GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA

PAPER 74-17

ONTARATUE RIVER (106J), TRAVAILLANT LAKE (106-O), AND CANOT LAKE (106P) MAP-AREAS, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

D.G. Cook and J.D. Aitken

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Energy, Mines and Resources Canada
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Available by mail from *Information Canada*, Ottawa, K1A 0S9

from the Geological Survey of Canada
601 Booth St., Ottawa, K1A 0E8

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Price - Canada: $3.50
Other Countries: $4.55

Catalogue No. M44-74-17

Price subject to change without notice

Information Canada
Ottawa
1975

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ABSTRACT

The exposed stratigraphic succession in the three NTS map-areas (106J, 106-O, and 106P) consists of Middle Devonian, Upper Devonian, and Lower Cretaceous strata. Older rocks down to and including Proterozoic strata have been encountered in exploratory wells. The total succession is interrupted by at least five unconformities, the most pronounced of which is the sub-Cretaceous unconformity. Relief on the sub-Cretaceous surface appears to be primarily paleotopographic with some structural modification.

Local folding and faulting affected Devonian strata and apparently pre-dated Cretaceous strata. Broader, more regional structures appear to be in part older and in part younger than Cretaceous rocks.

Among the engineering problems expected within the map-areas are those which would result from the tendency of several formations to undergo gravity slumping, and also the sparse distribution of rocks suitable for riprap.

Although it is possible that base metals exist in the report-area, the greatest economic potential is for oil and gas.

RÉSUMÉ

La succession stratigraphique exposée dans les trois régions des T.N-O. (106J, 106-O, et 106P) se compose de couches du Dévonien moyen, du Dévonien supérieur et du Crétacé inférieur. Dans les puits d'exploration, on a trouvé des roches plus anciennes, jusqu'à et y compris des couches du Protérozoïque. Dans son ensemble la succession présente au moins cinq discordances, la plus prononcée étant la discordance sous-jacente au Crétacé. La surface sous-jacente au Crétacé présente principalement un relief paléotopographique dont la structure a subie certaines modifications.

Les couches du Dévonien sont plissées et faillées par endroits et il semble en être de même pour les couches antérieures au Crétacé. Des structures plus étