept. 1898:124-133 and 1899:139-148.

Keyword: Physiography.

Location: H.B.L., H.B.R.

130. LOW, A.P. 1912. James Bay. Ont. Bur. Mines, vol. 21 Pt. Z:180-191.

Keyword: Physiography.

Location: Qué. H.B.L., Ont. H.B.L., H.B.R. (James Bay)

131. MALCOLM, W. 1924. Limestone of Abitibi and Mattagami rivers. Geol. Surv. Can. Summ. Rept. 1924 pt. C:96-98.

This is a short discussion of the economic potential of these limestones. The author presents 3 chemical analyses.

Keywords: Economic Geology.

Location: Ont. H.B.L. (Abitibi and Mattagami rivers)

132. UNIVERSITY OF MANITOBA. 1969. Soil. Science in Agriculture Research and Experiment Report. Faculty Agr. Home Econ., Univ. Manitoba, Winnipeg Manitoba: 78-84.

This paper describes some chemcial and physical properties of three types of frozen organic soils; Cryic Cumulo Mesisol, Cryic Sphagno-Fibrisol and Cryic Fibrisol (Mesic and Fibric Organic Cryosols under the 1978 Canadian System of Soil Classification). These soils were described from the York Factory area of Manitoba and represent two types of frozen peat landforms ('minerotrophic' palsas - Mesisol and Ombrotrophic palsas and peat plateaus-Fibrisols). This is a summary paper only and does not present any discussion or interpretations.

Keywords: Pedology (organic), Permafrost, Cryosols, Peatland Landforms

Location: Man. H.B.L. (York Factory)

133. MANNING, T.H. 1947. Coast I, south coast of Hudson Bay. unpub. report filed in the Arctic Institute North Am. Library, Montréal.

The author describes the shoreline and river estuaries along the south coast of Hudson Bay (as referenced in Moir 1958).

Keywords: Coastal Morphology, Estuaries

Location: Ont. H.B.L. and Man. H.B.L. (along Hudson Bay Coast)

134. MANNING, T.H. 1951. Remarks on the tides and driftwood strand lines along the east coast of James Bay. Arctic 4(2):122-130.

The paper is based on the observation of the author based on a canoe trip along the east side of James Bay from Moosonee. The main purpose of the trip was to make a faunal survey.

Manning established temporary tide scales to measure relative high and low water levels at each location where he camped. He measured a range in tides generally less than 2 ft but as high as 6 ft. He also briefly describes driftwood strand lines and discusses their origin, the highest of which are well above the present high tides. He accounts for this as evidence of a drop in sea level of at least 10 ft. Manning's tidal observations are recorded in a table and in graphs. They constitute in intermittent record from June 29 until September 6, 1950.

Keywords: Tides, Strand Lines, Isostacy, Coastal Morphology.

Location: Qué., Qué. H.B.L.

135. MANNING, T.H. and R.W. RAE. 1950. Tidal observations in Arctic waters: notes. Arctic 3:95-104.

Keywords: Tides, Strand Lines, Isostacy, Coastal Morphology

Location: Ont. H.B.L. (James Bay Shore)

136. MARTINI, I.P. 1981a. Ice effect on erosion and sedimentation on the Ontario shores of James Bay, Canada. Zeit, fur Geomorph. N.F. 25:1-16.

Seasonal ice effects on the Ontario coast of James Bay are described, including: erosion in the form of ice and boulder scour, ice block freezing of sediment, ice pressure boulder ridges and pavements and enhanced tidal/wave erosion of coasts and tidal flats due to ice patterns; the transport of material by shore ice; and the deposition of material resulting from ice crevice filling, ice block dumping, slumping from the sides of shrinking ice cakes and elevated rims formed from the melting of buried ice blocks. Martini offers explanations for the various erosional and depositional forms observed and describes seasonal ice patterns in various parts of the bay. He also discusses some ice controls on marsh formation-degradation and considers characteristic "Jigsaw" patterns of hummock and hollow in salt marshes to be the result of ice scour.

Keywords: Seasonal Ice Effects, Ice Scour, Ice Deposition, Salt Marsh Formation, Sea Ice, Coastal Geomorphology.

Location: Ont. H.B.L. (Ontario coast of James Bay) and James Bay.

137. MARTINI, I.P. 1981b. Morphology and sediments of the emergent coast of James Bay, Canada. Geogr. Ann. 63 A (1-2):81-94.

This paper provides a general description of the major features and dominant sediments along the Ontario coast of James Bay. There is some interpretation of marine environments and processes but the paper is primarily descriptive. It is a very short condensation of the earlier Martini et al. (1979, 1980a and b) and Martini and Protz (1978, 1980) reports and paper and, as such, provides a concise overview of the James Bay coast in Ontario. Martini describes the coast in four major sections: 1) Ontario-Québec border to Albany River, 2) Albany River to Ekwan Point, 3) Ekwan Point to Lake River and 4) Lake River to Cape Henrietta Maria.

He includes line diagrams interpreted from 1:60,000 black and white aerial photography and Landsat reproductions of the entire coast and ground photos and aerial photos of selected areas.

Keywords: Coastal Geomorphology and Sedimentology, Tidal Flats, Beach Ridges, Promontories.

Location: Ont. H.B.L. (James Bay Coast).

138. MARTINI, I.P. and R. PROTZ. 1977. Geomorphological and pedological studies in the coastal zone of the Hudson Bay Lowland. Interim Rept. 1977 Lab. Work (unpub. ms.), contract # OSU 77-00085, U. Guelph, Ontario: 9 p.

This report describes field and lab. methology and provides figures and tables of preliminary soil and sediment analyses. Complete descriptions and results of analyses are published in Martini and Protz (1978).

Keywords: Coastal Geomorphology, Coastal Sedimentology, Pedology, Chemical Analyses, Physical Analyses of Sediment.

Location: Ont. H.B.L. (southwestern James Bay)

139. MARTINI, I.P. and R. PROTZ. 1978. Coastal Geomorphology, sedimentology and pedology of sourthern James Bay, Ontario, Canada. Dept. Land Res. Sci., Guelph, Tech. Memo 78 -1:149 p. (12 appendices).

This report is a 'working document' of an ongoing project on the coasts of James Bay and Hudson Bay. The work is being carried out under contract from Environment Canada with support from the National research Council of Canada. This report represents the most exhaustive work carried out to date on the sedimentology and pedology of the Hudson Bay Lowland coast. A great deal of data is printed in the body and appendicies of the report which is well illustrated with graphs, photographs, maps and tables. Most of the discussions and interpretations deal with the sedimentology. Portions of the 'Synopsis' from this report is reprinted below.

"... in Southwestern James Bay natural units of the landscape are: (a) a coast that is characterized by a uniform, gentle offshore slope of approximately 0.5m/km.

It bounds a shallow brackish inland sea that is covered by ice for approximately six months of the year. (b) Wide bays, particularly in the southern part, receiving large amounts of fresh waters from rivers such as the Harricanaw and the Moose. (c) Wide, low promontories that expose Paleozoic carbonate bedrock, tills, or accumulations of erratics. Erosional (half-heart bays) and depositional (spits) landforms develop on their southern downdrift sides. (d) Narrow promontories that extend several kilometers on the shallow shelf and may develop transverse ridges, some of which have characteristic seaward bifurcations such as at Puskuake Point. Between Longridge Point (LR) and Nomansland Point (NM) sets of these promontories bound narrow deep bays. (e) Sequences of beach ridges and spits that build parallel to the main coasts. (f) Wide tidal flats, some of which are characteristized by shallow sinusoidal sand waves. (g) In the Lowlands some coastal features are obscured by growth of vegetation and development of wide wetlands. Some features, such as promontory complexes, longitudinal beach ridges, and chevron beach ridges (a landform characterised by a combination of transverse and longitudinal ridges) are recognizable because they support well developed forests.

"The material and biological characteristics of these environments are: (a) Large boulders, pebbles, and sand of local origin, having a predominantly calcareous (limestone and dolostone) composition. Calcareous shales and silts become locally important near outcrops of Paleozoic red-beds such as at Cockispenny Point. (b) Precambrian igneous, metamorphic, and a few sedimentary boulders, pebbles and sands which have been transported into this area by glaciers presumably from exposures of the Superior Province in Quebec. (c) Clays derived both from local till deposits and from the widespread substratum of the marine clay of the Tyrrell Sea, cover most of the coastal area. (d) Clay, silt and predominantly organic suspended material are transported into marshes. (e) A restricted faunal assemblage is found in the tidal flats and marshes, and mollusks are important in the modification of sedimentary desposits. They also constitute a source of food for migratory shore birds.

"These coastal environments and materials are acted upon by: (a) Glacial rebound. (b) Marine semidiurnal tides that generally have a low range (0.7 - 1.5m) reaching a maximum at some localities of 3 meters. The tides can rework the surface of sandy, silty tidal flats and they carry much fine material onto high tidal flats and lower marshes. (c) Wind generated waves that form in the open bay during storms can sweep tidal flats and rework sands and pebbles, piling them up locally on coastal ridges. However, this is considered on the whole a low energy coast. (d) A slow but apparently regular marine current that moves in an anticlockwise direction. In Bays, such as Hannah Bay, local currents and gyres develop which redistribute or trap sediments along their coasts. (e) Sea ice covers the coast for approximately six months of the year, protecting it. However, during freeze-up and thaw ice floes raft such material along the tidal flats, and push and scour the sedimentary surfaces. (f) Wind may locally and for short periods of time rework and reshape sediments of upper parts of tidal flats. (g) The cold climate of this coast sustains freeze-and-thaw processes of weathering, especially for suscepitble rocks such as bedded limestones and dolostones. (h) The physical and biochemical action of organisms in the tidal flats and inland areas, combined with other types of chemical weathering, modify the primary characterists of parts of the mineral deposits.

"The response of the landscape to these processes generates a variety of sedimentary deposits which singly are not unique to James Bay, but whose association of elements characterizes regressive coastal sequences of a cold inland sea..

"... Pedogenetic processes change the characteristics of parts of the coastal sedimentary sequences, as they are uplifted. The slow rebound of the land allows detailed analysis of these progressive changes by studying transects from the recent coasts inland. (a) The depletion of Sodium and other salts of marine salt water, and the drainage of marshes is not impeded. (b) Reversal of this setting may occur where salts are added to more interior profiles by locally better drainage and evaporation of marine brackish waters, such as in the east coast of Hannah Bay. (c) The Gleysols of coastal marshes retain primary sedimetnary laminations, but also develop ferrans around plant roots. (d) Podzols develop on inland beach ridges. Many of them have cemented Bh horizons that contain abundant cutans of organic matter around grains. (e) Montmorillonite clays are forming in the Ae horizons of Podzols. (f) Among other differences that exist between environments that lead to the formation of Podzols from those of Gleysols, the summer soil temperatures have been found to be consistently 5 to 8°C lower in the drier ridges than in the wet lower lands...."- SYNOPSIS

Keywords: Coastal Geomorphology, Coastal Sedimentology, Pedology, Chemical Analyses, Physical Analyses of Sediment.

Location: Ont. H.B.L. (southwestern James Bay)

140. MARTINI, I.P. and R. PROTZ. 1979. Coastal Geomorphology, sedimentology and pedology of northwestern James Bay. Interim Rept. 1979 Field Work (unpub. ms.), contract # OSU79-00087, U. Guelph, Ontario: 9 p.

This short paper reviews the progress of field studies during the summer of 1979 along the coast of James and Hudson Bay. Coastal geomorphological, sedimentological and pedological studies were continued north (see Martini and Protz 1978 and Martini et al. 1978) from Ekwan Point on James Bay to Cape Henrietta Maria and westward along Hudson Bay to the mouth of the Sutton River. These are described in more detail in Martini and Protz (1980). The paper also reviews progress of the fluvial and coastal studies in the Attawapiskat River - Akimiski Strait areas, and salt marsh ecological studies at North Point.

Keywords: Coastal Geomorphology and Sedimentology, Fluvial Geomorphology and Sedimentology, Pedology, Salt Marsh Ecology.

Location: Ont. H.B.L. ((northwest James Bay and south Hudson Bay coasts)

141. MAERINI, I.P. and R. PROTZ. 1980. Coastal Geomorphology, sedimentology and pedology of northern James Bay, Ontario, Canada. Dept. Land Res. Sci., U. Guelph, Tech. Memo 78-1: 111 p.

This report is similar in format to Martini and Protz (1978) but the area of investigation is northwestern James Bay including Cape Henrietta Maria area. Portions of this 'Synopsis' from the report is reprinted below:

"... The northwestern coast of James Bay is comprised of two embayments, one containing the Swan River and the second several streams among which is the Lakitusaki River; two large promontories, one north of the Swan River, and the second at the northern tip of James Bay (Cape Henrietta Maria); and a long straight barrier beach and spit system on the coast north of the Lakitusaki River.

"The embayments act as sediment traps and they develop wide silty sand flats. They show regular landward fining of surficial sediments, and a rapid increase in organic matter in the high tidal flats and marshes. Associated with accumulations of organic matter, particularly where it exceeds ten percent of the whole sample, there is a significant increase in Na-pyrophosphate extractable iron and aluminum. In the marshes other trends show an inland decrease in electrical conductivity and calcium carbonate equivalent. Local relatively large electrical conductivity values of high tidal flats may be related to the high salinities (up to 32‰) reached by sea water during winter and spring. Mollusks are abundant in the intertidal zone, and regular well defined zonations occur in the marshes with *Puccinellia phryganodes* being the colonizing plant of the lower marshes everywhere, except near river mouths where *Hippurus* prevails.

"The two promontories are very different. The one of Cape Henrietta Maria is at the junction between James Bay and Hudson Bay. It is subjected to intense wave action. Its eastern flank is erosional with well developed benches cut into fractured, highly fossiliferous carbonate bedrock. The pebbles formed though this erosion are reworked into high, complex, anastomosing beach ridges. Whereas this environment is not used much by birds, it is most important for polar bears in the summer. The second promotory (SRN) is a wide one. It sits on a Precambrian high, and it has a till substratum. Till is exposed in parts of the intertidal zone, or it is covered by thin deposits of sand and silt. Gravelly (fine pebbles) coastal ridges develop throughout the intertidal area and shelter silty zones in their inland sides. The marshes are well structured with double vergency, with bare patches at the center, grading laterally toward the ridges into plant associations characterized successively by <u>Puccinellia phyryganodes</u>, and <u>Puccinellia lucida</u> and <u>Carex</u>. Ponds containing <u>Hippurus</u>, and in more inland areas <u>Senecio</u>, separate the central part of the marshes from the ridges which contain at their margin <u>Calimagrostic</u> and <u>Salix</u> associations.

"The stretch of coast north of Lakitusaki River is unique because it has a narrow, but well developed sandy barrier beach, locally capped by highly deflated small foredunes. The coastal dunes are colonized by <u>Honkeya</u>, <u>Metensia</u> and <u>Elymus</u> assemblages. Farther inland, tundra vegetation covers the high deflated, uplifted ridges, and whereas permafrost features are rare along the coast, inland inter-ridge areas have well developed patterned grounds and thaw ponds. In the offshore zone, characteristic thick (50 cm) silty deposits form along a narrow (few tens of meters) strip in front of the beach. They grade seaward into either a sand flat, or locally into exposed till. In the southern part of this coast, very few large arcuate ridges form in the upper intertidal area. They shelter wide and thick silt deposits which become rapidly colonized by algae and marsh plants. To the north, the neach is characterized by land spits, mostly migrating southward, but locally reversing to the north. They too protect silty high tidal flats and marshes. Associated with these various accumulations of silt, there is a sensible increase in concentration of calcium carbonate equivalent and electrical conductivity. Conversely a strong decrease in calcium carbonate content, conductivity and pH is recorded first in the coastal dunes where more siliceous particles are accumulated, and progressively more intensely inland on the tundra.

"Vegetation development is lower on the northwestern coast of James Bay in respect to the southern shores. Consequently, soils are slightly less well devleped to the north, and sedimentary features persist throughout the profile. The subarctic cold environment of that area is recorded in the soils primarily as ice lenses or traces of them reflected in this layers with very low bulk density. The low buly density is attributed to formation of voids by growing ice crystals...." - SYNOPSIS.

Keywords: Coastal Sedimentology and Geomorphology, Pedology, Tidal Flats, Beach Ridges, Promontories, Chemical and Physical Analyses of Sediment, Isostacy, Beaches, Surficial Geology.

Location: Ont. H.B.L. (northwestern James Bay), Northwest Territories (Akimiski Island)

142. MARTINI, I.P., R. PROTZ, D. GRINHAM, A. KING and K. CLARKE. 1978. Coastal geomorphology, sedimentology and pedology of James Bay: Albany River to Ekwan Point, and Akimiski Island; and Ecology of northern salt marsh, North Point, Ontario. Interim Rept. 1978 Field Work (unpub. ms.), D.S.S. contract # OSU78-00125, U. Guelph, Ontario: 42 p.

This report consists of a series of 5 papers (one by each author) describing the objectives and field and labratory methods of the 1978 studies along the James Bay coast. These studies are part of the overall Hudson Bay Lowland project co-ordinated by Environment Canada. The papers include coastal geomorphology and sedimentology (Martini), pedology of marsh and beach ridge soils (Protz), geomorphology and sedimentology of Akimiski Strait (Grinham) and the lower Attawapiskat River (King) and salt marsh ecology at North Point (Clarke). Except for the latter study all field work for 1978 took place between the Albany River and Ekwan Point of the James Bay coast. Some preliminary descriptions and findings are presented but otherwise the report is primarily methodology. The detailed results will be written as M.Sc. level theses and an overall final report.

Keywords: Coastal Geomorphology and Sedimentology, Fluvial Geomorphology and Sedimentology, Pedology, Salt Marsh Ecology.

Location: Ont. H.B.L. (westcentral James Bay coast)

143. MARTINI, I.P., R. PROTZ, D. GRINHAM, A. KING and K. CLARKe. 1979. Studies of coastal sediments, soils and biota, James Bay, Ontario, Canada. Dept. Land Res. Sci., U. Guelph, Tech. Memo 79-1: 290 p.

This report reviews studies carried out during 1978 and 1979 by the authors along various portions of the west coast of James Bay. It compliments the reports by Martini and Protz 1978 and 1980. A series of individual papers are included. These are (1) a review of coastal morphology and macroprocesses, north of the Albany River, by Martini with figures and tables: (2) a short review of investigations in the Akimiski Strait (Grinham); (3) a very preliminary review of soil studies north of the Albany (Protz); (4) sedimentological and chemical studies in Akimiski Strait (Martini and Grinham); (5) a preliminary report on observations and early results of the Attawapiskat River Estuary (King); and (6) a report on salt marsh ecology at North Point (Clarke). The report also includes an excellent review of literature pertaining to tidal flats by Grinham. Portions of the 'Synopsis, are included below.

"... The coasts north of Ekwan Point are exposed to the open sea-swells of James Bay, and develop flat-topped, long, wide (15 m), and repetitive sand

and gravel beach ridges which resemble the ones of Hudson Bay. The coasts of the mainland between the Albany River and Ekwan Point are greatly affected by three factors: a) They receive large inputs of water and sediment primarily from the three major rivers: the Albany, the Attawapiskat and the Ekwan; b) They are protected from open sea-swells by Akimiski Island; c) They are affected by longshore tidal currents (maximum 0.8 m/sec.) channelized along Akimiski Strait. Because of the narrow (17 km) and shallow (maximum depth 11 m) characteristics of the strait, sea-ice has considerable indirect affect on the dispersal of sediments, by transforming the strait itself into a bay plugged to the north during critical periods in the fall and spring, and by restricting the strait into ice walled, narrow canals. The coasts between the Albany and Attawapiskat Rivers develop silty tidal flats and wide coastal-deltaic plains interspersed with shallow, Salix- thicket bearing, coastal ridges. These ridges flare out from the mouths of the streams, and are separated from each other by slot and serpentine lakes. The west coasts of Akimiski Strait develop narrow tidal flats (2,300 m) barred by longshore intertidal bars heavily colonized by Macoma balthica. Many of these bars maintain their identity when raised onto the marshes because the associated tidal channels are kept open, run for several kilometers parallel to the shore, and develop charactertic 'U' patterns.

"The coasts of Akimiski Island are characterized everywhere by low rates of deposition. Thin veneers of silt cover tills on the western and northern coasts where relatively wide, but thin marshes develop, which are fertile habitats for migratory birds. The eastern coasts have discontinuous longitudinal ridges which together with a few transversal narrow promontories form embryonic chevron complexes. In the south, the coasts are either erosional and face a wave cut bench associated with a deep (11 m) trough in Akimiski Strait, or they develop thin silty tidal flats and narrow (3-500 m) marshes in wide embayments. These southern coasts are backed by inactive sets of forested, well developed, sand and gravel beach ridges which began developing approximately 3500 to 4000 years ago when the southern Tyrrell Sea extended approximately 100 km farther onto the Hudson Bay Lowland.

"Some of the tidal flats evolve characteristic sedimentary sequences associated with ice reworking and ice-rafting of sediments. Ice gouging is preserved as steep sided cuts filled with poorly sorted, structureless materials of highly variable composition. Ice-rafted deposits are characterized by rapid lateral and vertical variations in texture and composition of sediments.

"The tidal flats and salt marshes of North Point are major staging grounds for migratory waterfowl and shorebirds in both the spring and fall. A coastal ridge system acts as a natural breakwater to the brackish waters of southern James Bay. Landward of the ridge well developed tidal flats and extensive salt marshes have formed.

"The tidal flats are reworked by ice in the spring, as evidenced by numerous ice-rafted boulders and cobbles, gouges, and shallow scoured pools. Parts of the salt marsh may remain ice-covered until late June, and it is not until mid-July that the entire marsh is vegetated with new growth.

"... The Attawapiskat River is entrenching due to a falling baseline and has developed an anastomosing pattern of distributary channels. The calculated sinuosities are between 1.27 and 1.03, which are less than those sinuosities ($>$ 1.5) used to classify anastomosing rivers. In the lower reaches of the river random avulsion is the prominent form of channel switching, rather than lateral migration. The main channel has a irregular meander form which decreases in wavelength downstream (Mean meander wave-length 8.6 km).

"Spring flow is the dominant flow event of the year (maximum recorded flow = 3115 m^3/s; mean annual flow = 508 m^3/s), and flooding is common. River banks increase in height inland to 3.7 m. Steepness is maintained by ice gouging during break-up and by slumping.

"Modern facies have been defined (tidal flat, marsh and forest stages) and described. Bank exposures have been interpreted to show this sequence vertically although delineation of the facies boundaries is difficult. The tidal flat deposits are organic deficient and are characterized by sandy silt with occasional thin laminae displaying ripple marks, lensitic sand, scattered ice-rafted pebbles, and molluscs. Levee construction commences during the marsh stage and continues into the forest stage. The levees fine upward and contain predominantly fine sand and silt separated by organic rich laminae. Abandoned side channels are partially filled with silt and organic material.

"Tidal cycle monitors done in the main channel and one side channel show a marked difference in sediment transport, velocity fluctuations, and temperature range. The side channel is flood dominated and maximum sediment transport (0.954 g/l) and flow velocities (1.07 m/s) occur at this time. The main channel is ebb dominated and maximum sediment transport (0.208 g/l) and velocities (0.98 m/s) occur during the initial stages of ebb flow. Tidal flat sediments are put into suspension during flood tide and transported upstream, principally in the side channel.

"The slow rebound of the land mass in the James Bay Lowland results in a good opportunity for quantitative studies of general geomorphological - pedological - vegetation sequences. These same sites yield samples from which quantitative studies can be made on pedological development as a function of latitudinal (climatic function) changes. It is also apparent that many micro and meso sequences can be defined in the James Bay Lowland on many of the transects.

"The Podzols north of Attawapiskat and on Akimiski Island are not as well devleoped as are the Podzols in Southern James Bay.

"The clay mineralogy is relatively uniform from the Albany River to the Ekwan River and on Akimiski Island. Electrical conductivities (i.e. implied salt content) vary significantly within the region studied in 1978 ..." - SYNOPSIS.

Keywords: Coastal Sedimentology and Geomorphology, Estuarine Geomorphology and Chemistry,

Pedology, Tidal Flats, Beach Ridges, Chemical and Physical Analyses of Sediment, Beaches, Tides, Salt Marsh.

Location: Ont. H.B.L. (west coast James Bay), Northwest Territories (Akimiski Island)

144. MARTINI, I.P., D.W. COWELL and G.M. WICKWARE. 1980a. Geomorphology of southwestern James Bay: A low energy, emergent coast. Proc. Coast. Can. Conf., Geol. Surv. Can. Paper 80-110:293-301.

"The southwestern coastline of Hudson and James Bays in Ontario and Manitoba is the longest low gradient, emergent shoreline in the world. It maintains an uninterrupted offshore slope about 0.5-1m/km over a distance of approximately 1700 kilometers. The land has been subjected to active rebound for the last 7000-8000 years, and is still rising at a rate of less than 1m/100 years.

"The Ontario coast consists of three main morphologies: coasts dominated by abundant parallel beach ridges and spits; coasts dominated by estuarine system; and coasts with promontories and transverse ridges.

"All three types of coastlines are represented in the southern part of James Bay. Longitudinal beach ridges fringe upper tidal flats on the southern and eastern sides of promontories and in areas where storm waves are not greatly attentuated by extensive sandy flats. The longitudinal ridges vary in elevation from 1.5-2m (composite sandy and gravelly ridges), to 0.3-0.4m (coastal single sandy bars), and in sandy flats, to 0.2m (sinusoidal sandy waves). Promontories and transverse ridges are related to bedrock highs or glacial depositional features modified by deposition of coastal sands and gravels. A marked counter-clockwise marine current in the southern part of James Bay redistributes the fluviatile materials to the south east of estuaries, onto extensive, featureless, low lying tidal flats.

"With emergence, incorporation of these

features into the peatland complex is manifested through a progressive paludification of the landscape, an in older parts of the Lowland, only high ridges and promontories (larger than 1m) with well developed coniferous forests, remain as recognizable marine landforms." - ABSTRACT.

Keywords: Coastal Geomorphology, Wetland Geomorphology, Tidal Flats, Raised Beach Ridges, Peatland, Upland Forest, Paludification, Promontories, Sand bars, Beach Ridges.

Location: Ont. H.B.L. (southwestern James Bay Coast)

145. MARTINI, I.P., R.I.G. MORRISON, W.A. GLOOSCHENKO and R. PROTZ. 1980b. Coastal studies in James Bay, Ontario. Geosci. Can. 7(1):11-21.

This is a good, concise review of the coastal sedimentology, geomorphology, pedology, salt marsh and wildlife studies carried out on the west coast of James Bay by Environment Canada and the University of Guelph's Department of Land Resource Science. The sedimentological and pedological studies are described in more detail in Martini and Protz 1978 and 1980 and Martini _et al_. 1979.

Keywords: Coastal Sedimentology and Geomorphology, Pedology, Tidal Flats, Promontories, Beaches, Beach Ridges, Salt Marsh, Vegetation, Wildlife.

Location: Ont. H.B.L. (west coast of James Bay)

146. MARTISON, N.W. 1953. Petroleun possibilities of the James Bay Lowland area. Ont. Dept. Mines Ann. Rept. 61 Pt.6:1-58.

This is the first full-scale attempt to study and map the lithology and structure of the Moose River Basin.

One of the prime objectives of this study was to determine the oil possibilities of the Moose River Basin. It produced the first complete geological map of this basin based on one summer's field work covering 23,000 mi. by plane and canoe. Drill holes were sunk completely through the Paleozoic strata at Jaab Lake in the interior (between Moose and Albany Rivers) and at Puskwuche Pt. on the James Bay coast.

Martison also briefly describes the Pleistocene sequences occurring in the drill holes at Onakawana and in some river exposures. He notes the presence of up to 280 ft of glacial deposits consisting of 2 till sheets separated by a nonglacial interval and overlain by Tyrrell Sea marine clays and postglacial peat deposits.

Keywords: Paleozoic Stratigraphy, Paleozoic Geology, Economic Geology, Pleistocene Stratigraphy and Lithology.

Location: Ont. H.B.L. (Moose River Basin)

147. MAYER-OAKES, W.J. 1967. Life, land and water. Proc. 1966 Conf. Env. Studies Glacial Lake Agassiz Reg. Occasional Papers, Dept. Anthropology, U. Man. 1:414 p.

This is a compendium of 18 papers presented at the conference dealing with physical, paleoenvironmental and social characteristics of the Lake Agassiz Region.

Keywords: Bibliography, Conference Proceedings.

Location: H.B.R., Northwestern Ontario, Eastern and Northern Manitoba

148. MCDONALD, B.C. 1969. Glacial and interglacial stratigraphy, Hudson Bay Lowland. Geol. Surv. Can., Paper 68-53:78-99.

This paper presented an account of studies carried out during "Operation Winisk" by the Geological Survey of Canada in 1967. River bank sections of Quaternary deposits were studied on 11 rivers across the Lowland including the Hayes, tributaries of the Echoing, the Severn, Fawn, Shagamu, Attawapiskat, Kapiskau, Kwataboahegan, Soweska and Mattagami rivers. In addition, data from previous studies on some of these and other rivers (Seal, Harricanaw, Abitibi, Onakawana, Missinaibi and Opasatika) were incorporated. Most of the description and discussion deals with the inter-till, nonglacial "Missinaibi Beds" which McDonald believes to be interglacial (probably Sangamon) and not interstadial as Terasmae (1958) and Terasmae and Hughes (1960) believed. This was preferred because of the presence of marine deposits with the nonglacial beds in two sections not described by Terasmae and Hughes (1960). This indicated that Hudson Bay and Strait were free of ice when the nonglacial Missinaibi beds were deposited. It also shows the Hudson Bay area was a depression (basin) during the Sangamon.

McDonald notes that the Quaternary sediments exposed in river banks are consistent throughout the Lowland. The main variation is the absence of freshwater lacustrine deposits above the upper till and beneath the Tyrrell Sea sediments in the central part of the Lowland. Their presence in sections in the southeast and northwest are attributed to glacial lakes Bartlow-Ojibway and Agassiz, respectively. The author briefly discussed the glacial and postglacial chronology as depicted in 7 composite sections representing much of the Lowland. Generaly the sections show up to 3 basal tills overlain by sand, clay silt and peat of the Missinaibi beds, followed by two tills separated by stratified sediments (lacustrine). These are overlain by proglacial lake sediments (in the northwest and southeast) which are in turn overlain by Tyrrell Sea deposits followed by peat and/or alluvium. He briefly discusses the lithologies of the various units but does not correlate them with deposits or events outside the Lowland.

Keywords: Pleistocene Stratigraphy and Lithology, Interglacial Missinaibi Beds, Glaciation, Deglaciation, Palynology, Pleistocene Chronolgoy, Surficial Geology.

Location: H.B.L.

149. MCDONALD, B.C. 1971. Later Quaternary stratigraphy and deglaciation in eastern Canada, in The Late Cenozoic Glacial Ages, Karl Turekian (ed.), Yale University Press:331-353.

Keywords: Quaternary Stratigraphy, Quaternary Chronology, Deglaciation.

Location: H.B.L., H.B.R., Eastern Canada

150. MCGREGOR, D.C. and M. CAMFIELD. 1976. Upper Silurial? to Middle Devonian spores of the Moose River Basin, Ontario. Geol. Surv. Can., Bull. 263:63 p. (includes 8 plates).

Spores taken from drill holes samples (at Jaab Lake, Puskwuche Pt. and the Kenogomi River) have been identified in order to determine the position of the Silurian-Devonian boundary and more precise ages of the Devonian strata. This approach is needed because of a lack of good animal fossils from these strata.

Keywords: Paleozoic, Paleonotology and Stratigraphy, Palynology.

Location: Ont. H.B.L.

151. MCINNES, W. 1906. The Winisk River, Keewatin District. Geol. Surv. Can., Ann. Rept. 1902-1903, 15 Pt. (AA):100-108.

This paper accounts on a survey carried out along the Winisk River during 1902 and 1903 from Winisk Lake (Weibikwei Lake) to Hudson Bay. McInnes describes the physiography of the river and surrounding country and the bedrock, timber, fossils, clays (tills and marine) and fauna found along the Winisk River. This is one of the first published descriptions of this river. The author provides a discharge estimation 30 mi upstream from Hudson Bay of 25,000 ft^3/sec) early August.

Keywords: Physiography, Paleozoic Geology, Surficial Geology, Quaternary and Paleozoic Paleontology.

Location: Ont. H.B.L. (Winisk River)

152. MCLEARN, F.H. 1927. The Mesozoic and Pleistocene deposits of the lower Missinaibi, Opazatika and Mattagami rivers, Ontario. Geol. Surv. Can., Summ. Rept. 1926 Pt. (C):16-47.

This is a very significant paper because it represents the first detailed examination of the Pleistocene and Mesozoic deposits of the Moose River Basin. Numerous explorers had reported peat and lignites outcropping along the rivers of this basin (R. Bell 1879, J.M. Bell 1904, Williams 1921) but considered them all as being Pleistocene in age. The work of McLearn and others accompanying the author, assisted botanists and paleobotanists who identified plant remains (Auer 1927), indicated that the lignites and clays outcropping near river level in the Mattagami River were Mesozoic deposits whereas the peats, sands, silts and clays outcropping between tills on the Missinaibi and Opazatika rivers were interglacial Pleistocene deposits.

McLearn describes the lithology and stratigraphy of the Mesozoic sand and clay-lignite deposits along the Mattagami River (Mattagami Formation) and noted they were well eroded by glacial ice in places. He then describes the Pleistocene deposits in terms of the Tyrrell Sea ("Marine Champlainian") clays and silts and the 'till and gravel' sequences including the interglacial peat, sand, silt and clay depostis. Although he provides numerous descriptions and measures of river bank sections, he does not discuss the various Pleistocene sediments in terms of their history of deposition except for the interglacial beds which he notes occur between 2 drift sequences. The author provides one of the first detailed accounts of the environments of deposition of the interglacial beds which seems to hold up well in light of more recent findings (Skinner 1973a and b) and noted the absence of marine sediments in the interglacial deposits this far upsteam. These were later discovered lower in the basin (Prest 1970, Skinner 1973 a and b). He also noted Auer's (1927) conclusion, based on samples McLearn collected, that the flora of the interglacial beds indicated a climate similar to today. He concludes the report by discussing the economic possibilities of the various peat and lignite deposits based on occurrence and energy potential. The Mesozoic lignites are the only deposits in sufficient quantity and of high enough energy (ash content 4 to 56%, 3800 to 11,500 BTU's) to have mining potential.

Keywords: Mesozoic Lithology and Stratigraphy, Pleistocene Lithology and Stratigraphy, Paleobotany, Interglacial Deposits, Economic Geology, Mattagami Formation, Clay, Lignite, Till, Peat.

Location: Ont. H.B.L. (Moose River Basin)

153. MILLS, G.F. 1975. The Pedological Characterization of the paleosol in the Hudson Bay Lowland, Manitoba. 19th Ann. Man. Soil Sci. Meet., Dec. 10 & 11, 1975, U. Manitoba: 16-28.

This paper describes specific physical and chemical characteristics of a soil profile located within the Hudson Bay Lowland (approx. 55°55'N, 94°40'W) on a well drained, sand and gravel, raised beach ridge (marine). The profile is that of an active Degraded Eutric Brunisol overlying a buried Brunisolic Paleosol. The author notes the similarities of both sequences and discusses their origin and age in terms of the geological history of the Hudson Bay Lowland. He also considers ecological and climatological implications arising from the similarities of the two soils. Physical and chemical data provided includes colour, structure, texture, pH, conductivity, $CaCO_3$, calcite, dolomite, organic C, C/N, CEC and Ca^{++},

Mg^{++}, Na^{+}, K^{+} and H^{+} exchangeable cations.

Keywords: Pedology, Chemical and Physical Analyses, Paleosol, Raised Beach Ridge.

Location: Man. H.B.L.

154. MILLS, G.F. 1976. Biophysical Land Classification of northern Manitoba. Proc. Can. Com. Ecol. Land Class., Petawawa, Ontario, Ecol. Land Class. Series #1, Lands Directorate Environment Canada:201-219 (includes 3 appendices and a glossary).

This paper summarizes the logistical and operational aspects of an extensive biophysical (ecological) land classification project of northern Manitoba (see Mills et al. 1976). It also describes the format of data presentation (i.e. biophysical mapping at a scale of 1:125,000) and provides an example of the mapping (from the Hayes River area), definitions of terms, and a summary of biophysical concepts and the major characteristics of Land Regions, Land Districts, and Land Systems of the Hayes River map sheet.

The project commenced as a pilot study in 1974. In 1975 biophysical land classification was carried out on 62,640 Km^2 between Lake Winnipeg and the Hudson Bay Lowland. The equivalent of the two map sheets were completed in the Lowland in 1974; these are the Kettle Rapids Sheet (map sheet 54D, National Topographic Series) and the Hayes River Sheet (54c - see Mills et al. 1976).

Field studies were helicopter supported and included the group truthing of 80 to 90 stops per map sheet. Inventories covering landform, surface deposits, vegetation, soil profiles, drainage, permafrost, aquatic systems and wildlife were prepared in the field at these stops.

Although the paper primarily discusses the logistics and methods involved, Appendix II provides a brief summary of portions of the Hayes River map sheet. These include characteristic landforms (organic and mineral), surface materials, vegetation and soil type (subgroup level). This paper should be read in conjunction with the guide accompanying the Kettle Rapids map sheet (Mills et al. 1976) and the two map sheets in the Hudsn Bay Lowland for more specific information on landforms, materials and soils (as well as vegetation).

This ecological land classification follows the methodology presented by Lacate (1969) and supported by the Canada Committee on Ecological Land Classifications, although the author notes a stronger emphasis on the role of the soil profile. It is considered as the most stable element of the landscape, especially in terms of extrapolating the group truthing to other area.

Keywords: Ecological Classification, Pedology, Vegetation, Landform, Survey Methology.

Location: Man. H.B.L. (Kettle Rapids and Hayes River map sheets), Northern Manitoba

155. MILLS, G.F., H. VELDUIS, D.B. FORRESTER. 1976. A guide to Biophysical Land Classification Kettle Rapids, 54D. Northern Res. Inf. Prog., Can-Man. Soil Surv., Winnipeg Manitoba: 30 p. (accompanies Map sheet 54D, Kettle Rapids, Scale 1:125,000). Also available: Map sheet 54C, Hayes River, Scale 1:125,000.

This program was am ambitious biophysical mapping survey of more than half the province of Manitoba to be carried out by the Canada - Manitoba Soil Survey (also see Mills 1976). It was intended to provide ecological maps for the northern portion of the province, including all of Manitoba's Hudson Bay Lowland, incorporating data on landform, climate, soils, permafrost, vegetation and water to supply basic resource information for resource planners. Unfortunately the federal government withdrew its share of the funding in 1977 after 3 years of field work had been completed. Consequently only two map sheets within the Hudson Bay Lowland portion of Manitoba have been ground truthed and published; the Kettle Rapids and Hayes River Sheets.

These maps have been published at a scale of 1:125,000. The Kettle Rapids sheet has an accompanying guide to Biophysical Land Classification which explains the system of classification and summarizes some information on Land Regions and Land Districts. Approximately a third of this map is in the Lowland. The Hayes River Sheet is almost entirely in the Lowland south and southwest of York Factory.

The maps display ecological units of polygons which are annotated as to their constituent environmental ecological parameters. These symbols are in turn keyed to an extended legend via the soil association. This legend lists the drainage, topography, dominant vegetation, parent material, and dominant and 'significant' soil classes (classed at the subgroup level according to the Canadian system of Soil Classification). Although there is no specific site data on the maps, the information is available from the Canada - Manitoba Soil Survey, Department of Soil Science, University of Manitoba. The site data includes descriptions of the soils, vegetation, ecology and landforms.

Keywords: Ecological Classification, Pedology, Vegetation, Permafrost, Surficial Geology, Landforms.

Location: Man. H.B.L. (Kettle Rapids and Hayes River map areas)

156. MOIR, D.R. 1954. Beach ridges and vegetation in the Hudson Bay Region. Ann. Proc. North Dak. Acad. Sci. vol 8:45-48.

The author briefly reviews the glacial and postglacial history of the Region, as known to that time. He then discusses some of the factors influencing beach ridge development along the coast of Hudson Bay and briefly describes the sediments, spacing and size of raised ridges located 8 mi inland and east of Fort Severn. He also describes stage in vegetational colonization from the coast inland.

Keywords: Raised Beach Ridges, Coastal Geomorphology, Physiography, Vegetation.

Location: Ont. H.B.L. (Severn River area near Hudson Bay coast)

157. MOIR, D.R. 1958. A floristic survey of the Severn River drainage basin of north western Ontario. U. Minnesota, Ph.D. Thesis:261 p.

Although primarily a disertation on the flora and their biogeography in the Severn River basin, this thesis presents an excellent desription of the physiography of the basin and discusses the evolution of the Shield and Lowland landscapes. Moir studies the area by plane and canoe and using his observations he managed to bring together the descriptions and ideas of some of the earlier explorers of the area, including Tyrrell, Bell, McInnes and so on. His concepts of landscape evolution, particularly with respect to the development of the drainage in relation to late glacial events and deposits and the development of beach ridges on the coast and their incorporation with peat deposits inland, are the most accurate and comprehensive of any published to that date and remains as a useful study. These concepts are based on observations and descriptions of the general character of the rivers, Pleistocene deposits (tills and stratified materials), marine inundation, beach ridges, tidal flats, salt marsh, isostacy and glacial straie.

Keywords: Physiography, Raised Beach Ridges, Beaches, Landscape Evolution, Isostacy, Marine Inundation and deposits, Tidal Flats, Glacial Straie, Seasonal Ice Rafting in Rivers, Surficial Geology, Vegetation, Drainage, Pleistocence Events.

Location: Ont. H.B.L. (Severn, Fawn Rivers), Northern Ontario

158. MONTGOMERY, R.J. 1929. Laboratory tests on northern Ontario fire clays. Ont. Dept. Mines Ann. Rept. 32 pt. 4:23-24.

This is a short paper reporting on tests of Mesozoic clays for commerical brick manufacture.

Keywords: Economic Geology, Mattagami Formation, Clay.

Location: Ont. H.B.L. (Moose River Basin)

159. NATIONAL COMMITTEE ON FOREST LAND, Subcommittee on Biophysical Land Classification. 1969. Guidelines for biophysical land classification, for classification of forest lands and associated wildlands. D.S. Lacate(editor), Can. For. Serv., Pub. 1264:61 p.

These are guidelines for heirarchical classification and mapping of land based on interpretations of ecological characteristics. Units of land are classified and mapped at various levels and scales based on combinations of soil, vegetation and landform characteristics. Included are a proposed open water and wetland classification and examples of reconnaissance-level biophysical pilot projects.

Keywords: Ecological Classification, Mapping, Methodology.

Location: Not Applicable.

160. NELSON, S.J. 1952. Ordovician paleontology and stratigraphy of the Churchill and Nelson rivers, Manitoba. unpub. Ph.D. thesis McGill, Montréal:190 p.

Keywords: Paleozoic, Paleontology and Stratigraphy, Paleozoic Geology.

Location: Man. H.B.L. (Churchill and Nelson rivers)

161. NELSON, S.J. and R.D. JOHNSON. 1966. Geology of Hudson Bay Basin. Bull. Can. Petrol. Geol. 14(4):520-578.

Although the title refers to the Hudson Bay Basin the paper actually considers the whole Hudson Platform. It is based on studies of outcrops in the Hudson Bay Lowland (and islands in northern Hudson Bay) as well as well-log data from a few drill holes. The authors briefly discuss aspects of the physiography and wildlife of the lowlands and review some of the previous work. This paper presents a good review of geological information known to that time and is stil useful although slightly out of date due to information obtained during Operation Winisk in 1967.

Keywords: Paleozoic Geology and Stratigraphy.

Location: H.B.L., H.B.R.

162. NETTERVILLE, J. 1974. Quaternary stratigraphy of the lower God's River region, Hudson Bay Lowlands, Manitoba. Unpub. M.Sc. Thesis, U. Calgary:79 p.

Keywords: Quaternary Stratigraphy, Pleistocene Deposits, Till, Nonglacial Deposits, Missinaibi Formation.

Location: Man. H.B.L. (God's River).

163. NEWBURY, J.R.W. 1968. The Nelson River: As study of subarctic river processes. unpub. Ph.D. Thesis, Johns Hopkins U., Baltimore, Md.:320 p.

"The Nelson River traverses 400 miles of the Canadian Shield between Lake Winnipeg and Hudson Bay in the subarctic climatic zone of central Canada. The upper Nelson flows through a series of rock-bound lake basins connected by steep channels with numerous rapids and falls. The lower Nelson flows over a series of bedrock controls and rapids between banks of permanently frozen glacial till. The present channel is the final outlet of glacial Lake Agassiz, impounded during the late-Wisconsin glaciation.

"Severe ice formation and destruction processes occur in the river channel for eight months of the year. Field observation programs were undertaken throughout the winter and summer of 1966 and 1967 to discover the characteristics and effects of ice phenomena. A general ice regime theory was developed, based on flow conditions in the Nelson channel and the net heat transferred at the river surface.

"An ice cover is formed on the Nelson by a combination of border ice growth from channel boundaries; slush ice, former within the upper layers of the flow, bridging the channel locally; and unconsolidated ice accumulating above bridged sections throughout the winter. The rate of growth of border ice and the rate of formation of slush ice were related to the net rate of heat transfer at the river surface, using the heat budget technique developed for natural open water surfaces with suitable modifications for surface temperature dependent terms and the surface condition. The rate of ice accumulation was found to be generally in agreement with parameters developed for the thickness and stability of an unconsolidated river cover.

"The ice destruction period on the Nelson River occurs in May and early June. The major portion of the ice cover melts in place as the river is subdivided by a series of ice barriers, in some cases over 40 feet thick, that form during the winter through rapids zones. The rate of melting and accumulation of ice pans above barriers is subject to the heat budget and stability analyses developed for ice cover formation processes with suitable adjustments of surface conditions and the ice structure.

"The principal effects of ice phenomena in the Nelson channel were found to be: (1) an annual cycle of bed erosion and infilling occurred where unconsolidated material was present in zones of ice accumulation, (2) bank and bed material of a size greater than that corresponding to the hydraulic competency of the river were striated and shifted downstream in local zones of ice cover movement, (3) a vegetation trim-line was developed along the channel boundaries corresponding to the maximum ice level, and (4) local sections of terraces and braiding were developed by flow shifts in rapids zones during the annual period of ice accumulation." - ABSTRACT.

This thesis presents a comprehensive review of ice conditions on the Nelson River over a one year period. The author divides the Nelson into 4 main reaches which he describes in some detail. The lowest reach, from long Spruce Rapids to Hudson Bay, represents the Hudson Bay Lowland section. In addition to physical descriptions and analyses of ice accumulation and destruction processes, the author examines the question of river engineering (channel and control structures) in terms of river ice characteristics on the Nelson. He provides a summary of the kind of studies and data required to evaluate river reaches for engineering design.

Newbury also reviews the literature with respect to exploration and scientific studies in the Nelson Basin and discusses the drainage development in the Nelson - Churchill Trough (including the drainage of glacial lake Agassiz).

Keywords: Hydrology, Hydraulics, River Ice Processes, River Engineering, Microclimatology, Drainage.

Location: Man. H.B.L. (Nelson River), Northern Manitoba

164. NORRIS, A.W. and B.V. SANFORD. Paleozoic and Mesozoic geology of the Hudson Bay Lowlands. Geol. Surv. Can. Paper 68-53:169-205.

This is similar to the paper by Sanford et al. (1968) but more concise. It includes small-scale maps of the geology including stratigraphy, facies maps and isopach maps.

Keywords: Stratigraphy, Paleozoic Geology, Mesozoic Geology.

Location: H.B.L.

165. NORRIS, G. 1979. Mesozoic palynology of the Moose River Basin. in Mesozoic geology and mineral potential of the Moose River Basin, District of Cochrane, P.G. Telford and H.M. Verma (editors). Ont. Geol. Surv. Open File Rept.: 154-222.

The author presents the results of the palynological investigations of samples from drill holes made through the Mesozoic sediments and coals of the Moose River Basin between 1975 and 1978 (Telford et al. 1975 and Verma et al. 1978). He examines 160 spore-pollen species from the Mattagami Formation, representing 4 internal zones from the Middle to Upper Albian (Cretaceous) and correlates these with deposits elsewhere in North America. The author also examines the palynoflora of the Mistuskwia Beds and correlates these with Middle Jurassic palynofloras of the western Canadian Plains. The assemblages are illustrated in part.

Keywords: Mesozoic Palynology, Mesozoic Biostratigraphy, Mesozoic Lithology, Mattagami Formation.

Location: Ont. H.B.L. (Moose River Basin).

166. OILWEEK. 1972. Major push planned by oil-hunters for next year in Hudson Bay Region. Oilweek 23(42):60-62.

This is a short review of drilling and seismic programs to take place during the following year (1973) in Hudson Bay.

Keywords: Economic Geology, Hydrocarbons.

Location: Southwestern Hudson Bay.

167. ONAKAWANA DEVELOPMENT LTD. 1973. Onakawana Project; lignite mine and power plant development, engineering feasibility study and economic analysis. Ont. Min. Nat. Res. Rept. 5366-4-73, 2 vol.

Keywords: Economic Geology, Engineering Feasibility, Lignite Mine, Power Plant.

Location: Ont. H.B.L. (Onakawana - Abitibi rivers)

168. ONTARIO MINISTRY OF ENVIRONMENT. 1981. EA Update. Vol. VI (3), Dec. 1981: 39 p.

Keywords: Economic Geology, Lignite.

Location: Ont. H.B.L. (Moose River Basin).

169. ONTARIO RESEARCH FOUNDATION. 1933. A technical and economic investigation of northern Ontario lignite. Ont. Dept. Mines. Ann. Rept. 42 Pt. 3:1-45.

Keywords: Economic Geology, Lignite.

Location: Ont. H.B.L. (Moose River Basin)

170. O'SULLIVAN, O. 1906. A survey of the coast of Hudson Bay from York Factory to Severn River. Geol. Surv. Can. Summ. Rept. 1905:73-76.

Keywords: Physiography, Coastal Morphology.

Location: Man. H.B.L., Ont. H.B.L.

171. O'SULLIVAN, O. 1908a. Survey of the south coast of Hudson Bay from the Severn River to Cape Henrietta Maria. Geol. Surv. Can. Summ. Rept.:93-94.

Keywords: Physiography, Coastal Morphology.

Location: Ont. H.B.L. (south coast Hudson Bay, Severn River to Cape Henrietta Maria)

172. O'SULLIVAN, O. 1908b. Track survey from Hayes River to Severn Post through Shamattawa, Sturgeon and Castorum Rivers. Geol. Surv. Can., Notebook 3940.

Keywords: Physiography, River Morphology.

Location: Ont. H.B.L. (Hayes-Severn rivers)

173. O'SULLIVAN, O. 1912. South and west coasts of James Bay. Ont. Bur. Mines, Ann. Rept. 21(2):185.

Keywords: Physiography, Coastal Morphology.

Location: Ont. H.B.L. (south and west coast of James Bay)

174. PARKS, W.A. 1913. Preliminary list of the fossils collected by J.B. Tyrrell, in the District of Patricia, etc. Ont. Bur. Mines, Ann. Rept. 22 pt. 1.

Keywords: Paleozoic Paleonotology.

Location: Ont. H.B.L.

175. PELLETIER, B.R. 1969. Submarine physiography, bottom sediments and models of sediment transport in Hudson Bay. Geol. Surv. Can., Paper 68-53:100-135.

This paper is a reasonably in-depth examination of the physical characteristics of Hudson Bay including its currents, temperature, dissolved oxygen, salinity, bottom topography and sediments. It is based on data from various depths including soundings and samples of bottom sediment collected during track surveys made from 3 different trips in Hudson Bay during 1961 and 1965. Of particular interest with respect to the Lowland are the bathymetry studies which provide evidence for preglacial drainage from the Lowland across the foor of present-day Hudson Bay toward Hudson strait. The author shows the position of several troughs in the bottom of the bay which he suggests represent preglacial channels associated with the present Churchill, Nelson, Severn and Winisk estuaries. Other troughs occur north of James Bay and southeast from Chesterfield Inlet.

Keywords: Preglacial Drainage, Bathymetry, Physiography, Marine Processes, Salinity, Marine Sediments, Currents, Tides.

Location: Hudson Bay, H.B.R.

176. POTZGER, J.E. and A. COURTEMANCHE. 1956. A series of bogs across Québec from the St. Lawrence valley to James Bay. Can. J. Bot. 34:473-500.

This paper reports on the detailed anlayses of pollen assemblages from 19 bogs between latitudes 45°07'N (eastern Ontario) and 51°59'N (James Bay, Québec). The authors describe the pollen assemblages and attempt to relate them to forest invasion and succession as deglaciation took place in Québec. They identify 5 major climatic periods of which the most northerly bogs have representation of only the most recent. Pollen assemblages from bogs in central Québec show evidence of a climatic cooling period immediately following the first warm period (Lake Timiskaming Retreat) which the authors correlate with the Cochrane halt and readvance. The major xerothermic period of postglacial time immediately follows the Cochrane readvance wich is indicated by predominance of spruce and jack pine (<u>Picea mariana</u> and <u>Pinus banksiana</u>).

Keywords: Palynology, Climate, Forest Succession, Deglaciation, Cochrane Readvance.

Location: Western Québec, Eastern Ontario, Southern H.B.R.

177. PREST, V.K. 1963. Red Lake - Lansdowne House area, northwestern Ontario, surficial geology. Geol. Surv. Can., Paper 63-6:23 p.

This paper describes the surficial geology and glacial-deglacial events for a portion of north-central Ontario. It is predominately on the Shield but includes a small portion of the Lowland around the Attawapiskat River. Maps of surficial geology shows the Lowland primarily as organic but glacial fluting, eskers and straie are shown to be present. Prest indicates that the maximum limit of marine overlap is 550 ft a.s.l. in this area.

Keywords: Surficial Geology, Glaciation, Deglaciation, Marine Inundation.

Location: Ont. H.B.L. (Attawapiskat River), North-Central Ontario

178. PREST, V.K. 1966. Glacial studies, northeastern Ontario and northwestern Québec. Geol. Surv. Can., Rept. Act., Paper 66-1:202-203.

Prest reports on work being carried out in Ontario - Québec in the vicinity of glacial Lake Barlow - Ojibway in support of the Glacial Map of Canada. He describes his attempt to map the southern limit and extent of Cochrane till in Québec and Ontario and notes the presence of marine clays underlying what he interprets as Missinaibi beds along the Abitibi River. Prest concludes that the Missinaibi beds must represent an interglacial period because the marine clays indicate Hudson Bay must have been open and connected to Hudson Strait.

Keywords: Surficial Geology, Deglaciation, Cochrane Readvance, Marine Inundation, Interglacial Sediments, Missinaibi Beds.

Location: Northwestern Ontario, Northwestern Québec, Southern H.B.R.

179. PREST, V.K. 1970a. Quaternary geology of Canada. in Geology and Economic Minerals of Canada. R.J.W. Douglas (editor), Dept. Energy, Mines and Res. Can., Ottawa: 687-690, 733-734.

pp. 687-690. Prest focuses on the nonglacial Missinaibi beds of the Lowland. He provides brief descriptions of occurrences on the Harricanaw, Nettogami, Little Abitibi, Abitibi, Missinaibi and Opasatika, Kawataboabegan, Albany, Kenogami, Attawapiskat, Gods and Seal rivers and from a drill hole at Campbell Lake. These were taken from various sources but in each case Prest attributed the occurrence of these sediments to the Quaternary. He notes that there was some confusion in the literature around the turn of the century as to whether certain occurrences were Quaternary or Cretaceous (Mattagami Formation lignites). McDonald (1969) believes the Missinaibi beds to be intergalcial (Sangamon) but Prest questions their flora as representing a climate which was too cool, even allowing for the latitude, to correlate with the Sangamon Don beds in Toronto. He suggests they may prove to be interstadial, early Winconsin. He does not discuss other aspects of the glacial chronology of the Lowland but in Fig. XII-1 he shows the sequence of time-stratigraphic relationships of the Lowland relative to southern Ontario. In this Figure he shows the Missinaibi beds as deposited during the late Sangamon.

pp. 733-734. In this section the author briefly discusses glacial retreat during the late Winconsin in northern Ontario. He illustrates his concept of retreat on several stage maps, primarily showing the relationships between the position of the ice front and various glacial lakes. He coins the term 'Lake Antevs' for a large glacial lake which replaced Barlow-Ojibway and drained northwest along the ice front into the Hudson Bay area in Manitoba. Prest dates marine incursion at about 8,100 years, correlative with the Cochrane II advance and suggests the advance may have been a surge caused by marine inundation. He also correlates the Kipling Till (Skinner 1973a and b) with the Cochrane Till in noting that the ice retreated well into the Lowland before readvancing. According to Skinner (1973b) there is not yet enough evidence to make this correlation. Also Prest places early Tyrrell Sea inundation to the northwest, from Hudson Strait to the Manitoba part of the Lowland and expanding to the east and southeast as the ice front finally retreated toward Labrador-Ungava. This is inconsistent with the interpretations of Lee (1968), Andrews (1969) and Skinner (1973b).

Keywords: Pleistocene Stratigraphy, Interglacial Missinaibi Beds, Deglaciation, Cochrane Readvance, Marine Inundation.

Location: H.B.L., H.B.R.

180. PREST, V.K. 1970b. Quaternary geology of Canada. in Geology and Economic Minerals of Canada. R.J.W. Douglas (editor), Dept. Energy, Mines and Res. Can., Ottawa: 676-764.

Keywords: Pleistocene History, Glaciation, Deglaciation, Marine Inundation.

Location: Canada.

181. RAILTON, J.B. and J.H. SPARLING. 1973. Preliminary studies on the ecology of palsa mounds in northern Ontario. Can. J. Bot. 51:1037-1044.

This paper reports on a detailed study of palsas in the Hawley Lake area of the Hudson Bay Lowland (cf Sjörs 1961). The study was designed to determine the mechanism of palsa formation and degradation. Measurements of incoming solar radiation, albedo, evapotranspiration, soil head flux, heat involved in ice melt and vegetation communities were made during July, 1967 on mature palsas, partially eroded palsas and collapsed palsas. The energy budget was calculated from the data. In addition, palsa length and height ratios were determined and peat samples were taken at 2 depths (2.5 to 7.5 and 90 cm) for C^{14} dating.

The authors suggest that the continuous origin theory of palsa development is more plausible than the relic theory. They found that although albedo changes significantly with palsa formation (from 6.8% for bog to 21.3% for mature palsa) it has little effect on the absolute value in the energy equation. They conclude that palsa formation results from the insulating effect of surface peat which dries out in the summer. The collapse of palsas is due to natural disturbances in the living vegetation cover due to changes in surface-volume relationships. The authors also present a map showing permafrost zones of Canada which is of interest because they show the southern limit of the continuous permafrost zone further north in Hudson Bay than does Brown (1967). Their line passes south of Churchill but does not enter the Ontario portion of the Lowland at all.

Keywords: Palsa, Permafrost, Vegetation, Microclimate.

Location: Ont. H.B.L. (Hawley Lake)

182. RICHARDS, H.G. 1941. Post-Wisconsin fossils from the west coast of Hudson Bay. Acad. Nat. Sci. Phil., Notulae Naturae No. 84:1-10.

This paper reports on fossil shell collections made between Churchill and Chesterfield Inlet and to the north, in 1940. Richards collected cold water marine shells from raised beaches as much as 100 ft above sea level and attributes their origin to a higher post-glacial marine sea. He includes a list of 21 species identified with photographs of most of these. Included in the list is the blue mussel Mytilus edulis which is abundant and considered diagnostic in raised beaches in the region.

Keywords: Quaternary Paleontology, Isostacy, Marine Inundation, Raised Beach Ridges.

Location: Man. H.B.L. (Churchill), Keewatin

183. RITCHIE, J.C. 1957. The vegetation of northern Manitoba II. A prisere on the Hudson Bay Lowlands. Ecology 38:429-435.

This paper is primarily a study in vegetation zonation and succession as controlled by uplift in the Churchill area of Manitoba. The author describes the vegetation sequence from the Churchill estuary-inland through a forest zone to an area of 'mound topography'. The 'mounds' are palsas which he identifies as 'Palsa Bogs' in his 1960 paper. He describes their vegetation and presents a cross-section showing the peat-permafrost relationship. He also notes the depth to permafrost in late summer as being 60 to 100 cm.

Keywords: Vegetation, Permafrost, Peatland Characteristics, Palsas.

Location: Man. H.B.L. (Churchill)

184. RITCHIE, J.C. 1960. The vegetation of northern Manitoba V. Establishing the major zonation. Arctic 13(4):210-229.

Ritchie mapped the major vegetation zones in northern Manitoba based on extensive field work and aerial photo interpretation. The zones on the Shield and in the Lowland, north of 56°latitude, are presented and briefly described in terms of dominant vegetation and vegetation physiognomy. Four zones compose the Hudson Bay Lowland portion; transitional, moss muskeg, treeless bog and lowland complex. The latter two (nearest the coast) include significant areas of 'Palsa Bog' which Ritchie defines as "small mounds of peat with cores of permafrost, capped by a _Ledum_ - _Sphagnum_ - _Carex_ community with scattered black spruce.... forms large complexes, with wet sedge peat or open water between individual palsas". He also notes that "permafrost" is present in many of the drier peat deposits, with the active layer 30 to 50 cm deep. The paper includes two small-scale maps and is well illustrated with vertical aerial photos.

Keywords: Vegetation, Peatland, Permafrost, Palsas.

Location: Man. H.B.L.

185. ROBINSON, J.L. 1968. Geography of Hudson Bay. _in_ Science, History and Hudson Bay. C.S. Beals and D.A. Shenstone (editors). Dept. Energy, Mines Res., Queen's Printer, Ottawa:201-235.

This paper presents a summary of the major physiographic regions surrounding Hudson Bay. One of these is the Hudson Bay Lowland (referred to as 'South Coast

Lowland') which the author describes in terms of its general physiography, resources (hydroelectric potential and minerals) and settlement. In describing the physiography, Robinson relies on the zonation and description of Coombs (1954) almost entirely.

Keywords: Physiography, Socio-Economics.

Location: H.B.L., H.B.R.

186. ROGERS, D.P., J.S. HANCOCK, S.A. FERGUSON, W.O. KARVINEN & P. BECK. 1975. Preliminary report on the geology and lignite deposits of the Cretaceous Basin, James Bay Lowlands, Ontario. Ont. Div. Mines Open File Rept. 5148. pt.1:157 p. (5 append., 6 maps).

This is the first report describing recent drilling and geophysical explorations in the Moose River Basin carried out by the Ontario Geological Survey between 1975 and 1978. The objectives of these investigations were "to determine the characteristics, thickness and continuity of the major stratigraphic units of the Cretaceous Basin and their relationships with the underlying and overlying formations", and to identify favourable areas for detailed investigation of the lignite deposits.

The authors report on the preliminary results of drilling operations in the basin carried out during the winter of 1975. Six drill holes were completed through the Mesozoic deposits (2 penetrated the Paleozoic) along a north-south winter road constructed for the drilling. The road crosses the basin from Smoky Falls in the south to near Jaab Lake in the Lowland. The report includes drill logs, air temperature tables for Kapuskasing, Moosonee and Smoky Falls, summarizes the sedimentology in the drill holes, describes environments of deposition of the lignite and associated sands and clays and provides a good description of the stratigraphy and history of geological exploration in the Moose River Basin. It does not discuss the economic implications of the findings or the overall extent, thickness and quality of the depostis. The drill logs include descriptions of the Pleistocene deposits.

Keywords: Mesozoic Stratigraphy, Economic Geology, Geophysics, Mattagami Formation.

Location: Ont. H.B.L. (Moose River Basin)

187. ROUSE, W.R. and K.A. KERSHAW. 1973. Studies on lichen dominated systems. VI Interrelations of vegetation and soil moisture in the Hudson Bay Lowlands. Can. J. Bot. 51:1309-1316.

The authors compare vegetation cover and surface organic content to soil moisture and evaporation at 9 sites on the Hudson Bay coast near East Pen Island. Measurements of soil moisture were taken using a neutron depth probe from July 7 to August 17, 1971. The sites extend from the coast to 4 km inland representing gravel beach ridges of varying vegetative cover (increasing inland), as well as 2 wet sites and 2 disturbed sites (a burn and a vehicle track). Soil moisture was found to increase with vegetative cover and vary significantly within each site above and below 20 cm depth. Upland ridges were found to have the highest evaporation rates and the presence of thick non-transpiring _Cladina alpestris_ inhibited evapotranspiration.

Keywords: Vegetation, Soil Moisture, Microclimate, Permafrost, Physiography, Raised Beach Ridges.

Location: Ont. H.B.L. (near East Pen Island)

188. SANDFORD, B.V., A.W. NORRIS and H.H. BOSTOCK. 1968. Geology of the Hudson Bay Lowlands (Operation Winisk). Geol. Surv. Can., Paper 67-60:118 p.

This paper is based on data collected in 1967 for 'Operation Winisk'. It is one of the most comprehensive reviews of the geology of the Hudson Bay Lowland including Precambrian and Paleozoic strata. It includes a geological map of the entire Lowland, a good review of economic geology, and a very good bibliography. This report assembles and re-defines the stratigraphic nonmenclaure as it is used today.

Keywords: Paleozoic Stratigraphy, Economic Geology, Paleozoic and Precambrian Geology, Bibiography.

Location: H.B.L.

189. SANDFORD, B.V. and A.W. NORRIS. 1975. Devonian stratigraphy of the Hudson Platform. Geol. Surv. Can., Memoir 379: 2 parts.

This memoir is a detailed treatment of the Devonian strata of the Hudson Bay Lowland based primarily on field work carried out during 'Operation Winisk' in 1967. It includes a good bibliography of many outcrops and well logs. The authors discuss each formation with respect to lithology, distribution, thickness, contacts, fossils, age and correlation. It is weakest on interpretations of paleoenvironments of deposition.

Keywords: Paleozoic Stratigraphy, Paleozoic Geology, Paleontology, Bibliography.

Location: H.B.L.

190. SAVAGE, T.E. and F.M. VAN TUYL. 1919. Geology and stratigraphy of the area of Paleozoic rocks in the vicinity of Hudson and James bays. Geol. Soc. Am. Bull. 30:339-377.

This is one of the earliest attempts at organizing the Paleozoic stratigraphy of the Hudson Bay Lowland. It is based on the descriptions of the earliest geological explorers as well as field work carried out by the authors.

Keywords: Paleozoic Geology, Economic Geology.

Location: H.B.L.

191. SCINTREX SURVEYS LTD. 1976. Geophysical studies on Onakawana lignite fields, District of Cochrane. Ont. Div. Mines Open File Rept. 5196:47 p.

During 1975 and 1976 Scintrex Surveys Ltd. carried out geophysical studies of the Onakawana lignite fields and vicinity. These consisted of physical properties measurements, group resistivity, induced polarization and an airborne electro-magnetic survey. The main objective was to determine if such geophysical methods could be employed to outline the extent and thickness of the lignite deposits and also to explore the Onakawana area for deposits other than those already known.

The results indicate that resistivity soundings can be used to determine the depth to the top of the lignite-clay unit ($\pm$ 10% at 20m) and the thickness of the unit provided its dimensions are sufficient (about 10 m thick). In addition the airborne elctro-magnetic survey indicated possible further deposits to the east of the known fields.

Keywords: Geophysics, Economic Geology, Lignite.

Location: Ont. H.B.L. (Moose River Basin - Abitibi River)

192. SHILTS, W.W. 1980a. Flow patterns in the central North American ice sheet. Nature 286 (5770): 213-218.

Shilts evaluates the sources and distribution of erratics representing four main rock types in the area surrounding Hudson Bay. He attempts to reconstruct ice flow lines of the central portion of the Laurentide ice sheet on the basis of the dispersal patterns of lithologically distinctive erratics. These show that the Hudson Bay Lowland was influenced primarily by the westward and southwestward flowing Labradorean-based ice during the last glacial maximum. Shilts notes, however, that the western Lowland formed a contact zone between the Keewatin and Labradorean ice sheets. The Keewatin ice mass displaced the Québec-based ice mass from time to time in the southwestern Lowland. Generally though the author believes that the Keewatin sheet played only a minor role with respect to erosion and transport in the Hudson Bay Lowland.

Keywords: Glaciation, Laurentide Ice Sheet, Keewatin Ice Sheet, Labradorean Ice Sheet, Ice Flow Patterns.

Location: H.B.R., H.B.L.

193. SHILTS, W.W. 1980b. Geochemical profile of till from Longlac, Ontario to Somerset Island. Can. Min. Metallurg. Bull. Oct., 1980:1-10.

This paper reports the results of geochemical analyses of borehole-till samples, which were collected for geotechnical analyses for the Polar Gas Consortium. The Consortium examined the technical and environmental characteristics along a proposed natural gas pipeline route from the high arctic, through Keewatin and northern Manitoba to Longlac, Ontario. Most of the proposed route bypassed the Lowland except for the southwestern edge in Manitoba.

Geochemical analyses of Cu, Pb, Zn, Co, Ni, Ag, Mo, Cr, Mn and Fe were carried-out on samples from 166 boreholes which intersected till. The results reported for the Longlac, Ontario to Churchill, Manitoba portion of the route reflect regional bedrock characteristics up-ice (northeast) in the Hudson Bay Lowland.

This was noted to affect, in particular, the concentrations of U and Mn. Uranium was believed to be diluted by the Paleozoic-derived till whereas Mn was probably enriched. Manganese concentrations were "significantly elevated" in this region and the samples were also rich in siderite ($FeCO_3$). High Mn concentrations probably represent a rhodochrosite phase of the siderite mineralization. The author suggests this may indicate that "siderite deposits may be much more extensive than previously thought in the Paleozoic section" of the Hudson Bay Basin.

Keywords: Geochemistry, Till Profiles, Glacial Deposits, Economic Geology, Polar Gas Consortium.

Location: Man. H.B.L., northern Ontario and Manitoba, Keewatin, Boothia Peninsula.

194. SHILTS, W.W. In press. Quaternary evolution of the Hudson/James Bay region. Ms. accepted for pub. Hudson/James Bay Symp. U. Guelph, Guelph, Ont. April 1981: 37 p. (to be published in special issue of Nat. Can.).

This paper was presented in the plenary session of the Hudson/James Bay Symposium at the University of Guelph. As such, it presents an excellent overview and summary of the major literature describing the Pleistocene of the Hudson Bay region. It also presents the most recent findings of the author in more detail than in his previous papers (Shilts 1980 and Shilts et al. 1979).

The prime focus of this paper is the growth and activity of the Laurentide ice sheet throughout the Wisconsin in the region of Hudson Bay. Many of the references used, and much of the evidence described, relate directly to the Hudson Bay Lowland. Shilts first describes historical evidence and thought relating to the Laurentide ice sheet in this region. He then describes the general geology of the region including source areas of 4 major erratic lithologies; glacial dispersion patterns based on erratic distribution, till lithologies (based on more than 1200 till or till-like samples), and new amino acid dating techniques of marine shells collected from tills in the Hudson Bay Lowland; and the Wisconsin glacial history based on this new evidence.

The last part of the paper considers aspects of the deglaciation history of northwest Hudson Bay (this latter discussion has been dropped from the published version of the paper - W. Shilts, pers. comm.).

The major findings of this paper, based on the recent evidence he describes are that the Laurentide ice sheet originated from at least two centres of accumulation, Keewatin and Québec-Labrador, which were active throughout the Wisconsin; that there was no stable, single core or dome of ice over Hudson Bay; and that Hudson Bay was open to marine waters at least twice during the Wisconsin. This latter finding indicates a very dynamic ice sheet. The author suggests these conditions probably occurred prior to the last interglacial (Sangamon) as well. Evidence which suggests the Bay was open periodically during the Wisconsin is derived from amino acid dating of marine shells. Shilts assigns an age of 135,000 + years to the Bell Sea (interglacial-Missinaibi beds) and notes that amino acid ratios of shells, collected from post-Missinaibi tills throughout the Lowland, occur in 4 groupings. These ratios (relative ages) are tentatively assigned ages of around 135,000 - 106,000 years (Bell Sea), 76,000; 35,000; and 8,500 (Tyrrell Sea) years. The author shows a proposed stratigraphic reconstruction for the Hudson Bay Lowland based on interpretations from the amino acid dating and on earlier descriptions from the Lowland (Skinner 1973b, McDonald, unpublished notes and Netterville 1974). His reconstruction shows 3 post-Missinaibi tills and is based on the presence of marine deposits which were incorporated into these 3 tills. This is somewhat problematic, as noted by the author, because marine beds between Bell Sea and Tyrrell Sea deposits have not yet been identified in the Lowland, and because 3 post-Missinaibi tills have been identified only in the Fawn-Severn-Winisk area of the Lowland.

The paper reports on the most recent of evidence and describes the most up to date interpretations of the Pleistocene of the Hudson Bay Region, and especially the Hudson Bay Lowland. The implications of the findings in this paper are far-reaching. Shilts notes that, for example, the presence of a single ice dome over Hudson Bay as opposed to many smaller centres around the bay has important consequences with respect to earlier isostatic response models. Also, the configuration and dynamic history of the Laurentide ice sheet affects interpretations of events and conditions throughout northeastern North America during the Pleistocene.

Keywords: Glaciation, Laurentide Ice Sheet, Bell Sea, Wisconsin Glacial History, Amino Acid Dating, Missinaibi Beds, Till Deposits, Erratics, Sangamon Interglacial.

Location: H.B.R., H.B.L.

195. SHILTS, W.W., C.M. CUNNINGHAM AND C.A. KASZYCKI. 1979. Keewatin ice sheet - re-evaluation of the traditional concept of the Laurentide ice sheet. Geol. 7: 537-541.

The authors review previous concepts of the origin and development of the Laurentide ice sheet with respect to the importance of the Keewatin region (northwestern Hudson Bay) as a major glacial accumulation and dispersion centre. They then examine the evidence collectd to date from the western Hudson Bay region. This includes recent findings based on the analyses of till samples collected from boreholes along the proposed route of the natural gas pipeline between Longlac, Ontario and the high arctic. A number of these boreholes are within the Manitoba portion of the Hudson Bay Lowland.

The proportion of Paleozoic to Precambrian granules, and the dispersion pattern of distinctive red erratics (Dubawnt Group) in the Baker Lake-Eskimo Point area, suggest a much more prominent role for the Keewatin ice sheet than traditionally accepted. Estimates of the minimum dispersion rate of the red erratics in this area suggest that the Keewatin ice sheet was active early in the Wisconsin. The authors conclude that it existed throughout the Wisconsin and originated in Keewatin as a distinct ice sheet. They also suggested that the Labradorean ice sheet may have originated by the coalescing of a number of smaller centres.

Keywords: Laurentide Ice Sheet, Keewatin Ice Sheet, Glaciation, Deglaciation, Erratics, Till Analyses.

Location: H.B.R., Man. H.B.L.

196. SIMPSON, S.J. 1972. The York Factory area, Hudson Bay. unpub. Ph.D. Thesis, U. Man.:287 p.

"York Factory and the Hayes River estuary, located on the southwestern coastline of Hudson Bay, have an unique heritage of early trade and exploration. In 1957 this historic fur trading post closed after two hundred and seventy-five years of trading with the Indians. A series of early maps, dating from the 17th century, when compared with contemporary surveys, indicate the distinct seaward progression and changes in the configuration of Beacon Point.

"An inter-disciplinary studies group comprising representatives from the fields of Botany, Geomorphology, History and Soil Science visited the York Factory area during the 1969 and 1970 summer field seasons. The objective was the collection of botancial, geomorphological and pedological data concerning the existing environmental patterns, and the evolution of the point of land between the mouths of the Nelson and Hayes Rivers. This data has subsequently been synthesised within a geographical framework.

"The most conspicuous relief elements of the area are the series of raised beach and inter-beach systems. There occurs a generally consistent zonation of soils and vegetation from the present coast inland, reflecting the emergence of new habitats and parent materials as the coastline of Hudson Bay recedes seaward. The occurrence and initiation of permafrost, following emergence, is closely related to the evolutionary sequence of soil, vegetation and topographic patterns. Radiocarbon dating of beach materials indicate the relatively recent emergence of the York Factory area in the last 2,500 years.

"The progression seaward of Beacon Point is a function of glacial rebound on a regional scale along the southwestern coastline of Hudson Bay, and of localised channel and coastal aggradation processes operative nearshore in the estuarine environment. Present rates of post-glacial uplift are of the order of 4 feet per century. The combined effects of the endogenetic and exogenetic processes operative in the area have been the extension bayward of Beacon Point at a contemporary rate of 18 - 20 feet per year. Initially (i.e. circa 2,000 B.P.) this rate was of the order of 70 - 75 feet per year." - ABSTRACT.

This thesis presents a fairly detailed and complete analysis of a small but interesting portion of the Lowland's coast. In-depth studies were carried out of the physiography, soils, permaforst landforms, vegetation, a coastal geomorphology and estuarine geomorpholgy of the complex Hayes - Nelson Estuary in Manitoba. Landforms and geomorphic processes were evaluated in order to explain the initiation and development of the penisula between the two rivers (Beacon Point). In addition, the author reviews the exploration and commercial development of the York Factory area relative to the importance of Hudson Bay and the Nelson River basin in Canada's history. The author also provides a review of the physical setting of the area within the Hudson Bay Lowland Region including regional physiography, climate, bedrock and surficial geology.

The field studies were carried out along a transect ('baseline') surveyed across the major physiographic sequences of the point along the exposed bluff of the north bank of the Hayes River. Nine soil series are described and reference profile descriptions and sedimentary histories are provided in an appendix. In another appendix the author provides 13 detailed descriptions of river bank exposures along the south edge of Beacon Point. Driftwood samples taken from a coarse marine bed in these exposures were radiocarbon dated to determine uplift rates for the area. These dates, plus a date from Craig (1969) from further inland (375' a.s.l.), were used to construct an emergence curve which provided calculated estimates of between 3.12 ft (.94 m) and 4.29 ft (1.30 m) per century for current uplift. The author indicated a preference for the higher rate. He also discussed the controversy between R. Bell and J. Tyrrell as to whether or not the land in this part of Hudson Bay was still (as of late 1800's) undergoing uplift. Simpson used geomorphologic and physiographic evidence among others to show that uplift is still continuing and that Beacon Point has been continuously prograding seaward since its initation 2500 year B.P.

Keywords: Physiography, Pedology, Isostacy, Vegetation, Coastal Geomorphology, Beach Ridge Development, Raised Ridge Morphology and Colonization, Fluvial Sedimentation, Erosion and Hydrology, Quaternary History, Permafrost, Exploration and Development, Estuarine Processes, Landscape Development.

Location: Man. H.B.L. (Nelson - Hayes Estuary), H.B.L.

197. SIMS, R.A., J.L. RILEY and J.K. JEGLUM. 1979. Vegetation, flora and vegetational ecology of the Hudson Bay Lowland: a literature review and annotated bibliography. Can. For. Serv., Sault Ste. Marie, Ont., Inf. Rept. 0-X-297:177 p.

This report consists of i) a reivew of literature on the Hudson Bay Lowland under four headings: study area, floristics and phytogeography, vegetation ecology and natural impacts upon vegetation and ii) an annotated bibliography together with keyword and location indicies.

Keywords: Annotated Bibliography, Vegetation Ecology, Peatland.

Location: H.B.L.

198. SIMS, R.A., D.W. COWELL and G.M. WICKWARE. in press. The classification and characteristics of coastal fens, southwest James Bay, Ontario. submitted to Can. J. Bot.

"Forty-seven fens occuring within one to forty-three km of the southwest James Bay coast were classified into four fen types (graminoid, low shrub, graminoid-rich treed and Sphagnum-rich treed) on the basis of vegetation physiognomy. Variability of the four fen types are shown in relation to vegetation, thirteen water quality parameters of the groundwater, depth to water table, peat thickness and minimum distance from coast.

"Principal Components Analysis is used to demonstrate the relationship between the fen types vegetationally, but other analyses indicate that separations can also be made using environmental measures on the four fen types with the following parameters, in decreasing order of importance, to be best discriminators: pH, depth of peat, SO_4^-, K^+, and depth to water table.

"Because of isostatic rebound distance from the coast represents a temporal as well as a spatial gradient. Peat depth is directly related to distance from the coast, increasing at a mean rate of 4.7 cm for each kilometer inland. Na^+ plus Cl^- in the groundwater in the fens decreases asymptotically with increasing distance from the coast." - ABSTRACT.

Keywords: Fens, Vegetation, Ecological Classification, Water Quality, Peatland Characteristics, Chemical Analysis of Groundwater, Pedology.

Location: Ont. H.B.L. (coastal zone south and southeast of Albany River)

199. SJÖRS, H. 1959. Bogs and fens in the Hudson Bay Lowlands. Arctic 12 (1):2-19.

The author discusses the chemical and hydrological differences between bogs and fens, provides some general information on the Hudson Bay Lowland and describes the drainage, topography and vegetation of peatlands in the Attawapiskat and Muketei rivers area. This area was described by Sjörs in much more detail in a later publication (1963 - see below). He also briefly discusses permafrost features of the Attawapiskat ('black spruce islands') and Hawley Lake (palsas - see Sjörs 1961) areas, characteristics of sedimentation and erosion along the Attawapiskat River and climatic controls on bog formation. His discussions on the relationship between bog and fen morphology, which he expands even further in his 1963 paper, are particularly interesting. The paper is well illustrated with photographs, maps and cross-sections (of a raised bog and palsa) and presents a good summer of the author's work in the Hudson Bay Lowland.

Keywords: Peatland Characteristics, Vegetation, Physiogrphy, Permafrost, Palsas, Black Spruce Island.

Location: Ont. H.B.L. (especially Hawley Lake - Attawapiskat River)

200. SJÖRS, H. 1961. Forest and peatland at Hawley Lake, northern Ontario. Nat. Mus. Can., Cont. Bot. Bull. 171:1-31.

This paper is primarily a discussion of vegetation ecology and peatland types in the Hawley Lake area of Ontario's Hudson Bay Lowland. The author includes a description of the physiography of the Hawley Lake district, a podzolic profile, peat type and depth in an organic soil profile and the morphology, origin and occurrence of palsas in the area. Sjörs discussion of palsa origin (from moss hummocks) and development (freezing of water in the hummocks) is particularly interesting (also see Railton and Sparling 1973). He provides a cross-section of a palsa which shows the occurrence of ice within the upper 2 meters. He was not able to core beneath this depth into the mineral substrate (at 3m in the surrounding fen). Sjörs notes that permafrost is restricted to palsas in the Hawley Lake area. Seasonal ice occurs beneath small *Sphagnum fuscum* hummocks.

Keywords: Vegetation, Peatland Characteristics, Physiography, Permafrost, Pedology, Palsas.

Location: Ont. H.B.L. (Hawley Lake - Sutton Ridges)

201. SJÖRS, H. 1963. Bogs and fens on the Attawapiskat River, northern Ontario. Nat. Mus. Can., Cont. Bot. Bull. 186:45-133.

This paper is a classic in Canadian peatland literature. It is a thorough, well-illustrated and clearly written monograph on the chemical, hydrological and vegetational characteristics and control on peatland development and pattern in the central Hudson Bay Lowland. Sjörs utilizes a number of excellent photographs, including colour plates, black and white photos and vertical aerial photos; cross-sections; tables of water chemistry and vegetation species; and interpretive sketches of aerial photos to illustrate his discussions. He uses the concepts of minerotrophy (fens) and ombrotrophy (bogs) to discuss the various peatland patterns and types and to organize the majority of the paper.

Sjörs begins with a general account of the climate, physiography and phytogeography of the Lowland taken from a number of references. He then discusses concepts and definitions of minerotrophy and ombrotrophy as applied to European and Scandinavian peatlands, peatland types as defined by vegetation units and presents an overview of the Attawapiskat peatland. This is followed by more detailed discussions and descriptions of the topography, hydrology, chemistry and flora of ombrotrophic and minerotrophic peatlands in the study area including sections on oxidation, bog-pools, ice effects and patterns of ridges, flarks and fen-pools. The last part of the paper discusses 'black spruce islands', peat stratigraphy and peatland development in a raised bog, general peatland succession, the origin of peatland lakes and potential resources of the area.

Sjörs discussion of black spruce islands, as a characteristic permafrost feature in this area is especially interesting and is one of the most complete to date (pages 107-114). He considers them to be a southern type of 'frozen mound' genetically and morphologically separate from palsas. He describes an 'island' from the study area in detail noting its central unfrozen 'crater' formed by collapse and separated by a well forested frozen rim (not all the islands in the study area have collapse scars). Their occurrence south of the zone of continuous permafrost and the absence of active permafrost features in the study area suggests they are relic. Although there have not been any severe climatic changes since the study area emerged from the Tyrrell Sea, the author believes their degradation is due to recent minor increases in global temperatures. This seems quite plausible because they occur within the present zone of discontinuous permafrost and because peatlands are considered to be more susceptible to freezing than mineral terrain under the same climatic conditions (Brown 1968). This explanation may also explain the 'mysterious' ring features of the boreal forest peatlands observed by Dean (1959) and others.

This work represents the most detailed and comprehensive study of the Hudson Bay Lowland peatlands published to date and is highly recommended for any one interested in peatlands. It also has a fairly extensive bibliography covering peatland studies in Canada, Europe and Scandinavia.

Keywords: Vegetation, Peatland Characteristics, Peatland Development, Physiography, Permafrost, Black Spruce Islands, Palsas, Minerotrophy.

Location: Ont. H.B.L. (Attawapiskat River)

202. SKINNER, R.G. 1973a. Pleistocene stratigraphy of the Hudson Bay Lowland. Proc. Symp. Physical Env. Hudson Bay Lowland, U. Guelph, Ontario:1-16.

This paper is concise but useful précis of the author's succeeding report on the Quaternary of the Moose River Basin (Skinner 1973b). Skinner studied the river bank sections of the Moose River and its major tributaries in order to construct an interpretation of Quaternary events in the region. Drawing information from other reports, he attempts to review the sequence of deposits and reconstruct glacial - non-glacial environments in the Hudson Bay Lowland. He points out that deposits of the Hudson Bay region are very important because they are close to the centre of ice accumulation (Laurentide ice sheet) and should enhance the interpretations of events made from more southerly deposits. His interpretations of paleoenvironments are especially significant as they are the most complete and detailed to date and point out very clearly where further data are required.

Skinner describes 3 basal tills which he refers to as tills I, II and III separated by nonglacial, glaciolacustrine deposits I-II and II-III. Till III is followed by the nonglacial Missinaibi beds to which the author assigns formational status and agrees with McDonald (1969) that they are interglacial, probably late Sangamon. These are followed by the Adam Till, Friday Creek nonglacial (fluvial) sediments and Kipling Till which Skinner suggests may be correlative with the Cochrane Till to the south. The evidence for this however remains very thin. The density flow of saline water is incorporated to explain a marine clay-pebbly gravel above the Kipling Till and below the Tyrrell Sea clay and silt deposits. The marine deposits are overlain by alluvium, aeloian sands (in places) and peat. Skinner interprets each deposit according to possible paleoenvironments, and direction of deposition noting the simularities between the deposition of the Missinaibi Formation (including climate) and those of postglacial time. He also attempts some correlation with sequences in southeastern Canada.

Keywords: Quaternary Stratigraphy and Chronology, Missinaibi Beds, Paleoenvrionments, Palynology, Glaciation, Deglaciation, Interglacial Sediments, Cochrane Till, Till.

Location: Ont. H.B.L., H.B.R.

203. SKINNER, R.G. 1973b. Quaternary stratigraphy of the Moose River Basin, Ontario. Geol. Surv. Can., Bull. 225:77 p. (plus accompanying maps and diagrams).

In this bulletin, Skinner reports on the detailed studies carried out by himself and by some earlier workers in the Moose River Basin, especially on the

Mattagami, Missinaibi and Abitibi rivers and their main tributaries. It is the most complete work to date on the Quaternary deposits and interpretations in the Hudson Bay Lowland. In addition to a detailed account of the stratigraphy, lithology, composition and interpretation of glacial and nonglacial deposits, Skinner presents detailed and generalized fence diagrams of river bank exposures along the Abitibi, Kwataboahegan, Pivabiska, Soweska, Missinaibi, Moose, Mattagami, Opasatika rivers; Friday and Adams creeks; and Smoky Falls and Smoky Falls road. These are based on over 130 exposures described by the author and in earlier studies. He also lists 39 C^{14} age determinations for the James Bay Lowland including 22 which have known elevations. He uses these to draw a time-altitude curve for the area which shows isostatic recovery decreasing from about 8 m/100 yrs, 6000 years ago to about 1 m/100 yrs at present. Skinner uses analyses of grain size, carbonate content, palynology, ice and water flow directions and stratigraphic position presented in graphic and map form to describe and interpret the Quaternary deposits of this part of the Lowland. He presents convincing arguments for most of his interpretations especially with respect to the age of the Missinaibi beds (Sangamon), and the origin of the pebbly-clay marine sediments of the Tyrrell Sea (high density saline underflow). However he is careful not to conclude an age for the nonglacial, Friday Creek sediments; the route of marine transgression of the Tyrrell Sea from Hudson Bay; nor correlate the upper till of the Moose River Basin (Kipling Till) with the Cochrane Till to the south without more data. The author established the presence of marine sediments in the Missinaibi Formation ($>$ 53,000 years) which were first recognized by Prest (1966) and coins the name 'Bell Sea' for this marine incursion. Fossils from these sediments indicate the Bell Sea had a similar temperature and salinity as the Tyrrell Sea and present day Hudson Bay. He also shows isobases on the marine limit of the Tyrrell Sea which indicate maximum tilt toward the northeast which suggests the location of maximum ice accumulation to be on the northeast side of James Bay. This agrees with the conclusion of Andrews (1969).

The author's major conclusions are:

"a) Three pre-Wisconsin tills in the southwestern portion of the study area wer deposited when the margin of a southwestward flowing ice sheet fluctuated into a proglacial lake.

"b) The Missinaibi Formation was deposited during an interglaciation, probably the Sagamon. The formation includes an ubiquitous buried soil developed on glacial, marine, and fluvial sediments; a forest growing on the soil was killed and buried beneath thick deposits of a proglacial lake. The bulk of interglacial time is recorded beneath the lake sediments, not in them as previously thought.

"c) Two Wisconsin tills, both deposited by southwestward flowing ice, outcrop in the area. A nonglacial unit between the tills is either Middle or Late Wisconsin in age. A Middle Wisconsin age implies a significant decrease in volume of the world's ice sheets and relatively high sea levels. A Late Wisconsin age requires rapid rates of glacial advance and retreat during a time of rapid deterioration of the Laurentide Ice Sheet.

"d) A lake preceded the Tyrrell Sea in a large area south of James Bay. About 7,800 years ago when the Tyrrell Sea entered the region, sea water wedged under fresh water, apparently creating a current strong enough to rework lake clays into a clay-pebble gravel.

"e) A synchronous marine limit was established over a vast area. The inferred former water plane defined by marine limit is now warped up to the northeast having a gradient of about 30 cm/km in the direction of the supposed former ice center."

Keywords: Quaternary Stratigraphy and Lithology, Palynology, Glaciation, Deglaciation, Marine Inundation, Interglacial Marine Inundation ('Bell Sea'), Isostacy, Tills, Missinaibi Beds, Interglacial Sediments, Cochrane Till, Paleoenvironments.

Location: Ont. H.B.L. (Moose River Basin)

204. SOCIÉTÉ d'ENERGIE de la BAIE JAMES. 1978. Connaissance du milieu des territoires

de la Baie James et du Nouveau-Québec. Soc. D'énergie Baie James, Serv. Env., Montréal Québec:297 p.

Keywords: Socio-Economic, Surficial Geology, Ecological Studies, Pedology, Hydrology, Paleozoic and Precambiran Geology, Vegetation, Wildlife, Aquatic Ecology.

Location: Qué. H.B.L., North-Central Québec

205. STOCKWELL, C.H., J.C. MCGLYNN, R.F. EMSLIE, B.V. SANFORD, A.W. NORRIS, J.A. DONALDSON, W.F. FAHRIG and K.L. CURRIE. 1972. The Hudson Platform. in Geology and Economic Minerals of Canada. R.J.W. Douglas (editor). Geol. Surv. Can., Economic Geol. Rept. 1, 5th ed:137-147.

This is an excellent, concise review on the geology of the Hudson Platform of which the Lowland is part. It provides a good review for those who are not interested in detail.

Keywords: Paleozoic Stratigraphy, Paleozoic Geology, Economic Geology.

Location: H.B.L., H.B.R.

206. TARNOCAI, C. 1972. Some characteristics of Cryic Organic soils in northern Manitoba. Can. J. Soil. Sci. 52:485-496.

This paper compares the physical and chemical properties of two frozen organic soils and between two active and frozen layers of each profile. One soil was taken from a palsa in the southwest portion of the discontinuous permafrost zone and the other was taken from a peat plateau in the York Factory area of the Hudson Bay Lowland. The author describes the profiles, presents the chemical data and discusses characteristics of bulk density, water content and cation exchange. Bulk density was found to increase with depth (especially into the mineral substrate). Whereas the moisture content (ice) was highest in the frozen peat. An especially interesting finding was the high concentration of Ca^{++} in the frozen peat as compared to the active layer (2 times).

Keywords: Pedology (organic), Permafrost, Palsa, Peat Plateau.

Location: Man. H.B.L., Northern Manitoba.

207. TARNOCAI, C. 1974. Exploratory terrain study of northern Manitoba and southern Keewatin, N.W.T. Can. Soil Surv., Winnipeg, June 1974: 75 (plus map).

This report is predominately a study of landscape types on the west side of Hudson Bay. The author has mapped the terrain types (map included - scale approx. 1:1,000,000) and briefly describes each of his mapped units defined by glacial deposits (3 units), bedrock and organic deposits (5 units). The majority of the report describes the itinerary of the reconnaissance survey including ground truth data at each stop and landscape characteristics between stops. Ground truth data includes descriptions of surface morphology, presence of permafrost, dominant vegetation and soil profiles. Approximately 25 profiles are described in full or in part from the Hudson Bay Lowland; from sites near York Factory and Churchill. These soils are mainly Cryosols (Gleysolic, Organic), Regosols and Organic soils (Mesisols). Chemical data are listed for 6 of the Lowland soils from the Churchill area (1 Regosol and 5 Organic Cryosols).

Keywords: Pedology, Physiography, Vegetation, Permafrost.

Location: Man. H.B.L., Northern Manitoba, Keewatin

208. TASK FORCE ONAKAWANA. 1973. Report of Task Force Onakawana, being a preliminary investigation of the environmental effects of development of Onakawana lignite deposits. Ont. Min. Env., unpub. ms.:65 p.

This report discusses a number of environmental (soils, water, wildlife and vegetation) and social problems which will have to be dealt with if the proposed lignite mine and thermal generating station at Onakawana, south of Moosonee, is developed. The report is very preliminary and only attempts to point out areas of concern. It includes a section discussing physical and climatic characteristics of the site area (between the Abitibi and Mattagami rivers). This section briefly describes the bedrock geology, surficial deposits, landscape and soils of the area. The authors describe two characteristic soils including a Terric Mesisol and Gleysol [editor's intrepretation]. They provide a profile description and general descriptions of organic and mineral composition and texture.

Keywords: Socio-Economic, Pedology, Physiography, Water Quality, Wildlife, Vegetation, Environmental Impact.

Location: Ont. H.B.L. (Moose River Basin)

209. TELFORD, P.G. 1979. Mesozoic stratigraphy of the Moose River Basin. in Mesozoic geology and mineral potential of the Moose River Basin, District of Cochrane. P.G. Telford and H.M. Verma (editors). Ont. Geol. Surv., Open File Rept.: 62-93.

This paper is based primarily on the results of the 1975 and 1977 drilling programs by the Ontario Geological Survey to determine the nature, extent and mineral potential of the Mesozoic Mattagami Formation (see

Telford _et al_. 1975, and Verma _et al_. 1978). The author describes these drilling programs then discusses the distribution and thickness, lithology, age and correlation and stratigraphic relations of the Mesozoic sediments.

Keywords: Mesozoic Stratigraphy, Mesozoic Geology, Mattagami Formation, Drill Holes, Lignite.

Location: Ont. H.B.L. (Moose River Basin)

210. TELFORD, P.G., M.A. VOS and G. NORRIS. 1975. Geology and mineral desposits of the Moose River Basin, James Bay Lowlands, preliminary report. Ont. Div. Mines, Open File Rept. 5158:56 p.

This report discusses the preliminary results of palynologic, petrologic, stratigraphic and economic analyses of the geophysical and drilling programs carried out in the Moose River Basin during the winter of 1975. These studies were primarily engaged to determine the extent and nature of the Mesozoic clays, sands, and lignites in this basin (see Rogers _et al_. 1975). This is primarily a summary report outlining the kinds of studies undertaken, the kinds of analyses being carried out and presenting some preliminary results of palynological investigations and updating information on the nature and extent of the Mesozoic deposits. Summaries of the drill logs for 5 of the 6 holes are also included.

The results of the palynological investigations are particularly significant because they provide an age determination of the Mattagami Formation and help develop the palynological zonation for stratigraphic correlation. The work of Dr. Norris established a late Middle or Late Albian (Lower Cretaceous) age for the upper part of the Mattagami Formation. In addition the palynofloral evidence suggests the presence of a Middle Jurassic series ('Mistuskwia Beds') at the base of the Mattagami Formation in the north part of the basin. The authors inlcude complete species lists identified from samples in 5 of the 6 bore holes.

Keywords: Mesozoic Palynology, Mesozoic Petrography, Mesozoic Stratigraphy, Economic Geology, Pleistocene Stratigraphy, Mattagami Formation, Lignite.

Location: Ont. H.B.L. (Moose River Basin)

211. TELFORD, P.G. and H.M. VERMA. 1978. Cretaceous stratigraphy and lignite occurrences in the Smoky Falls area, James Bay Lowland; preliminary lithological logs from the 1978 drilling program. Ont. Geol. Surv., Open File Rept. 5255:60 p.

This is a compendium of drill logs from 8 holes drilled between August and October 1978 across the southern portion of the Moose River Basin between the Missinaibi and Abitibi rivers. This work was carried out as part of the Ontario Geological Survey program to define the extent and stratigraphy of the Mesozoic deposits (see Guillet 1979).

Keywords: Economic Geology, Mesozoic Stratigraphy, Drill Logs, Lignite, Mattagami Formation.

Location: Ont. H.B.L. (Moose River Basin, Missinaibi - Abitibi rivers)

212. TELFORD, P.G. and H.M. VERMA (editors). 1979. Mesozoic geology and mineral potential of the Moose River Basin, District of Cochrane. Ont. Geol. Surv., Open File Rept.: 311 p.

This is a compilation of 5 papers discussing the geology and economic potential of the Mattagami Formation in the Moose River Basin. It is based primarily on the results of the 1975, 1977 and 1978 drilling programs carried out by the Ontario Geological Survey (see Telford et al. 1975, Verma et al. 1978 and Telford and Verma 1978) including papers by Verma, Telford, Hamblin, Norris and Vos. The document is an open file report but is to be released as an Ontario Geological Survey publication.

Keywords: Mesozoic Stratigraphy, Mesozoic Palynology, Mesozoic Petrography, Economic Geology, Pleistocene Stratigraphy, Mattagami Formation, Lignite.

Location: Ont. H.B.L. (Moose River Basin)

213. TERASMAE, J. 1957. Paleobotanical studies of Canadian Pleistocene nonglacial deposits. Sci. 126 (3269):351-352.

This is a short paper summarizing preliminary palynological investigations of nonglacial peat desposits situated between glacial tills. Terasmae examined the pollen assemblages from deposits situated between glacial tills. Terasmae examined the pollen assemblages from deposits in the St. Lawrence Lowland, Québec and the Hudson Bay Lowland, Ontario (Missinaibi River). He noted the absence of marine deposits with the peats and reported ages of greater than 38,000 to 40,000 yrs B.P. based on radiocarbon dating. He concluded that the deposits probably represent a major nonglacial stage within the Wisconsin glaciation rather than an interglacial period. The pollen from the Hudson Bay Lowland deposits indicate an arctic or subarctic environment dominated by birch, alder, black spruce (*Picea mariana*) and white spruce (*Picea glauca*) plus nontree pollen. Relatively high values of pine pollen (*Pinus banksiana*) occurred in the middle of the sequence, possibly indicating a slightly warmer period.

Keywords: Glaciation, Palynology, Radiocarbon Dating, Forest Cover, Interglacial Deposits, Missinaibi Beds.

Location: Ont. H.B.L. (Missinaibi River), Southern Québec.

214. TERASMAE, J. 1958. Contributions to Canadian Palynology; Part III Non-glacial deposits along Missinaibi River, Ontario. Geol. Surv. Can., Bull. 46:29-34.

This paper is a more detailed account of pollen studies carried out on non-glacial peat beds of the Missinaibi River briefly described earlier by Terasmae (1957). In this account he describes the Pleistocene stratigraphy of river sections as described by O.L. Hughes of the Geological Survey of Canada from the Missinaibi River. He also discusses Auer's (1927) findings and quotes McLearn's (1927) account of the Pleistocene sequence (in terms of environments of deposition) described from the Soweska River.

Terasmae (1957) stated that a slight warming was indicated by increases in pine pollen (Pinus banksiana) in the middle of the sequence. In this paper however he concluded that "the climate throughout the non-glacial period remained fairly uniform and was probably slightly cooler than the present". The nonglacial period is estimated to have been only about 6000 years in duration. He again concludes that these beds indicate a major retreat substage of the early Wisconsin advance which at the time of writing was not identified in the accepted Pleistocene stratigraphic column for eastern North America.

Keywords: Palynology, Pleistocene Stratigraphy and Chronolgy, Glaciation, Interglacial Deposits, Paleoenvironments.

Location: Ont. H.B.L. (Missinaibi River)

215. TERASMAE, J. and O.L. HUGHES. 1960a. A palynological and geological study of Pleistocene deposits in the James Bay Lowlands, Ontario. Geol. Surv. Can., Bull. 62:15 p.

In this paper Hughes presents his descriptions of Pleistocene sediments from 3 sections described from the

Missinaibi and Opasatika rivers in 1954. In these descriptions he identifies 2 main till/drift deposits below the nonglacial beds and 1 main drift above followed by recent marine clays for a total of 5 units. The authors coined the term "Missinaibi beds" for the nonglacial sequence of silt, clay and peat which they propose for interstadial rank. Radiocarbon ages on peat and wood suggest an age of greater than 38,000 years and the authors report a possible radiocarbon age of more than 53,000 years (GRO 1435) which would make the Missinaibi beds older than the main Wisconsin Glaciation but younger than the Sangamon Interglacial. Also the palynology indicates a climate that was cooler or similar to the present, and other evidence (e.g. Don beds, Toronto) suggest the Sangamon was warmer than at present and of much longer duration (Terasmae 1958). Drilling east and west of the Abitibi River at Otter Rapids indicates the Missinaibi beds pinch out away from the river, suggesting them to be ancient river-laid deposits.

Terasmae presents palynological descriptions of two Missinaibi River sections (including pollen diagrams), of the Otter Rapids bore holes and a section from the Albany River described by M.Y. Williams in 1920 (Wiliams 1921). He also provides descriptions and pollen diagrams of the assemblages from 3 postglacial peat deposits to show the similarity of present ecological conditions to those represented by the Missinaibi beds. These sections are from the Ogoki Post bog and the Attawapiskat River sections studied in 1957 by H. Sjörs and W.K.W. Baldwin, and the Frederickhouse River bog west of Cochrane. The authors note however that it is more difficult to distinguish botancial variations due to climate in the past, in the north than in the south where there is greater species diversity and these are more climate sensitive.

Keywords: Pleistocene Stratigraphy and Chronology, Glaciation, Palynology, Forest Cover, Radiocarbon Dating, Interglacial deposits, Missinaibi Beds.

Location: Ont. H.B.L. (Missinaibi, Albany, Abitibi and Attawapiskat rivers)

216. TERASMAE, J. and O.L. HUGHES. 1960b. Glacial retreat in the North Bay area, Ontario. Sci. 131 (3411):1444-46.

The authors discuss aspects of deglaciation in the area of North Bay and north of the southern edge of the Hudson Bay Lowland. They suggest a minimum age for marine submergence at 7875 $\pm$ 200 years based on radiocarbon dates of shells from near the upper limit of the Tyrrell Sea along the Opasatika and Missinaibi rivers. This date is older than the 6380 $\pm$ 350 years previously reported in the literature, and noted by the authors, for final deglaciation in the Cochrane area.

Keywords: Pleistocene Chronology, Deglaciation, Marine Inundation, Radiocarbon Dates.

Location: Ont. H.B.L. (Opasatika and Missinaibi rivers), Northeastern Ontario

217. TYRRELL, J.B. 1890-91. Explorations in northern Manitoba in 1890 and 1891. Geol. Surv. Can., Ann. Rept. 1890 and 1891 pt. A.

Keywords: Physiography, Glaciation, Paleozoic Geology.

Location: Man. H.B.L., Northern Manitoba

218. TYRRELL, J.B. 1896. Is the land around Hudson Bay at present rising? Am. J. Sci. Ser. 4 vol 2:200-205.

This short paper is a reply to a critism made by R. Bell (1896) of Tyrrell's conclusion in an 1894 paper that there was no evidence of uplift at Churchill (Fort Prince of Wales), at least between the late 1700's and late 1800's. Tyrrell attempts to substantiate this by critizing Bell's proofs, dismissing most of the accounts as 'delusion' and indicating that the historical evidence indicates little or no uplift in the Churchill area over the previous 100 years (Tyrrell makes it clear that he believes there has been "an elevation of the land of several hundred feet in post-glacial times"). This evidence includes the height of names of seamen chisseled into the rock above high tide in the mid 1700's. Tyrrell used Bell's estimate of 7 ft/100 years for the Churchill area (Bell 1880) to disprove the occurrence of uplift at present. Much of the evidence Tyrrell uses however would allow an uplift of 2 or 3 ft/100 years as is now believed.

Keywords: Isostacy, Historical Accounts.

Location: Man. H.B.L. (Churchill)

219. TYRRELL, J.B. 1898. The glciation of north-central Canada. J. Geol. 6:147-160.

This paper is based on the author's field surveys west of Hudson Bay, primarily in the District of Keewatin. He reports on straie, erratics and other glacial features and concludes that the main Wisconsin ice sheet in northeastern North America was composed of a number of centres of activity including a major Keewatin glacier. This is a landmark paper because up to this point there was little or no evidence indicating more than one centre of accumulation and dispersion during the Wisconsin (also see Tyrrell 1913). It is also significant because at this time continental glaciation theory was not well developed and many still believed most glacial deposits and features were the product of floating/grounding icebergs (Zaslow 1975, p. 164).

Keywords: Glaciation, Pleistocene Deposits, Erratics, Glacial Straie.

Location: Keewatin (northwest Hudson Bay), H.B.R.

220. TYRRELL, J.B. 1900. The stability of the land around Hudson Bay. Geol. Mag., Ser. 4 vol. 7:266-267.

This is a short update to Tyrell's 1896 assertion that the land in the Churchill area is presently not rising and is in equilibrium. Tyrrell refers to a recently translated account of a voyage to Churchill made in 1619 by Danish explorer Jens Munck. In the account Churchill harbour is described and mention is made of a sunken rock just below sea level and a harbour depth of 7 or 8 fathoms. Tyrrell notes that this is how it was in 1893, 270 years later, which indicates uplift of 7 to 10 ft per 100 years (Bell 1880) has not taken place.

Keywords: Isostacy, Historical Account.

Location: Man. H.B.L. (Churchill)

221. TYRRELL, J.B. 1913. Hudson Bay exploring expedition, 1912. Ont. Bur. Mines 22 (1):161-209.

This report is an interesting account of the author's exploration of the Nelson, Hayes, Gods (Shamattawa), Severn and Fawn rivers in 1912. It is well illustrated with photos of the people and country visited. The explorations were undertaken in order to locate and survey frontage for the Province of Ontatio on the shore of the Nelson River, presumably for port facilities, under an agreement with the Province of Manitoba. It was also designed to learn as much as possible about the District of Patricia which had been added to Ontario's territory in the previous session of the Parliament of Canada.

Tyrrell describes the character of the rivers he travelled and briefly discusses the physiography, forests, climate, people, animals, minerals, potential for agriculture and geology of the District of Patricia. He compares the southern Shield portion with the poorly drained, flat Hudson Bay Lowland and provides interpretations of landscape developlment vis à vis glacial, fluvial and marine processes and events. He briefly describes the Precambrian, Ordovician and Silurian exposures along the Severn and Fawn rivers. He also includes detailed fossil lists and descriptions made by W.A. Parks.

The most significant geological and historical contribution of this paper is Tyrrell's description and interpretations of the Pleistocene sequence. He attempts to explain their origin by invoking 3 glacial advances from 3 different centres of accumulation during the last major glaciation. Tyrrell recorded at least 3 prominant orientations of glacial striae and assigned each to a separate glacial advance. One of these was the Patrician Glacier, which he postulated to have advanced from an accumulation centre on the height of land between lake Superior and Hudson Bay northward into Hudson Bay. The existence of a Patrician ice accumulation centre is now considered unlikely (Flint 1943, Prest 1970b, Shilts 1980).

Tyrrell was the first to describe nonglacial deposits of sand, gravel and peat between tills and assign them as interglacial. The report includes a map of his survey of the mouths of the Nelson and Hayes rivers and a map of the route of his explorations showing prominant features.

Keywords: Physiography, Quaternary, Pleistocene Deposits, Landscape Evolution, Glaciation, Isostacy, Interglacial Deposits, Paleozoic Stratigraphy and Paleontology.

Location: Ont. H.B.L. (Nelson, Hayes, Severn, Gods and Fawn rivers), H.B.R.

222. TYRRELL, J.B. 1916. Notes on the geology of the Nelson and Hayes rivers. Roy. Soc. Can., Trans. Ser. 3 vol. 10(4):1-27.

Keywords: Paleozoic Geology, Surficial Geology.

Location: Man. H.B.L. (Nelson and Hayes rivers)

223. UPHAM, W. 1889. An exploration of the Glacial Lake Agassiz in Manitoba. Appendix I. Course of glacial straie. Geol. Surv. Can., Ann. Rept. IV pt. E:111-120.

The paper is a monograph describing the beaches and basin of glacial lake Agassiz based on 3 years field work in Minnesota. An appendix lists over 200 orientations of glacial straie recorded by the author in the Lake Superior region and by R. Bell of the Geological Survey of Canada in the Hudson Bay region. In the latter most of the recorded orientations are taken from shield areas around the Lowland, especially east of Hudson Bay and near Churchill. This compendium is significant because it represents one of the first attempts to use geomorphic evidence to describe the nature of glaciation and deglaciation in northeastern North America.

Keywords: Pleistocene Landforms, Glaciation, Deglaciation, Glacial Straie.

Location: H.B.R.

224. UTARD, M. 1975. Report on refraction seismic and resistivity survey in the James Bay Lowlands Cretaceous basin for the Ontario Ministry of Natural Resources. Ont. Div. Mines, Open File Rept. 5148, pt. II:47 p.

This report describes the seismic and resistivitiy operations and results carried out during the winter of 1975 along a winter road across the Cretaceous portion of the Moose River Basin. These investigations form part of recent explorations of the extent and quality of Mesozoic lignite, sand and clay deposits in the Basin by the Ontario Geological Survey. Drilling operations in the same program are desribed in Part I of this report (see Rogers et al. 1975).

Keywords: Geophysics, Mesozoic Stratigraphy, Economic Geology, Mattagami Formation, Lignite.

Location: Ont. H.B.L. (Moose River Basin)

225. VERMA, H. 1979. History of geological exploration in the James Bay Lowland. *in* Mesozoic geology and mineral potential of the Moose River Basin, District of Cochrane. P.G. Telford and H.M. Verma (editors). Ont. Geol. Surv., Open File Rept.: 25-61.

An excellent and complete review of geological exploration and development in the Moose River Basin focussing primarily on the Mesozoic deposits (Mattagami Formation).

Keywords: Literature Review (Geological Exploration), Economic Geology, Bibliography, Lignite, Mattagami Formation.

Location: Ont. H.B.L. (Moose River Basin)

226. VERMA, H.M., P.G. TELFORD and G. NORRIS. 1978. Geological studies east of the Abitibi river in the vicinity of Onakawana, District of Cochrane. Ont. Geol. Surv., Open File Rept. 5253: 74 p.

In response to the findings of Scintrex Surveys Ltd. (1976) three drill holes were sunk east of the Abitibi River by the Ontario Gelogical Survey to determine if the lignite deposits extended each of the known Onakawana fields. The report is divided into two parts, the first describing the stratigraphic results and the second the palynology. Logs of the 3 drill holes are provided.

The drilling did not reveal significant quantities of lignite east of the Abitibi River. The palynological studies confirmed the lated Middle Cretaceous age for the Mattagami Formation as reported in Telford *et al.* (1975). In addition, the Pleistocene sediments *in one* hole consisted, in part, of clay-silt rhythmites and the upper Cretaceous sediments revealed evidence of glacial overriding and shearing.

Keywords: Mesozoic Stratigraphy, Mesozoic Palynology, Pleistocene Stratigraphy, Economic Geology, Drill Holes, Mattagami Formation, Lignite.

Location: Ont. H.B.L. (Moose River Basin - Abitibi River)

227. VINCENT, J.S. and L. HARDY. 1979. The evolution of glacial lakes Barlow and Ojibway, Québec and Ontario. Geol. Surv. Can. Bull. 316:18 p.

This is the most recent treatment of these glacial lakes based, in part, on new evidence collected by the authors. It outlines the various lacustrine water planes and describes controls on their outlets. They reconstruct the location of the ice-front and of outlets relative to the glacial lakes in a series of schematic illustrations (similar to Prest 1970a). Of particular interest for the Lowland is their interpretation of the ice-front during the Cochrane I and II advances in the southern James Bay area. They show final northward drainage of glacial Lakes Ojibway occurring during the Cochrane II maximum approximately 7900 years ago. They also show 2 ice frontal positions at the time of the Cochrane II advance. These are the Cochrane ice-front, south and southwest of James Bay, and the Sakami ice-front, east and southeast of James Bay.

Keywords: Deglaciation, Glacial Lakes Barlow - Ojibway, Tyrrell Sea, Cochrane Advance, Cochrane Readvance.

Location: Southern H.B.R., northern Ontario, northern Québec.

228. VOS, M.A. 1975. Economic geology of the Cretaceous deposits, Moose river Basin, Ontario, General Appraisal. Ont. Div. Mines, Open File Rept. 5157:70 p.

This is an interesting compendium on the origin, petrography, characteristics, quality and potential uses of the unconsolidated Mesozoic lignite, silica sand, kaolin and fire clay deposits in the Moose River Basin. The author reviews the history of exploration, development and economic investigations of these deposits and briefly describes four properties held commercially. He also describes the chronological history of development at the Onakawana lignite field and provides fence diagrams for the Onakawana field. The paper does not interpret the economic viability of these minerals in terms of actual production costs and markets. It has recently been updated and published in more available form (Vos 1979).

Keywords: Economic Geology, Mesozoic Petrography, Lignite, Clays, Mattagami Formation.

Location: Ont. H.B.L. (Abitibi, Missinaibi, Mattagami and Moose Rivers)

229. VOS, M.A. 1979. Lignite and industrial mineral resources of the Moose River Basin. in Mesozoic geology and mineral potential of the Moose River Basin, District of Cochrane. P.G. Telford and H.M. Verma (editors). Ont. Geol. Surv., Open File Rept.: 223-311.

This paper is an in-depth review of the potential economic minerals representing the Mattagami Formation including silica sand, kaolinite, refractory clays and lignite. In addition, the presence of high-Ca limestone, gypsum, sand, gravel and peat in the Moose River Basin is referred to. The author reviews the 1975 drilling program in the basin (Telford et al. 1975) and presents summary descriptions of the drill logs. He also discusses the geological history of the basin and the formation (environments of deposition) and chemical and physical characteristics of the Mesozoic sediments.

Keywords: Economic Geology, Mesozoic Sedimentation, Mesozoic Stratigraphy, Lignite, Mattagami Formation, Limestone, Gypsum, Sand and Gravel, Drill Logs, Mesozoic Paleoenvironments.

Location: Ont. H.B.L. (Moose River Basin)

230. WAGNER, F.J.E. 1967. Additional radiocarbon dates, Tyrrell Sea area. Maritime Sed. 3(4):100-104.

Wagner publishes radiocarbon dates of shells, plant material and peat from 33 localities surrounding Hudson Bay and James Bay. Of these, 9 are from the Lowland including sites near Missinaibi River, Attawapiskat River, Hawley Lake, Cape Henrietta Maria and the Churchill River area (5 sites). The dates are taken from a number of published and unpublished sources. She constructs 3 uplift curves from these dates representing the northern (20 dates), central (6 dates) and southern (7 dates) Tyrrell Sea areas which suggest minimum uplift rates of approximately 20 ft/100 yrs, 16.5 ft/100 yrs and 12.5 ft/100 yrs respectively prior to 6500 yrs; and more recently 4.7 ft/100 yrs, 3.8 ft/100 yrs and 3.1 ft/100 yrs, respectively.

Keywords: Isostacy, Radiocarbon Dates, Tyrrell Sea.

Location: Ont. H.B.L. (Missinaibi and Attawapiskat rivers, Hawley Lake and Cape Henrietta Maria), Man. H.B.L. (Churchill), H.B.R.

231. WALCOTT, R.I. 1970. Isostatic response to loading of the crust in Canada. Can. J. Earth Sci. 7(2):716-727.

This paper reviews the general pattern of mean Free Air anomalies in Canada, east of the Rockies and examines their relationships with topography and locations of former ice centres. Walcott states that remaining uplift can be obtained by multiplying the negative anomaly values by 7. This suggests remaining recovery in the Hudson Bay Region to be in the order of 140 to 350 m. The author notes that the values for Eskimo Point (northwest Hudson Bay) are 52 to 66% of the total crustal depression which conflicts with the values estimated by Andrews (1968). In addition Andrews' relaxation time is based on an exponentially decreasing curve with the evidence suggested by the gravity anomalies. This is a difficult divergence in theory to resove because it depends on the geophysical behaviour of the crust which is not sufficiently understood. The mean Free Air anomalies in the Hudson Bay Region does not conform with the localities of ice accumulation postulated by Andrews (1969 and 1973) or Webber et al. (1970). Walcott's map shows the highest anomalies south of the Keewatin accumulation zone with no large anomaly in the southeastern Hudson Bay area.

Keywords: Isostacy, Geophysics, Free Air Gravity Anomalies.

Location: Central and Eastern Canada, H.B.R.

232. WEBBER, P.J., J.W. RICHARDSON and J.T. ANDREWS. 1970. Post-glacial uplift and substrate age at Cape Henrietta Maria, southeastern Hudson Bay, Canada. Can. J. Earth Sci. 7(2):317-325.

This paper details the emergence history at Cape Henrietta Maria using leveling along a transect from the coast-inland with radiocarbon dates of shells (Mytilus edulis) and driftwood. The study was designed as a chronological determination of the substrate in order to examine biogeographical characteristics of a portion of Polar Bear Provincial Park. The dates are young (<2500 years), representing only the recent emergence history at the Cape and thus the authors use the equations and constants derived by Andrews (1968) to fit their curve and extrapolate back in time. From this they determined an uplift rate approximating 1.2 m/100 years for the past 1000 years and a marine limit between 350 and 540 m for the Cape area. The authors point out the high uncertainty of the marine limit determination because only small changes in the 'A' constant or in the location of their dated samples relative to true sea level (because of low maximum elevations involved) result in shifts in the upper portion of their curve.

Keywords: Isostacy, Radiocarbon Dates, Marine Shells, Driftwood, Raised Beach Ridges, Biogeography.

Location: Ont. H.B.L. (Cape Henrietta Maria)

233. WHITEAVES, J.F. 1880-81. On some Silurian and Devonian fossils from Manitoba and the valleys of the Nelson and Churchill rivers. Geol. Surv. Can., Rept. Prog. 1878-79 pt. C, Appendix I:45-51.

Keywords: Paleontology, Paleozoic Geology.

Location: Man. H.B.L.

234. WHITEAVES, J.F. 1910. Notes on some fossils from the Cambro-Silurian rocks of the Albany drainage system in northwestern Ontario. Geol. Surv. Cam., No. 980, Appendix I:34-41.

Keywords: Paleontology, Paleozoic Geology.

Location: Ont. H.B.L.

235. WHITMORE, D.R.E. and B.A. LIBERTY. 1968. Bedrock geology and mineral deposits. in Science, History and Hudson Bay. C.S. Beals and D.A. Shenstone (editors), Dept. Energy, Mines Res., Queen's Printer, Ottawa: 543-557.

Keywords: Paleozoic Geology, Economic Geology, Precambrian Geology.

Location: H.B.L., H.B.R.

236. WICKWARE, G.M., R.A. SIMS, R.K. ROSS and D.W. COWELL. 1980. The application of remote sensing techniques for an ecological land survey of the snow goose colony at Cape Henrietta Maria, Hudson Bay. Proc. 6th. Can. Symp. Remote Sen., Halifax, N.S.: 387-395.

"Detailed studies for a large and expanding snow goose colony in the Cape Henrietta Maria area of Hudson Bay have been carried out with the aid of a multilevel remote sensing program. Demographic and habitat studies of the colony and adjacent area utilized the following remote sensing data: analogue and digital Landsat data, small scale 1:60,000 black and white photography, large scale 23 cm x 23 cm 1:10,000 colour and 1:2,000 black and white photography, and large scale 1:2,000-1:4,000 70 mm colour and colour infrared photography. Results of these studies demonstrate that a multilevel approach offers an efficient and effective method for stratifying, classifying, and mapping areas in remote and previously unexplored areas." - ABSTRACT.

Keywords: Vegetation, Ecological Classification, Remote Sensing, Pedology, Landform, Peatland, Wetland, Wildlife.

Location: Ont. H.B.L. (Cape Henrietta Maria)

237. WICKWARE, G.M., D.W. COWELL and R.A. SIMS. 1981a. Peat Resources of the Hudson Bay Lowland coastal zone. Proc. 6th Int. Peat Congress, Duluth, Min., August 1980: 138-143.

"Wetlands along the coasts of Hudson and James Bays in Ontario have been studied as part of an Ecological Land Survey in the Hudson Bay Lowland Coastal Zone. The Coastal Zone, which varies in width from 5 to 50 km is dominated by minerotrophic saltmarshes, freshwater marshes, and treed and open fens. Ombrotrophic bogs occur less frequently throughout the zone.

"Peats in the Coastal Zone have been deposited comparatively recently as the land, subject to active rebound for the last 7,000-8,000 years, rises at a rate of 1 m/100 years.

"Along the James Bay coast, peat thickness generally increases steadily inland, reaching a maximum of 1.5-2.0 m within the Coastal Zone. Weakly to moderately humified (von Post H2-H5) sedge peats dominate at depth in all wetlands, although Sphagnum peats may occur in the upper layers of some older fens and bogs.

"Along the Hudson Bay coast, where permafrost is an important ecological factor, peats tend to accumulate more slowly, and are shallower than those along James Bay. In fens, peats are primarily sedge and non-Sphagnic and weakly or moderately humified (von Post H4-H5). On permafrost features such as palsas and peat plateaux, Sphagnum and lichen peats overlay the sedge peats. The upper layers in these features are found to be undecomposed to weakly decomposed (von Post H2-H4).

"It is concluded that the low degree of humification and the saturated nature of the peats, particularly in the extensive fen deposits along the James Bay coast or frozen peats along the Hudson Bay coast, combined with poor accessibility to the area precludes use of the Coastal Zone of the Hudson Bay Lowland for widescale peat extraction. Also, the unconfined nature of the peatlands and the high regional water table in this area makes the use of ditches or drainage techniques to help in any desaturation process before mining or drying of the peats impractical." - ABSTRACT.

Keywords: Peatland Characteristics, Organic Soils, Peat Utilization, Surficial Geology.

Location: Ont. H.B.L. (coastal zone near Winisk and south of Albany river)

238. WICKWARE, G.M., R.A. SIMS, and D.W. COWELL. 1981b abstract only. Landscape evolution and wetland ecosystems development in the Hudson Bay Lowland: a preliminary model. Presented at Hudson/James Bay Symp., U. Guelph, April 1981.

"Wetland ecosystems in the coastal zone of the Hudson Bay Lowland, Ontario have been classified, mapped, and their evolution and development studied as part of an ecological land survey in the region.

"Wetlands have been classified and described according to a hierarchical system proposed by Jeglum et al. (1974). Mapping has been carried out using an approach suggested by the Canada Committee on Ecological Land Classification (CCELC) and using various remote sensing data including: analogue and digital Landsat data, small scale 1:60,000 black and white photography and large scale 70 mm colour and colour infrared photography.

"Evolution and devleopment of the landscape is controlled by a combination of cool high boreal and low subarctic type climates, the presence of permafrost, and a low gradient gradually emerging marine plain. The continuing paludification of the landscape is expressed as a succession of wetland types across the coastal zone from the nutrient-rich coastal salt, brackish and fresh-water marshes, to the nutrient poor, ombrotrophic bogs of the interior. A preliminary model depicting this evolution has been developed and is presented." - ABSTRACT.

Keywords: Wetlands, Peatlands, Ecological Classification, Landscape Evolution, Landforms, Raised Beach Ridges, Pedology, Vegetation, Paludification, Wetland Geomorphology, Remote Sensing.

Location: Ont. H.B.L. (coastal zone of western James Bay)

239. WILLIAMS, M.Y. 1920. Paleozoic rocks of Mattagami and Abitibi rivers, Ontario. Ont. Dept. Mines, Summ. Rept. pt. G: 1-13.

Outcrops found along the Mattagami, Moose and Abitibi rivers are described. Williams is one of the first to recognize the presence of a geological basin between the Moose and Albany Rivers but underestimates its thickness. He compares the stratigraphy to that of southwestern Ontario and discusses economic minerals.

Keywords: Paleozoic Geology, Economic Geology.

Location: Ont. H.B.L. (Moose River area)

240. WILLIAMS, M.Y. 1921. Paleozoic stratigraphy of Pagwachuan, lower Kenogami, and lower Albany rivers, Ontario. Geol. Surv. Can., Summ. Rept. 1920, pt. D:18-25.

This report is a short account of an exploration made by the author in 1920 down the Kenogami and Albany rivers from the C.N.R. tracks to Fort Albany. The author describes the Silurian, Devonian and Quaternary stratigraphy observed along the river and discusses some economic possibilities including limestone (coarsing stone), brick (Cretaceous clays?) and oil.

Fossils were used to determine the age of the bedrock as compared to similar assemblages in Paleozoic rocks of southern Ontario. Faunal assemblage names from southern Ontario and New York were used to name the sequences (e.g. 'Niagrian' or 'Guelph').

Williams also describes Quaternary deposits exposed along the river including at least two tills (boulder clay) separated by water-laid sands, silts and clays with 'lignite' (peat). The clays immediately below the peat were leached which suggested to J. Keele, who studied the clays, that they were interglacial, especialy because they were situated below the peat materials.

Keywords: Paleozoic Lithology and Stratigraphy, Paleozoic Geology, Quaternary Stratigraphy and Lithology, Economic Geology, Paleontology, Interglacial Sediments, Missinaibi Beds, Limestone, Clay, Till, Hydrocarbons, Surficial Geology.

Location: Ont. H.B.L. (Albany River)

241. WILSON, W.J. 1906. Reconnaissance Surveys of four rivers southwest of James Bay. Geol. Surv. Can., Ann. Rept. vol. 15 pt. A:222-224.

Surveys were made along portions of several rivers belonging to the Moose, Albany and Kapiskau systems (including the Atikameg, Otadaonanis, Stooping, Kwataboahegan and Abitibi rivers). The report includes descriptions of outcrops found along the rivers as well as the physiography of the rivers. All the surveys were within the Lowland, usually starting from the mouths of the rivers. This represents one of the first attempts at exploring the interior Lowland away from the major rivers such as the Albany and Moose rivers.

Keywords: Physiography, Paleozoic Geology, Paleontology, Quaternary Deposits, Surficial Geology.

Location: Ont. H.B.L. (Kapiskau to Moose Rivers)

242. ZASLOW, M. 1975. <u>Reading the Rocks.</u> MacMillan of Can. Ltd., Toronto:599 p.

This book is a superb history of the Geological Survey of Canada (1842-1972). It includes interesting accounts of the travels of most of the early geological explorers working for the survey, including those who travelled through the Hudson Bay Lowland. It also describes the most significant contributions each explorer made to the geological knowledge of Canada.

Keywords: Historical, Bedrock Geology, Glacial Geology.

Location: H.B.R., Canada.

243. ZOLTAI, S.C. 1973. Vegetation, surficial deposits and permafrost relationships in the Hudson Bay Lowlands. Proc. Symp. Physical Env. Hudson Bay Lowland (B.D. Kay, editor), Guelph, Ontario: 17-34.

This is an interesting paper which provides a useful summary of the physiography, vegetation, peatland patterns and development and permafrost relationships (in peatland) in the Hudson Bay Lowland. The author's field experience in the Lowland was primarily in the Manitoba portion but his descriptions are more widely applicable. He discusses characteristic features of palsas and peat plateaux and describes the main differences in vegetation and peatland succession between southern and northern parts of the Lowland. He also presents a small-scale map showing broad vegetation zones in the Lowland (heath-fenland), open subarctic forest and closed forest-from north to south). The paper is descriptive and is well illustrated with photographs and cross-sections of permafrost features (peat plateaux).

Keywords: Peatland Characteristics, Permafrost, Vegetation, Physiography, Palsas, Peat Plateaux.

Location: Man. H.B.L.

244. ZOLTAI, S.C. and C. TARNOCAI. 1969. Permafrost in peat landforms in northern Manitoba. Proc. 13th Ann. Man. Soil Sci. Meet.: 3-16.

This paper is in two parts. The first deals with the morphology and distribution of permafrost in peat landforms in northern Manitoba and the second describes physical and chemical properties of frozen organic soils.

In the first part the authors briefly describe and give the occurrence of several characteristic permafrost peat landforms (palsas, plateaux and collapse scars). The distribution and abundance of the different types of permafrost peat landforms are used to define permafrost zones. Their most southerly zone is refered to as the "localized permafrost" zone, the southern limit of which is defined on the basis of the occurrence of collapse scars. This zone lies south of Brown's (1967) discontinuous zone. The Lowland portion of the province is represented by the continuous, widespread and northern part of the discontinuous zones; similar to those defined by Brown (1967).

In the second part the authors describe the profiles of 4 frozen organic soils, and compare water (ice) content, bulk density, cation exchange capacity, exchangeable Ca and Mg and so on. Only one soil (Cryic Cumulo Mesisol) is taken from the Hudson Bay Lowland (York Factory area). This profile is also discussed in the University of Manitoba (1969) summary report (see Tarnocai 1972).

Keywords: Permafrost, Pedology, Peatland Characteristics, Palsas, Peat Plateaux, Collapse Scars, Chemical Analyses of Organic Material.

Location: Man. H.B.L.

6. KEYWORD INDEX

KEYWORD	AUTHOR
Active Layer	Beckel, D.K.B. 1957., Guimont, P. and C. Laverdière. 1976a.
Aerial Photo Interpretation	Guimont, P. and C. Laverdière. 1976a.; Guimont, P. and C. Laverdière. 1976b.; Gussow, W.C. 1953b.
Aeromagnetic Survey	Bostock, H.H. 1971.
Air Photo Interpretation	Brown, R.J.E. 1968.
Aquatic Ecology	Société d'Energie de la Baie James. 1978.
Amino Acid Dating	Shilts, W.W. in press.
Annotated Bibliography	Sims, R.A., J.L. Riley and J.K. Jeglum. 1979.
Archeology	Andrews, JT, McGhee and McKenzie-Pollock. 1971
Attawapiskat Formation	Cowell, D.W. 1981.; Cowell, D.W. 1982.
Baseline Studies	Glooschenko, W.A. and I.P. Martini. 1978.
Bathymetry	Pelletier, B.R. 1969.
Beach Ridge Development	Simpson, S.J. 1972.
Beach Ridge Formation	Fairbridge, R.W. and Claude Hillaire-Marcel. 1977.
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Beaches	Martini, I.P. and R. Protz. 1980.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.; Moir, D.R. 1958.
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Bell Sea	Shilts, W.W. in press., Skinner, 1973a and b.
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Bore Holes	Guillet, G.R. 1979.
Canada Geese	Hanson, H.C. and R.H. Smith. 1950.
Chemical Analyses	Keele, J. 1920.; Martini, I.P. and R. Protz. 1977.; Martini, I.P. and R. Protz. 1978.
Chemical Analyses of Organic Material	Zoltai, S.C. and C. Tarnocai. 1969.

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Chemical Analyses of Groundwater	Sims, R.A., D.W. Cowell and G.M. Wickware.
Chemical and Physical Analyses	Mills, G.F. 1975.
Chemical and Physical Analyses of Sediment	Martini, I.P. and R. Protz. 1980.
	Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.
Chemical Composition	Dyer, W.S. 1929a.; Guillet, G.R. 1964.
Clay	Ballivy, G., G. Pouliot and A. Loiselle. 1971.; Dyer, W.S. and R.J. Montgomery. 1930.; Guillet, G.R. 1979.; Keele, J. 1920.; McLearn, F.H. 1927.; Montgomery, R.J. 1929.; Williams, M.Y. 1921.; Vos, M.A. 1975.
Climate	Hutton, C.L.A. and W.A. Black. 1975.; Johnston, W.A. 1917.; Potzger, J.E. and A. Courtemanche. 1956.
Coastal Classification	Guimont, P. and C. Laverdière. 1976a.; Guimont, P. and C. Laverdière. 1976b.; Gussow, W.C. 1953b.
Coastal Geomorphology	Glooschenko, W.A. and I.P. Martini. 1978.; Martini, I.P. 1981a.; Martini, I.P. 1981b.; Martini, I.P. and R. Protz. 1977.; Martini, I.P. and R. Protz. 1978.;

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	Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.; Moir, D.R. 1954.; Simpson, S.J. 1972.
Coastal Geomorphology and	Martini, I.P. and R. Protz. 1979.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1978.
Coastal Morphology	Bell, R. 1887.; Bell, R. 1896.; Bell, R. 1912.; Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.; Guimont, P. and C. Laverdière. 1976a.; Guimont, P. and C. Laverdière. 1976b.; Gussow, W.C. 1953b.; Herrick, R. 1977.; Low, A.P. 1889.; Manning, T.H. 1947.; Manning, T.H. 1951.; Manning, T.H. and R.W. Rae. 1950.; O'Sullivan, O. 1908a.; O'Sullivan, O. 1912.; O'Sullivan, O. 1906..
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Coastal Sedimentology and Geomorphology	Martini, I.P. 1981b., Martini, I.P. and R. Protz. 1980.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.

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Cochrane Readvance	Antevs, E. 1953.; Antevs, E. 1955.; Ballivy, G., G. Pouliot and A. Loiselle. 1971.; Boissonneau, A.N. 1966.; Cowan, W.R. 1980.; Falconer, G., J.D. Ives, O.H. Loken and J.T. Andrews. 1965b.; Falconer, G., J.T. Andrews and J.D. Ives. 1965a.; Flint, R.F. 1956.; Hughes, O.L. 1961.; Hughes, O.L. 1965.; Potzger, J.E. and A. Courtemanche. 1956.; Prest, V.K. 1966.; Prest, V.K. 1970a.; Vincent, J.S. and L. Hardy. 1979.
Cochrane Till	Skinner, R.C. 1973a.; Skinner, R.C. 1973b.
Collapse Scars	Zoltai, S.C. and C. Tarnocai. 1969.
Conference Proceedings	Mayer-Oakes, W.J. 1967.
Cryosols	University of Manitoba. 1969.
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De Geer Moraines	Lee, H.A. 1968.
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Deglaciation	Andrews, J.T. and G. Falconer. 1969.; Andrews, J.T. and W.R. Peltier. 1976.; Andrews, J.T. 1968.; Andrews, J.T. 1969.; Andrews, J.T. 1970.;

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Drainage	Brown, R.J.E. 1968.; Cumming, L.M. 1969.; Dean, W.G. 1959.; Herrick, R. 1977.; Hutton, C.L.A. and W.A. Black. 1975.; Moir, D.R. 1958.; Newbury, J.R.W. 1968.

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Driftwood	Bell, R. 1879a.; Low, A.P. 1889.; Webber, P.J., J.W. Richardson and J.T. Andrews. 1970.
Drill Holes	Charles, J.L. 1959.; Hamblin, A.P. 1979.; Hogg, N., J. Satterly and A.E. Wilson. 1953.; Telford, P.G. 1979.; Verma, H.M., P.G. Telford and G. Norris. 1978.
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Drilling	Gussow, W.C. 1953b.
Drumlins	Lee, H.A. 1959.; Lee, H.A. 1968.
Ecological Classification	Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.; Jurdant, M., J.L. Bélair, V. Gerardin and J.P. Ducruc. 1977.; Mills, G.F. 1976.; Mills, G.F., H. Velduis, D.B. Forrester. 1976.; National Committee on Forest Land, Subcommittee on Biophysical Land Class. 1969.; Sims, R.A., D.W. Cowell and G.M. Wickware.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.
Ecological Studies	Société d'Energie de la Baie James. 1978.
Ecology	Glooschenko, W.A. and I.P. Martini. 1978.
Economic Geology	Ayres, L.D., G. Bennett and R.A. Riley. 1969.; Baker, M.B. 1911.; Bell, J.M. 1904.; Bostock, H.H.

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Economic Geology	1971. Brown, D.D., G. Bennett and P.T. George. 1967.; Cumming, L.M. 1975.; Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.; Dyer, W.S. 1928.; Dyer, W.S. 1929a.; Dyer, W.S. 1929b.; Dyer, W.S. 1932.; Dyer, W.S. and R.J. Montgomery. 1930.; Dyer, W.S. and A.R. Crozier. 1933.; Gilmore, R.E. 1929.; Guillet, G.R. 1979.; Gussow, W.C. 1953a.; Gussow, W.C. 1953a.; Gussow, W.C. 1953b.; Hawley, J.E. 1926.; Hogg, N.J., Satterly and A.E. Wilson. 1953; Hood, P.J. (editor). 1969.; Hood, P., M. Bower and E.A. Godby. 1969.; Johnson, R.D. 1971.; Johnson, R.D. and S.J. Nelson. 1969.; Keele, J. 1920.; Lanning, J. 1926.; Malcolm, W. 1924.; Martison, N.W. 1953.; McLearn, F.H. 1927.; Montgomery, R.J. 1929.; Onakawana Development Ltd. 1973.; Ontario Ministry of Environment. 1981.; Ontario Research Foundation. 1933.; Rogers, D.P., J.S. Hancock, S.A. Ferguson, W.O. Karvinen & P. Beck.1975.; Sandford, B.V., A.W. Norris and H.H. Bostock. 1968.; Savage, T.E. and F.M. Van Tuyl. 1919.; Scintrex Surveys Ltd. 1976.; Shilts, W.W. 1980b.; Southwestern Hudson Bay.;

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Economic Geology	Stockwell, C.H., J.C. McGlynn, R.F. Emslie, B.V. Sanford, A.W. Norris, J.A. Donaldson, W.F. Fahrig and K.L. Currie. 1972.; Telford, P.G. and H.M. Verma (editors). 1979.; Telford, P.G. and H.M. Verma. 1978.; Telford, P.G., M.A. Vos and G. Norris. 1975.; Utard, M. 1975.; Verma, H. 1979.; Verma, H.M., P.G. Telford and G. Norris. 1978.; Vos, M.A. 1975.; Vos, M.A. 1979.; Whitmore, D.R.E. and B.A. Liberty. 1968.; Williams, M.Y. 1921.; Williams, M.Y. 1920.; Guillet, G.R. 1964.
End Moraines	Falconer, G., J.D. Ives, O.H. Loken and J.T. Andrews. 1965b.; Falconer, G., J.T. Andrews and J.D. Ives. 1965a.
Engineering Feasibility	Onakawana Development Ltd. 1973.
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Erosion	Ballivy, G., A.A. Loiselle and G. Pouliot. 1975.
Erosion and Hydrology	Simpson, S.J. 1972.
Erratics	Shilts, W.W. in press.; Shilts, W.W., C.M. Cunningham and C.A. Kaszycki. 1979.; Tyrrell, J.B. 1898.
Eskers	Johnston, W.A. 1917; Lee, H.A. 1959.
Estuaries	Manning, T.H. 1947.

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Estuarine Geomorphology and Chemistry	Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.
Estuarine Processes	Simpson, S.J. 1972.
Estuary	Guimont, P. and C. Laverdière. 1976a.; Guimont, P. and C. Laverdière. 1976b.; Gussow, W.C. 1953b.; Elson, J.A. 1969.; Gutenberg, B. 1941..
Exploration and Development	Simpson, S.J. 1972.
Fens	Sims, R.A., D.W. Cowell and G.M. Wickware. (in press).
Fluvial Erosion	Dole, R.B. and H. Stabler. 1909.
Fluvial Geomorphology and	Martini, I.P. and R. Protz. 1979.; Sedimentology Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1978.
Fluvial Sedimentation	Simpson, S.J. 1972.
Fluvio-Karst	Cowell, D.W. 1981.; Cowell, D.W. 1982.
Forest Composition	Auer, V. 1927.
Forest Cover	Terasmae, J. 1957.; Terasmae, J. and O.L. Hughes. 1960a.
Forest Succession	Potzger, J.E. and A. Courtemanche. 1956.
Forest Types	Antevs, E. 1955.
Formational Nomenclature	Cumming, L.M. 1975.
Free Air Gravity Anomalies	Andrews, J.T. and D.M. Barnett. 1972.; Walcott, R.I. 1970.

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Geochemistry	Ballivy, G., G. Pouliot and A. Loiselle. 1971.; Shilts, W.W. 1980b.
Geology	Isbister, A.K. 1855.
Geophysics	Andrews, J.T. and W.R. Peltier. 1976.; Grant, A.C. 1969.; Gutenberg, B. 1941.; Hobson, G.D. 1969.; Hodgkinson, J. 1969.; Hood, P.J. (editor). 1969.; Hood, P., M. Bower and E.A. Godby. 1969.; Innes, M.J.S. 1960.; Innes, M.J.S., A.K. Goodacre, J.A. Weston and J.R. Weber. 1968.; Kupsch, W.O. 1967.; Rogers, D.P., J.S. Hancock, S.A. Ferguson, W.O. Karvinen & P. Beck.; Scintrex Surveys Ltd. 1976.; Utard, M. 1975.; Walcott, R.I. 1970.
Geotechnical Properties	Ballivy, G., A.A. Loiselle and G. Pouliot. 1975.
Glacial Chronology	Craig, B.G. and B.C. McDonald. 1967.
Glacial Deposits	Shilts, W.W. 1980b.
Glacial Geology	Zaslow, M. 1975.
Glacial Lake Barlow-Ojibway	Antevs, E. 1953.; Ballivy, G., G. Pouliot and A. Loiselle. 1971.; Vincent, J.S. and L. Hardy. 1979.
Glacial Lake Ojibway	Cowan, W.R. 1980.
Glacial Landforms	Fyles, J.G. 1955.

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Glacial Straie	Andrews, J.T. and G. Falconer. 1969.; Bell, R. 1879a.; Moir, D.R. 1958.; Tyrrell, J.B. 1898.; Upham, W. 1889.
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Glaciomarine Landforms	Archer, D.R. 1968.
Gypsum	Guillet, G.R. 1964.; Lanning, J. 1926.; Vos, M.A. 1979.
Gypsum Karst	Bell, J.M. 1904.; Guillet, G.R. 1964.
Harricanaw Interlobate Moraine	Cowan, W.R. 1980.

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History	Bell, R. 1896.; Charles, J.L. 1959.
Hydraulics	Newbury, J.R.W. 1968.
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Inliers	Bostock, H.H. 1969.; Bostock, H.H. 1971.; Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.
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Interglacial Missinaibi Beds	McDonald, B.C. 1969.; Prest, V.K. 1970a.
Interglacial Peat Beds	Auer, V. 1927.
Interglacial Sediments	Prest, V.K. 1966.; Skinner, R.C. 1973a.; Skinner, R.C. 1973b.; Williams, M.Y. 1921.
Iron Ores	Baker, M.B. 1911.
Isostacy	Andrews, J.T. McGhee and McKenzie-Pollock. 1971.; Andrews, J.T. and G. Falconer. 1969.; Andrews, J.T. 1968.; Andrews, J.T. 1969.; Andrews, J.T. 1970.; Archer, D.R. 1968; Barnett, D.M. 1966.; Barnett, D.M. 1970.; Bell, R. 1877.; Bell, R. 1879a.; Bell, R. 1879b.; Bell, R. 1880.; Bell, R. 1896.; Bird, J.B. 1954.; Cooke, H.C. 1930.; Cooke, H.C. 1942.; Craig, B.G. 1969.; Elson, J.A. 1969.; Fairbridge, R.W. and Claude Hillaire-Marcel. 1977.; Gutenberg, B. 1941.; Gutenberg, B. 1954.; Hood, P.J. (editor). 1969.; Hunter, G. 1970.; Innes, M.J.S. 1960.; Innes, M.J.S., A.K. Goodacre, J.A. Weston and J.R. Weber. 1968.; Johnston, W.A. 1939.; Kupsch, W.O. 1967.; Lee, H.A. 1960.; Lee, H.A. 1968.; Low, A.P. 1887.; Low, A.P. 1889.; Manning, T.H. 1951.;

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Isostacy	Manning, T.H. and R.W. Rae. 1950.; Martini, I.P. and R. Protz. 1980.; Moir, D.R. 1958.; Richards, H.G. 1941.; Simpson, S.J. 1972.; Skinner, R.C. 1973b.; Tyrrell, J.B. 1890-91.; Tyrrell, J.B. 1896.; Tyrrell, J.B. 1900.; Tyrrell, J.B. 1913.; Wagner, F.J.E. 1967.; Walcott, R.I. 1970.; Webber, P.J., J.W. Richardson and J.T. Andrews. 1970.
Kaolin	Guillet, G.R. 1979.
Karren	Cowell, D.W. 1982.
Karst Geomorphology	Cowell, D.W. 1982.; Cowell, D.W. 1981.
Karst Landforms	Bell, J.M. 1904.
Keewatin Ice Sheet	Shilts, W.W. 1980a.; Shilts, W.W., C.M. Cunningham and C.A. Kaszycki. 1979.
Labradorean Ice Sheet	Shilts, W.W. 1980a.
Lacustrine Clay	Johnston, W.A. 1917.
Lacustrine Deposits	Craig, B.G. and B.C. McDonald. 1967.
Landform	Mills, G.F. 1976.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.; Craig, B.G. 1969.; Dean, W.G. 1959.; Guimont, P. and C. Laverdière. 1976a.;

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Landform	Guimont, P. and C. Laverdière. 1976b.; Gussow, W.C. 1953b.; Lee, H.A. 1960.; Lee, H.A. 1968.; Mills, G.F., H. Velduis, D.B. Forrester. 1976.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.
Landform, Hydrology	Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.
Landscape Development	Simpson, S.J. 1972.
Landscape Evolution	Cumming, L.M. 1969.; Dean, W.G. 1959.; Moir, D.R. 1958.; Tyrrell, J.B. 1913.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.
Laurentide Ice Sheet	Flint, R.F. 1943.; Shilts, W.W. 1980a.; Shilts, W.W. in press.; Shilts, W.W., C.M. Cunningham and C.A Kaszycki. 1979.
Lignite	Bell, R. 1872.; Dyer, W.S. 1928.; Dyer, W.S. and A.R. Crozier. 1933.; Gilmore, R.E. 1929.; Guillet, G.R. 1979.; McLearn, F.H. 1927.; Ontario Ministry of Environment. 1981.; Ontario Research Foundation. 1933.; Scintrex Surveys Ltd. 1976.; Telford, P.G. 1979.; Telford, P.G. and H.M. Verma (editors). 1979.; Telford, P.G. and H.M. Verma. 1978.; Telford, P.G., M.A. Vos and G. Norris. 1975.; Utard, M. 1975.; Verma, H. 1979.; Verma, H.M., P.G. Telford and G. Norris. 1978.; Vos, M.A. 1975.;

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Lignite	Vos, M.A. 1979.
Lignite Mine	Onakawana Development Ltd. 1973.
Limestone	Bell, R. 1872.; Dyer, W.S. 1929a.; Dyer, W.S. 1929b.; Gussow, W.C. 1953a.; Gussow, W.C. 1953a.; Vos, M.A. 1979.; Williams, M.Y. 1921.
Literature Review (Geological Exploration)	Verma, H. 1979.
Lithology	Ballivy, G., G. Pouliot and A. Loiselle. 1971.
Mapping	Jurdant, M., J.L. Bélair, V. Gerardin and J.P. Ducruc. 1977.; National Committee on Forest Land, Subcommittee on Biophysical Land Class.1969.
Marine Inundation	Andrews, J.T. and G. Falconer. 1969.; Andrews, J.T. and W.R. Peltier. 1976.; Andrews, J.T. 1968.; Andrews, J.T. 1969.; Bird, J.B. 1954.; Cowan, W.R. 1980.; Craig, B.G. 1969.; Craig, B.G. and B.C. McDonald. 1967.; Dean, W.G. 1959.; Dionne, J.C. 1972.; Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.; Elson, J.A. 1969.; Fairbridge, R.W. and Claude Hillaire-Marcel. 1977. Flint, R.F. 1956.; Fyles, J.G. 1955.; Lee, H.A. 1959.; Lee, H.A. 1960.; Lee, H.A. 1968.; Prest, V.K. 1963.; Prest, V.K. 1966.; Prest, V.K. 1970a.; Prest, V.K.

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Marine Inundation	1970b.; Richards, H.G. 1941.; Skinner, R.C. 1973b.; Terasmae, J. and O.L. Hughes. 1960b.
Marine Inundation and Deposits	Moir, D.R. 1958.
Marine Limit	Archer, D.R. 1968.
Marine Processes	Pelletier, B.R. 1969.
Marine Sediments	Pelletier, B.R. 1969.
Marine Shells	Andrews, J.T. and G. Falconer. 1969.; Craig, B.G. 1969.; Webber, P.J., J.W. Richardson and J.T. Andrews. 1970.
Mattagami Formation	Ballivy, G., G. Pouliot and A. Loiselle. 1971.; Baker, M.B. 1911.; Dyer, W.S. 1928.; Dyer, W.S. and R.J. Montgomery. 1930.; Dyer, W.S. and A.R. Crozier. 1933.; Guillet, G.R. 1979.; Hamblin, A.P. 1979.; Keele, J. 1920.; McLearn, F.H. 1927.; Montgomery, R.J. 1929.; Norris, G. 1979.; Rogers, D.P., J.S. Hancock, S.A. Ferguson, W.O. Karvinen & P. Beck. 1975.; Telford, P.G. 1979.; Telford, P.G. and H.M. Verma (editors). 1979.; Telford, P.G. and H.M. Verma. 1978.; Telford, P.G., M.A. Vos and G. Norris. 1975.; Utard, M. 1975.; Verma, H. 1979.; Verma, H.M., P.G. Telford and G. Norris. 1978.;

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Mattagami Formation	Vos, M.A. 1975.; Vos, M.A. 1979.
Mesozoic Biostratigraphy	Norris, G. 1979.
Mesozoic Clays	Dyer, W.S. and R.J. Montgomery. 1930.
Mesozoic Geology	Gilmore, R.E. 1929.; Hood, P.J. (editor). 1969.; Norris, A.W. and B.V. Sanford. 1969; Telford, P.G. 1979.
Mesozoic Lithology	Baker, M.B. 1911.; Dyer, W.S. and A.R. Crozier. 1933.; Guillet, G.R. 1979.; Hamblin, A.P. 1979.; Keele, J. 1920.; Norris, G. 1979.
Mesozoic Lithology and Stratigraphy	McLearn, F.H. 1927.
Mesozoic Paleoenvironments	Vos, M.A. 1979.
Mesozoic Palynology	Norris, G. 1979.; Telford, P.G. and H.M. Verma (editors). 1979.; Telford, P.G., M.A. Vos and G. Norris. 1975.; Verma, H.M., P.G. Telford and G. Norris. 1978.; Telford, P.G. and H.M. Verma (editors). 1979.; Telford, P.G., M.A. Vos and G. Norris. 1975.; Vos, M.A. 1975.
Mesozoic Sedimentation	Vos, M.A. 1979.

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Mesozoic Stratigraphy	Dyer, W.S. 1928.; Guillet, G.R. 1979.; Rogers, D.P., J.S. Hancock, S.A. Ferguson, W.O. Karvinen & P. Beck. 1975.; Telford, P.G. 1979.; Telford, P.G. and H.M. Verma (editors). 1979.; Telford, P.G. and H.M. Verma. 1978; Telford, P.G., M.A. Vos and G. Norris. 1975.; Utard, M. 1975.; Verma, H.M., P.G. Telford and G. Norris. 1978.; Vos, M.A. 1979.
Methodology	National Committee on Forest Land, Subcommittee on Biophysical Land Class. 1969.
Microclimate	Railton, J.B. and J.H. Sparling. 1973.; Rouse, W.R. and K.A. Kershaw. 1973.
Microclimatology	Newbury, J.R.W. 1968.
Mineralogy	Ballivy, G., G. Pouliot and A. Loiselle. 1971.; Bostock, H.H. 1971.; Brown, D.D., G. Bennett and P.T. George. 1967.
Minerotrophy	Sjörs, H. 1963.
Mining	Lanning, J. 1926.
Missinaibi Beds	Craig, B.G. and B.C. McDonald. 1967.; Prest, V.K. 1966.; Shilts, W.W. in press.; Skinner, R.C. 1973a.; Skinner, R.C. 1973b.; Terasmae, J. 1957.;

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	Terasmae, J. and O.L. Hughes. 1960a.; Williams, M.Y. 1921.
Missinaibi Formation	Auer, V. 1927.; Lee, H.A. 1968.; Netterville, J.A. 1974.
Moraine	Hughes, O.L. 1965.
Muskeg	Coombs, D.B. 1952.; Coombs, D.B. 1954.; Dean, W.G. 1959.; Guillet, G.R. 1964.; Hanson, H.C. and R.H. Smith. 1950.; Herrick, R. 1977.; Hustich, I. 1957.; Johnston, W.A. 1917.
Nonglacial Deposits	Netterville, J.A. 1974.
Onakawana	Dyer, W.S. and A.R. Crozier. 1933.
Ordovician Lithology	Cumming, L.M. 1975.
Ordovician Strata	Cumming, L.M. 1971.
Ordovician Stratigraphy	Cumming, L.M. 1975.
Organic Soils	Wickware, G.M., D.W. Cowell and R.A. Sims. 1981.
Organo-Karst	Cowell, D.W. in press.; Cowell, D.W. 1981.
Palentology	Williams, M.Y. 1921.; Wilson, W.J. 1906.
Paleobotany	McLearn, F.H. 1927.
Paleoclimate	Fairbridge, R.W. and Claude Hillaire-Marcel. 1977.
Paleoenvironments	Skinner, R.C. 1973b.; Terasmae, J. 1958.; Skinner, R.C. 1973a.

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Paleonotology and Stratigraphy	McGregor, D.C. and M. Camfield. 1976.
Paleontology	Cumming, L.M. 1975.; Cumming, L.M. 1971.; Dyer, W.S. 1929b.; Hogg, N., J. Satterly and A.E. Wilson. 1953.; Hood, P.J. (editor). 1969.; Keele, J. 1920.; Nelson, S.J. 1952.; Sanford, B.V. and A.W. Norris. 1975.; Whiteaves, J.F. 1880-81.; Whiteaves, J.F. 1910.
Paleosol	Mills, G.F. 1975.
Paleozoic	McGregor, D.C. and M. Camfield. 1976.; Nelson, S.J. 1952.
Paleozoic and Mesozoic Geology	Bell, J.M. 1904.; Bell, R. 1872.
Paleozoic and Precambrian Geology	Société d'Energie de la Baie James. 1978.; Herrick, R. 1977.; Sandford, B.V., A.W. Norris and H.H. Bostock. 1968.
Paleozoic and Quaternary Stratigraphy	Hood, P.J. (editor). 1969.
Paleozoic Geology	Bell, R. 1879b.; Cumming, L.M. 1975.; Cumming, L.M. 1971.; Dyer, W.S. 1931.; Grant, A.C. 1969.; Guillet, G.R. 1979.; Hobson, G.D. 1969.; Hodgkinson, J. 1969.; Hood, P.J. (editor). 1969.;

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Paleozoic Geology	Hood, P., M. Bower and E.A. Godby. 1969.; Johnson, R.D. and S.J. Nelson. 1969.; Lanning, J. 1926.; Low, A.P. 1887.; Martison, N.W. 1953.; McInnes, W. 1906.; Nelson, S.J. 1952.; Norris, A.W. and B.V. Sanford. 1969.; Sandford, B.V. and A.W. Norris. 1975.; Savage, T.E. and F.M. Van Tuyl. 1919.; Stockwell, C.H., J.C. McGlynn, R.F. Emslie, B.V. Sanford, A.W. Norris, J.A. Donaldson, W.F. Fahrig and K.L. Currie. 1972.; Tyrrell, J.B. 1916.; Whiteaves, J.F. 1880-81.; Whiteaves, J.F. 1910.; Whitmore, D.R.E. and B.A. Liberty. 1968.; Williams, M.Y. 1920.; Williams, M.Y. 1921.; Wilson, W.J. 1906.
Paleozoic Geology and Paleontology	Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.; Bell, R. 1877.
Paleozoic Geology and Stratigraphy	Nelson, S.J. and R.D. Johnson. 1966.
Paleozoic Lithology	Baker, M.B. 1911.; Guillet, G.R. 1964.
Paleozoic Lithology and Stratigraphy	Williams, M.Y. 1921.

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Paleozoic Paleonotology	Baker, M.B. 1911.; McInnes, W. 1906.; Parks, W.A. 1913.; Tyrrell, J.B. 1913.
Paleozoic Stratigraphy	Bell, R. 1887.; Bell, R. 1912.; Dyer, W.S. 1929a.; Dyer, W.S. 1929b.; Martison, N.W. 1953.; Sandford, B.V. and A.W. Norris. 1975.; Sanford, B.V., A.W. Norris and H.H. Bostock. 1968.; Stockwell, C.H., J.C. McGlynn, R.F. Emslie, B.V. Sanford, A.W. Norris, J.A. Donaldson, W.F. Fahrig and K.L. Currie. 1972.; Tyrrell, J.B. 1913.
Paleozoic Stratigraphy and Lithology	Hogg, N., J. Satterly and A.E. Wilson. 1953.
Palsa	Railton, J.B. and J.H. Sparling. 1973.; Tarnocai, C. 1972.; Brown, R.J.E. 1968.; Cowell, D.W., G.M. Wickware and R.A. Sims, in press.; Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.; Hustich, I. 1957.; Ritchie, J.C. 1957.; Ritchie, J.C. 1960.; Sjörs, H. 1951.; Sjörs, H. 1959.; Sjörs, H. 1963.; Zoltai, S.C. 1973.; Zoltai, S.C. and C. Tarnocai. 1969.
Paludification	Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.

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Palynology	Antevs, E. 1955.; Auer, V. 1927.; McDonald, B.C. 1969.; McGregor, D.C. and M. Camfield. 1976.; Potzger, J.E. and A. Courtemanche. 1956.; Skinner, R.C. 1973a; Skinner, R.C. 1973b.; Terasmae, J. 1957.; Terasmae, J. 1958.; Terasmae, J. and O.L. Hughes. 1960a.
Patrician Glacier	Flint, R.F. 1943.
Peat	Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.; McLearn, F.H. 1927.
Peat Plateau	Tarnocai, C. 1972.; Brown, R.J.E. 1968.; Cowell, D.W., G.M. Wickware and R.A. Sims, in press.; Zoltai, S.C. 1973.; Zoltai, S.C. and C. Tarnocai. 1969.
Peat Thickness	Beckel, D.K.B. 1957.; Brown, R.J.E. 1968.
Peat Utilization	Wickware, G.M., D.W. Cowell and R.A. Sims. 1981.
Peatland	Brown, R.J.E. 1968.; Charles, J.L. 1959.; Coombes, D.B. 1952.; Coombs, D.B. 1954.; Cowell, D.W. in press.; Cowell, D.W. 1981.; Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.; Cowell, D.W., G.M. Wickware and R.A. Sims, in press.; Dean, W.G. 1959.; Hanson, H.C. and R.H. Smith. 1950.; Herrick, R. 1977.; Hustich, I. 1957.; Jurdant, M., J.L. Bélair, V. Gerardin and J.P. Ducruc.

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	1977.; Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.; Ritchie, J.C. 1960.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.
Peatland Characteristics	Ritchie, J.C. 1957.; Sims, R.A., D.W. Cowell and G.M. Wickware. (in press).; Sjörs, H. 1951.; Sjörs, H. 1959.; Sjörs, H. 1963.; Wickware, G.M., D.W. Cowell and R.A. Sims. 1981.; Zoltai, S.C. 1973.; Zoltai, S.C. and C. Tarnocai. 1969.
Peatland Development	Sjörs, H. 1963.
Peatland Landforms	University of Manitoba. 1969.
Peatlands	Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.;
Peatlands	Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.
Pedology	Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.; Martini, I.P. and R. Protz. 1977.; Martini, I.P. and R. Protz. 1978.; Martini, I.P. and R. Protz. 1979.; Martini, I.P. and R. Protz. 1980.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1978.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.; Mills, G.F. 1975.; Mills, G.F. 1976.; Mills, G.F., H. Velduis, D.B. Forrester. 1976.; Simpson, S.J. 1972.;

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	Sims, R.A., D.W. Cowell and G.M. Wickware. (in press).; Sjörs, H. 1951.; Société d'Energie de la Baie James. 1978.; Tarnocai, C. 1974.; Task Force Onakawana. 1973.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.; Zoltai, S.C. and C. Tarnocai. 1969.
Pedology (organic)	Tarnocai, C. 1972.; University of Manitoba. 1969.
Pelistocene Stratigraphy	Telford, P.G. and H.M. Verma (editors). 1979.
Permafrost	Beckel, D.K.B. 1957.; Brown, R.J.E. 1967.; Brown, R.J.E. 1968.; Charles, J.L. 1959.; Coombs, D.B. 1952.; Coombs, D.B. 1954.; Cowell, D.W., G.M. Wickware and R.A. Sims, in press.; Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.; Hustich, I. 1957.; Kershaw, K.A. 1976.; Mills, G.F., H. Velduis, D.B. Forrester. 1976.; Railton, J.B. and J.H. Sparling. 1973.; Ritchie, J.C. 1957.; Ritchie, J.C. 1960.; Rouse, W.R. and K.A. Kershaw. 1973.; Simpson, S.J. 1972.; Sjörs, H. 1951.; Sjörs, H. 1959.; Sjörs, H. 1963.; Tarnocai, C. 1972.;

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Permafrost	Tarnocai, C. 1974.; University of Manitoba. 1969.; Zoltai, S.C. 1973.; Zoltai, S.C. and C. Tarnocai. 1969.
Petrography	Hamblin, A.P. 1979.
Physical Analyses of Sediment	Martini, I.P. and R. Protz. 1977.; Martini, I.P. and R. Protz. 1978.
Physiographic Patterns	Coombs, D.B. 1954.
Physiography	Alcock, F.J. 1916a.; Alcock, F.J. 1916b.; Beckel, D,K.B., C.E. Law and B.R. Irvine. 1954.; Bell, R. 1872.; Bell, R. 1877.; Bell, R. 1879a.; Bell, R. 1879b.; Bell, R. 1880.; Bell, R. 1887.; Bell, R. 1912.; Bird, J.B. 1967.; Charles, J.L. 1959.; Clayton, J.S., W.A. Ehrlich, D.B. Cann, J.H. Day and I.B. Marshall.; Cooke, H.C. 1930.; Coombs, D.B. 1952.; Coombs, D.B. 1954.; Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.; Cumming, L.M. 1969.; Dean, W.G. 1959.; Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.; Dyer, W.S. 1929b.; Ehrlich, W.A., L.E. Pratt, J.A. Barr and F.P. LeClaire. 1959.; Hanson, H.C. and R.H. Smith. 1950.; Hawley, J.E. 1926.; Herrick, R. 1977.; Hustich, I. 1957.; Hutton, C.L.A. and W.A. Black.

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Physiography	1975.; Isbister, A.K. 1855.; Johnston, W.A. 1917.; Klassen, R.W. and J.A. Netterville. 1973.; Leroy, O.E. 1903.; Low, A.P. 1887.; Low, A.P. 1889.; Low, A.P. 1899.; Low, A.P. 1912.; McInnes, W. 1906.; Moir, D.R. 1954.; Moir, D.R. 1958.; O'Sullivan, O. 1906.; O'Sullivan, O. 1908a.; O'Sullivan, O. 1908b.; O'Sullivan, O. 1912.; Pelletier, B.R. 1969.; Robinson, J.L. 1968.; Simpson, S.J. 1972.; Sjörs, H. 1951.; Sjörs, H. 1959.; Sjörs, H. 1963.; Tarnocai, C. 1974.; Task Force Onakawana. 1973.; Tyrrell, J.B. 1890-91.; Tyrrell, J.B. 1913.; Wilson, W.J. 1906.; Zoltai, S.C. 1973.
Pleistocene Chronology	Hood, P.J. (editor). 1969.; Andrews, J.T. and D.M. Barnett. 1972.; Antevs, E. 1953.; Antevs, E. 1955.; Coleman. 1941.; Falconer, G., J.D. Ives, O.H. Loken and J.T. Andrews. 1965b.; Flint, R.F. 1956.; Flint, R.F. 1947.; Klassen, R.W. and J.A. Netterville. 1973.; Lee, H.A. 1959.; Lee, H.A. 1968.; McDonald, B.C. 1969.; Prest, V.K. 1970b.; Terasmae, J. and O.L. Hughes. 1960b.

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Pleistocene Deposits	Netterville, J. 1974.; Tyrrell, J.B. 1898.; Tyrrell, J.B. 1913.
Pleistocene Events	Moir, D.R. 1958.
Pleistocene Landforms	Upham, W. 1889.
Pleistocene Lithology	Hamblin, A.P. 1979.
Pleistocene Lithology and Stratigraphy	McLearn, F.H. 1927.
Pleistocene Stratigraphy and Lithology	Martison, N.W. 1953.; McDonald, B.C. 1969.
Pleistocene Stratigraphy	Auer, V. 1927.; Craig, B.G. and B.C. McDonald. 1967.; Prest, V.K. 1970a.; Telford, P.G., M.A. Vos and G. Norris. 1975.; Verma, H.M., P.G. Telford and G. Norris. 1978.
Pleistocene Stratigraphy and Chronology	Terasmae, J. 1958.; Terasmae, J. and O.L. Hughes. 1960a.
Polar Gas Consortium	Shilts, W.W. 1980b.
Polygon Fen	Cowell, D.W., G.M. Wickware and R.A. Sims, in press.
Pools	Beckel, D.K.B. 1957.
Power Plant	Onakawana Development Ltd. 1973.

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Precambrian Geology	Bell, R. 1883.; Bell, R. 1887.; Bell, R. 1912.; Bostock, H.H. 1969.; Bostock, H.H. 1971.; Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.; Hawley, J.E. 1926.; Hood, P.J. (editor). 1969.; Whitmore, D.R.E. and B.A. Liberty. 1968.
Preglacial Drainage	Cumming, L.M. 1969.; Pelletier, B.R. 1969.
Proglacial Lakes	Craig, B.G. 1969.
Promontories	Martini, I.P. 1981b.; Martini, I.P. and R. Protz. 1980.; Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.
Quaternary	Tyrrell, J.B. 1915.
Quaternary Chronology	McDonald, B.C. 1971.
Quaternary Deposits	Bell, R. 1887.; Bell, R. 1912.; Wilson, W.J. 1906.
Quaternary Geology	Flint, R.F. 1947.
Quaternary History	Simpson, S.J. 1972.
Quaternary Paleontology	Richards, H.G. 1941.
Quaternary Paleontology and Paleohistory	Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912; McInnes, W. 1906.
Quaternary Stratigraphy	Ballivy, G., G. Pouliot and A. Loiselle. 1971.; Klassen, R.W. and J.A. Netterville. 1973.;

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Quaternary Stratigraphy	McDonald, B.C. 1971; Netterville, J.A. 1974.
Quaternary Stratigraphy and Chronology	Skinner, R.C. 1973a.
Quaternary Stratigraphy and Lithology	Hogg, N., J. Satterly and A.E. Wilson. 1953.; Skinner, R.C. 1973b.; Williams, M.Y. 1921.
Radiocarbon Dates	Andrews, JT, McGhee and McKenzie-Pollock. 1971.; Andrews, J.T. and G. Falconer. 1969.; Andrews, J.T. 1968.; Andrews, J.T. 1969.; Andrews, J.T. 1970.; Antevs, E. 1953.; Antevs, E. 1955.; Craig, B.G. 1969.; Fairbridge, R.W. and Claude Hillaire-Marcel. 1977.; Falconer, G., J.D. Ives, O.H. Loken and J.T. Andrews. 1965b.; Falconer, G., J.T. Andrews and J.D. Ives. 1965a.; Flint, R.F. 1956.; Flint, R.F. 1947.; Terasmae, J. and O.L. Hughes. 1960b.; Wagner, F.J.E. 1967.; Webber, P.J., J.W. Richardson and J.T. Andrews. 1970.
Radiocarbon Dating	Lee, H.A. 1960.; Terasmae, J. 1957.; Terasmae, J. and O.L. Hughes. 1960a.
Raised Beach Ridges	Mills, G.F. 1975.; Beckel, D.K.B. 1957.; Bell, R. 1879a.; Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.; Cowell, D.W., G.M. Wickware and R.A. Sims, in

KEYWORD	AUTHOR
Raised Beach Ridges	press.; Craig, B.G. 1969.; Dean, W.G. 1959.; Fairbridge, R.W. and Claude Hillaire-Marcel. 1977.; Johnston, W.A. 1917.; Lee, H.A. 1959.; Low, A.P. 1889.; Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.; Moir, D.R. 1954.; Moir, D.R. 1958.; Richards, H.G. 1941.; Rouse, W.R. and K.A. Kershaw. 1973.; Webber, P.J., J.W. Richardson and J.T. Andrews. 1970.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.
Raised Ridge Morphology and Colonization	Simpson, S.J. 1972.
Refractory Properties	Dyer, W.S. and R.J. Montgomery. 1930.
Reefal Limestone	Bell, R. 1887.; Bell, R. 1912.
Remote Sensing	Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.
River Engineering	Newbury, J.R.W. 1968.
River Ice Processes	Newbury, J.R.W. 1968.
River Morphology	Cumming, L.M. 1969.; O'Sullivan, O. 1908b.
River Pattern	Cumming, L.M. 1969.
Rotational River Bank Slides	Ballivy, G., A.A. Loiselle and G. Pouliot. 1975.

KEYWORD	AUTHOR
Salinity	Pelletier, B.R. 1969.
Salt Marsh	Glooschenko, W.A. and I.P. Martini. 1978.; Martini, I.P. 1981a.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.
Salt Marsh Ecology	Martini, I.P. and R. Protz. 1979.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1978.
Sand	Hamblin, A.P. 1979.; Johnston, W.A. 1917.
Sand and Gravel	Vos, M.A. 1979.
Sand Bars	Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.
Sangamon Interglacial	Shilts, W.W. in press.
Sea Ice	Martini, I.P. 1981a.
Seasonal Ice	Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.
Seasonal Ice Effects (Marine)	Martini, I.P. 1981a.
Seasonal Ice Rafting in Rivers	Moir, D.R. 1958.
Sedge Swales	Beckel, D.K.B. 1957.
Seismic	Hobson, G.D. 1969.
Silica Sand	Guillet, G.R. 1979.
Silurian Lithology	Gussow, W.C. 1953a.; Gussow, W.C. 1953a.
Silurian Paleontology	Flower, R.H. 1968.
Sinkholes	Cowell, D.W. in press.; Cowell, D.W. 1981.

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Snow Depth	Beckel, D.K.B. 1957.
Socio-Economic	Glooschenko, W.A. and I.P. Martini. 1978.; Hutton, C.L.A. and W.A. Black. 1975.; Société d'Energie de la Baie James. 1978.; Task Force Onakawana. 1973.; Robinson, J.L. 1968.
Soil Classification	Canadian Soil Survey Committee, Subcommittee on Soil Classification 1978.; Clayton, J.S., W.A. Ehrlich, D.B. Cann, J.H. Day and I.B. Marshall.
Soil Climate	Clayton, J.S., W.A. Ehrlich, D.B. Cann, J.H. Day and I.B. Marshall.
Soil Description	Canadian Soil Survey Committee, Subcommittee on Soil Classification 1978.; Clayton, J.S., W.A. Ehrlich, D.B. Cann, J.H. Day and I.B. Marshall.
Soil Drainage	Johnston, W.A. 1917.
Soil Moisture	Rouse, W.R. and K.A. Kershaw. 1973.
Soils	Beckel, D.K.B. 1957.; Brown, R.J.E. 1968.; Ehrlich, W.A., L.E. Pratt, J.A. Barr and F.P. LeClaire. 1959.; Glooschenko, W.A. and I.P. Martini. 1978.; Jurdant, M., J.L. Bélair, V. Gerardin and J.P. Ducruc. 1977.
Solar Cycles	Fairbridge, R.W. and Claude Hillaire-Marcel. 1977.
Solar Radiation	Beckel, D.K.B. 1957.

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Strand Lines	Manning, T.H. 1951.; Manning, T.H. and R.W. Rae. 1950.; Andrews, J.T. and D.M. Barnett. 1972.
Stratigraphy	Alcock, F.J. 1916b.; Bell, R. 1872.; Bostock, H.H. 1969.; Bostock, H.H. 1971.; Dyer, W.S. 1931.; Dyer, W.S. 1932.; Norris, A.W. and B.V. Sanford. 1969.
Structural Geology	Dyer, W.S. 1931.
Surficial Deposits	Klassen, R.W. and J.A. Netterville. 1973.
Surficial Geology	Andrews, J.T. and G. Falconer. 1969.; Bell, R. 1879a.; Bell, R. 1880.; Bell, R. 1887.; Bell, R. 1912.; Boissonneau, A.N. 1966.; Cowan, W.R. 1980.; Dean, W.G. 1959.; Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.; Dyer, W.S. and A.R. Crozier. 1933.; Falconer, G., J.D. Ives, O.H. Loken and J.T. Andrews. 1965b.; Falconer, G., J.T. Andrews and J.D. Ives. 1965a.; Guillet, G.R. 1979.; Hood, P.J. (editor). 1969.; Hughes, O.L. 1961.; Hughes, O.L. 1965.; Johnston, W.A. 1917.; Lee, H.A. 1959.; Lee, H.A. 1960.; Martini, I.P. and R. Protz. 1980.; McDonald, B.C. 1969.; McInnes, W. 1906.; Mills, G.F., H. Velduis, D.B. Forrester. 1976.; Moir, D.R. 1958.;

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Surficial Geology	Prest, V.K. 1963.; Prest, V.K. 1966.; Société d'Energie de la Baie James. 1978.; Wickware, G.M., D.W. Cowell and R.A. Sims. 1981.; Williams, M.Y. 1921.; Wilson, W.J. 1906.; Tyrrell, J.B. 1916.; Hogg, N., J. Satterly and A.E. Wilson. 1953.
Survey Methodology	Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.; Jurdant, M., J.L. Bélair, V. Gerardin and J.P. Ducruc. 1977.; Mills, G.F. 1976.
Terrain Types	Beckel, D.K.B. 1957.; Beckel, D.K.B., C.E. Low and B.R. Irvine. 1954.; Brown, R.J.E. 1968.
Tertiary Drainage Patterns	Bird, J.B. 1967.
Tidal Flats	Kershaw, K.A. 1976.; Martini, I.P. 1981b.; Martini, I.P. and R. Protz. 1980.; Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.; Moir, D.R. 1958.
Tidal Flats and Raised Beach Ridges	Herrick, R. 1977.
Tidal Levels	Barnett, D.M. 1966.; Barnett, D.M. 1970.
Tidal Range	Dohler, G.C. 1968.
Tide Gauge Data	Cooke, H.C. 1942.

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Tide Gauge Records	Gutenberg, B. 1941.; Gutenberg, B. 1954.; Kupsch, W.O. 1967.; Barnett, D.M. 1966.
Tides	Dohler, G.C. 1968.; Manning, T.H. 1951.; Manning, T.H. and R.W. Rae. 1950.; Martini, I.P., R. Protz, D. Grimham, A. King and K. Clarke. 1979.; Pelletier, B.R. 1969.
Till	Craig, B.G. and B.C. McDonald. 1967.; Hughes, O.L. 1961.; Hughes, O.L. 1965.; Lee, H.A. 1959.; McLearn, F.H. 1927.; Neqterville, J.A. 1974.; Skinner, R.C. 1973a.; Williams, M.Y. 1921.; Skinner, R.C. 1973b.
Till Analyses	Shilts, W.W., C.M. Cunningham and C.A. Kaszycki. 1979.
Till Deposits	Shilts, W.W. in press.
Till Profiles	Shilts, W.W. 1980b.
Tyrrell Sea	Cowan, W.R. 1980.; Craig, B.G. and B.C. McDonald. 1967.; Dionne, J.C. 1972.; Elson, J.A. 1969.; Lee, H.A. 1960.; Lee, H.A. 1968.; Vincent, J.S. and L Hardy. 1979.; Wagner, F.J.E. 1967.
Tyrrell Sea Clays	Ballivy, G., A.A. Loiselle and G. Pouliot. 1975.
Tyrrell Sea Deposits	Ballivy, G., G. Pouliot and A. Loiselle. 1971.
Upland Forest	Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.
Varves	Antevs, E. 1953.; Antevs, E. 1955.; Hughes, O.L. 1961.; Hughes, O.L. 1965.

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Vegetation	Beckel, D.K.B. 1957.; Brown, R.J.E. 1968.; Coombs, D.B. 1952.; Coombs, D.B. 1954.; Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.; Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.; Dean, W.G. 1959.; Glooschenko, W.A. and I.P. Martini. 1978.; Herrick, R. 1977.; Hustich, I. 1957.; Jurdant, M., J.L. Bêlair, V. Gerardin and J.P. Ducruc. 1977.; Kershaw, K.A. 1976.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.; Mills, G.F. 1976.; Mills, G.F., H. Velduis, D.B. Forrester. 1976.; Moir, D.R. 1954.; Moir, D.R. 1958.; Railton, J.B. and J.H. Sparling. 1973.; Ritchie, J.C. 1957.; Ritchie, J.C. 1960.; Rouse, W.R. and K.A. Kershaw. 1973.; Simpson, S.J. 1972.; Sims, R.A., D.W. Cowell and G.M. Wickware. (in press).; Sjörs, H. 1951.; Sjörs, H. 1959.; Sjörs, H. 1963.; Société d'Energie de la Baie James. 1978.; Tarnocai, C. 1974.; Task Force Onakawana. 1973.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.; Zoltai, S.C. 1973.

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Vegetation Ecology	Sims, R.A., J.L. Riley and J.K. Jeglum. 1979.
Water Quality	Sims, R.A., D.W. Cowell and G.M. Wickware. (in press).; Task Force Onakawana. 1973.
Wetland	Kershaw, K.A. 1976.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.
Wetland Geomorphology	Dean, W.G. 1959.; Martini, I.P., D.W. Cowell and G.M. Wickware. 1980a.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.
Wetlands	Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.
Wildlife	Glooschenko, W.A. and I.P. Martini. 1978.; Herrick, R. 1977.; Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.; Société d'Energie de la Baie James. 1978.; Task Force Onakawana. 1973.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.
Wisconsin Glaciation	Archer, D.R. 1968.; Shilts, W.W. in press.

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LOCATION	AUTHOR
Canada	Brown, R.J.E. 1967.; Prest, V.K. 1970b.; Zaslow, M. 1975.
Central and Eastern Canada	McDonald, B.C. 1971.; Walcott, R.I. 1970.
Hudson Bay	Oilweek. 1972.; Pelletier, B.R. 1969.
H.B.L.	Coombs, D.B. 1952.; Coombs, D.B. 1954.; Craig, B.G. and B.C. McDonald. 1967.; Cumming, L.M. 1969.; Cumming, L.M. 1975.; Dole, R.B. and H. Stabler. 1909.; Haworth, S.E., D.W. Cowell and R.A. Sims. 1978.; Herrick, R. 1977.; McDonald, B.C. 1969.; Norris, A.W. and B.V. Sanford. 1969.; Sandford, B.V. and A.W. Norris. 1975.; Sandford, B.V., A.W. Norris and H.H. Bostock. 1968.; Savage, T.E. and F.M. Van Tuyl. 1919.; Shilts, W.W. 1980a.; Shilts, W.W. in press.; Sims, R.A., J.L. Riley and J.K. Jeglum. 1979.
H.B.L. (southern), Northern Ontario	Innes, M.J.S. 1960.
H.B.L., Canada	Clayton, J.S., W.A. Ehrlich, D.B. Cann, J.H. Day and I.B. Marshall.

LOCATION	AUTHOR
H.B.L., H.B.R.	Andrews, J.T. 1969.; Craig, B.G. 1969.; Low, A.P. 1899.; McDonald, B.C. 1971.; Nelson, S.J. and R.D. Johnson. 1966.;
H.B.L., H.B.R.	Prest, V.K. 1970a.; Robinson, J.L. 1968.; Stockwell, C.H., J.C. McGlynn, R.F. Emslie, B.V. Sanford, A.W. Norris, J.A. Donaldson, W.F. Fahrig and K.L. Currie. Whitmore, D.R.E. and B.A. Liberty. 1968.
H.B.R.	Andrews, J.T., McGhee and McKenzie-Pollock. 1971; Andrews, J.T. and W.R. Peltier. 1976.; Andrews, J.T. and D.M. Barnett. 1972.; Antevs, E. 1953.; Antevs, E. 1955.; Archer, D.R. 1968.; Bell, R. 1896.; Bird, J.B. 1967.; Cooke, H.C. 1930.; Dionne, J.C. 1972.; Falconer, G., J.D. Ives, O.H. Loken and J.T. Andrews. 1965b.; Falconer, G, J.T. Andrews and J.D. Ives. 1965a.; Flint, R.F. 1943.; Flint, R.F. 1947.; Grant, A.C. 1969.;

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H.B.R.	Hodgkinson, J. 1969.; Hood, P.J. (editor). 1969.; Hood, P., M. Bower and E.A. Godby. 1969.; Innes, M.J.S., A.K. Goodacre, J.A. Weston and J.R. Weber. 1968.; Kupsch, W.O. 1967.; Lee, H.A. 1959.; Lee, H.A. 1960.; Lee, H.A. 1968.; Pelletier, B.R. 1969.; Shilts, W.W. 1980a.; Shilts, W.W. in press.; Shilts, W.W, C.M. Cunningham and C.A. Kaszycki. 1979.; Tyrrell, J.B. 1898 and 1913.; Upham, W. 1889.; Walcott, R.I. 1970.; Zaslow, M. 1975.
H.B.R. (Ottawa Islands N.W.T.)	Andrews, J.T. and G. Falconer. 1969.
H.B.R. (eastern Hudson Bay)	Fairbridge, R.W. and Claude Hillaire-Marcel. 1977.
H.B.R. (southern and eastern)	Cowan, W.R. 1980.
H.B.R. (southwestern Hudson Bay	Johnson, R.D. 1971.
H.B.R. Northwestern Ontario, Eastern and Northern Manitoba	Mayer-Oakes, W.J. 1967.
Keewatin (west coast of Hudson Bay)	Fyles, J.G. 1955.; Lee, H.A. 1959.; Tarnocai, c. 1974.; Tyrrell, J.B. 1898.

LOCATION	AUTHOR
Man. H.B.L.	Cumming, L.M. 1971.; Mills, G.F. 1975.; O'Sullivan, O. 1906.; Ritchie, J.C. 1960.; Shilts, W.W. 1980b.; Shilts W.W., C.M. Cunningham and C.A. Kaszycki. 1979.; Tarnocai, C. 1974.; Tyrrell, J.B. 1913.; Whiteaves, J.F. 1880-81.; Zoltai, S.C. 1973.; Zoltai, S.C. and C. Tarnocai. 1969.
Man. H.B.L. (Churchill and Nelson Rivers)	Bell, R. 1880.; Nelson, S.J. 1952.
Man. H.B.L. (Churchill area), H.B.R.	Andrews, J.T. 1968.
Man. H.B.L. (Churchill River)	Alcock, F.J. 1916a.; Alcock, F.J. 1916b.
Man. H.B.L. (Churchill)	Barnett, D.M. 1966.; Barnett, D.M. 1970.; Beckel, D.K.B. 1957.; Beckel, D.K.B., C.E. Low and B.R. Irvine. 1954.; Cooke, H.C. 1942.; Johnston, W.A. 1939.; Ritchie, J.C. 1957.; Tyrrell, J.B. 1900.
Man. H.B.L. (Churchill), H.B.R. North-eastern North America	Gutenberg, B. 1941.; Gutenberg, B. 1954.
Man. H.B.L. (Churchill), Keewatin	Richards, H.G. 1941.
Man. H.B.L. (God's River)	Netterville, J. 1974.

LOCATION	AUTHOR
Man. H.B.L. (Kaskattama River)	Johnson, R.D. and S.J. Nelson. 1969.
Man. H.B.L. (Kettle Rapids and Hayes River map area)	Mills, G.F., H. Velduis, D.B. Forrester. 1976.
Man. H.B.L. (Kettle Rapids and Hayes River map sheets), Northern Manitoba	Mills, G.F. 1976.
Man. H.B.L. (Nelson and Hayes Rivers)	Bell, R. 1879b.; Tyrrell, J.B. 1916.
Man. H.B.L. (Nelson river to Churchill) Northern Manitoba	Charles, J.L. 1959.
Man. H.B.L. (Nelson River), Northern Manitoba	Newbury, J.R.W. 1968.
Man. H.B.L. (Nelson-Hayes Estuary), H.B.L.	Simpson, S.J. 1972.
Man. H.B.L. (Nelson, Hayes and Gods rivers), Northern Manitoba	Klassen, R.W. and J.A. Netterville. 1973.
Man. H.B.L. (York Factory)	University of Manitoba. 1969.
Man. H.B.L., H.B.R.	Dohler, G.C. 1968.; Isbister, A.K. 1855.
Man. H.B.L., Northern Manitoba	Johnston, W.A. 1917.; Tarnocai, C. 1972.; Tyrrell, J.B. 1890-91.
Man. H.B.L. (Churchill)	Tyrrell, J.B. 1896.
Northeastern North America including H.B.R.	Andrews, J.T. 1970.

LOCATION	AUTHOR
North America	Coleman, A.P. 1941.
Northern Manitoba	Ehrlich, W.A., L.E. Pratt, J.A. Barr and F.P. LeClaire.1959.; Shilts, W.W. 1980b.; Tarnocai, C. 1974.; Vincent, J.S. and L. Hardy, 1979.
Northern Ontario	Bell, R. 1883.; Shilts, W.W. 1980b.; Vincent, J.S. and L. Hardy, 1979.
Northern Ontario, H.B.R. (southern)	Hughes, O.L. 1961.; Hughes, O.L. 1965.
Northern Ontario, South H.B.R.	Boissonneau, A.N. 1966.
Northern Québec	Archer, D.R. 1968.
Northwestern Hudson Bay (Keewatin)	Bird, J.B. 1954.
Northwestern Ontario, Northwestern Québec, Southern H.B.R.	Prest, V.K. 1966.
Ont & Qué HBL & E.Coast Hudson & James Bay	Bell, R. 1879a.
Ont. H.B.L. (Moose River)	Bell, J.M. 1904.
Ont. H.B.L. (Sutton Ridges)	Bostock, H.H. 1971.
Ont. H.B.L. (west coast of James Bay)	Martini, I.P., R.I.G. Morrison, W.A. Glooschenko and R. Protz. 1980b.
Ont. H.B.L. (Hawley Lake)	Railton, J.B. and J.H. Sparling. 1973.

LOCATION	AUTHOR
Ont. H.B.L.	Brown, R.J.E. 1968.; Hustich, I. 1957.; Hutton, C.L.A. and W.A. Black. 1975.; McGregor, D.C. and M. Camfield. 1976.; O'Sullivan, O. 1906.; Parks, W.A. 1913.; Tyrrell, J.B. 1913.; Whiteaves, J.F. 1910.
Ont. H.B.L. (Albany River)	Dyer, W.S. 1929b.
Ont. H.B.L. & Man. H.B.L. (along Hudson Bay Coast)	Manning, T.H. 1947.
Ont. H.B.L. & Man. H.B.L. (Moose River to Nelson River)	Hanson, H.C. and R.H. Smith. 1950.
Ont. H.B.L. (Abitibi & Mattagami rivers)	Malcolm, W. 1924.
Ont. H.B.L. (Abitibi River)	Brown, D.D., G. Bennett and P.T. George. 1967.; Gilmore, R.E. 1929.
Ont. H.B.L. (Abitibi, Missinaibi, Mattagami and Moose Rivers)	Vos, M.A. 1975.
Ont. H.B.L. (Albany River)	Williams, M.Y. 1921.
Ont. H.B.L. (Albany River), N. Ontario	Bell, R. 1872.
Ont. H.B.L. (Albany & Attawapiskat rivers)	Bell, R. 1887.; Bell, R. 1912.
Ont. H.B.L. (Attawapiskat River)	Gussow, W.C. 1953a.; Cowell, D.W. 1981.; Cowell, D.W. 1982.; Sjörs, H. 1963.

LOCATION	AUTHOR
Ont. H.B.L. (Attawapiskat River), North-Central Ontario	Prest, V.K. 1963.
Ont. H.B.L. (Cape Henrietta Maria)	Webber, P.J., J.W. Richardson and J.T. Andrews. 1970.; Wickware, G.M., R.A. Sims, R.K. Ross and D.W. Cowell. 1980.
Ont. H.B.L. (coastal zone near Winisk and south of Albany river)	Wickware, G.M., D.W. Cowell and R.A. Sims. 1981.
Ont. H.B.L. (coastal zone of western James Bay	Martini, I.P. 1980a and b.; Wickware, G.M., R.A. Sims, and D.W. Cowell. in press.
Ont. H.B.L. (coastal zone south & south-east of Albany River)	Sims, R.A., D.W. Cowell and G.M. Wickware. (in press).
Ont. H.B.L. (coastal zone - Southern James Bay)	Cowell, D.W., G.M. Wickware and R.A. Sims. 1979.
Ont. H.B.L. (East Pen Island)	Kershaw, K.A. 1976.

LOCATION	AUTHOR
Ont. H.B.L. (Ekan River, Sutton Ridges and James Bay Coast)	Dowling, D.B. 1905.; Dowling, D.B. 1904.; Dowling, D.B. 1912.
Ont. H.B.L. (especially Hawley Lake - Attawapiskat River)	Sjörs, H. 1959.
Ont. H.B.L. (Fort Albany)	Hunter, G. 1970.
Ont. H.B.L. (French - Abitibi rivers)	Guillet, G.R. 1964.
Ont. H.B.L. (Hawley Lake - Sutton Ridges)	Sjörs, H. 1951.
Ont. H.B.L. (Hayes-Severn rivers)	O'Sullivan, O. 1908b.
Ont. H.B.L. (James Bay Shore)	Manning, T.H. and R.W. Rae. 1950.
Ont. H.B.L. (Kapiskau to Moose River)	Wilson, W.J. 1906.
Ont. H.B.L. (Kinoje Lakes)	Cowell, D.W., J.K. Jeglum and J.C. Merriman. 1978.
Ont. H.B.L. (Mattagami River)	Baker, M.B. 1911.; Dyer, W.S. and R.J. Montgomery. 1930.
Ont. H.B.L. (Mattagami & Missinaibi rivers)	Keele, J. 1920.
Ont. H.B.L. (Missinaibi & Attawapiskat rivers, Hawley Lakes & Cape Henrietta Maria), Man. H.B.L. (Churchill), H.B.R.	Wagner, F.J.E. 1967.
Ont. H.B.L. (Missinaibi River)	Auer, V. 1927.; Terasmae, J. 1958.

LOCATION	AUTHOR
Ont. H.B.L. (Missinaibi River), Southern Québec	Terasmae, J. 1957.
Ont. H.B.L. (Missinaibi, Albany, Abitibi and Attawapiskat rivers)	Terasmae, J. and O.L. Hughes. 1960a.
Ont. H.B.L. (Moose & Albany River Basins)	Dean, W.G. 1959.
Ont. H.B.L. (Moose & Albany rivers)	Dyer, W.S. 1929a.
Ont. H.B.L. (Moose River area)	Dyer, W.S. 1928.; Williams, M.Y. 1920.
Ont. H.B.L. (Moose River Basin - Abitibi R.	Scintrex Surveys Ltd. 1976.; Verma, H.M., P.G. Telford and G. Norris. 1978.
Ont. H.B.L. (Moose River Basin)	Dyer, W.S. 1932.; Dyer, W.S. and A.R. Crozier. 1933.; Gussow, W.C. 1953b.; Hamblin, A.P. 1979.; Hogg, N., J. Satterly and A.E. Wilson. 1953.; Martison, N.W. 1953.; McLearn, F.H. 1927.; Montgomery, R.J. 1929.; Norris, G. 1979.; Ontario Ministry of Environment. 1981.; Ontario Research Foundation. 1933.; Rogers, D.P., J.S. Hancock, S.A. Ferguson, W.O. Karvinen & P. Beck. 1975.; Skinner, R.C. 1973b.;

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Ont. H.B.L. (Severn River), Man. H.B.L. (Ontario to York Factory), N. Manitoba	Low, A.P. 1887.
Ont. H.B.L. (Severn, Fawn Rivers), Northern Ontario	Moir, D.R. 1958.
Ont. H.B.L. (south & west coast of James Bay)	O'Sullivan, O. 1912.
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Ont. H.B.L., Qué. H.B.L. (southern James Bay	Low, A.P. 1889.
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Qué. H.B.L., H.B.R.	Ballivy, G., G. Pouliot and A. Loiselle. 1971.
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Qué. H.B.L., North-Central Québec	Jurdant, M., J.L. Bélair, V. Gerardin and J.P. Ducruc. 1977.

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Qué., Qué. H.B.L.	Manning, T.H. 1951.
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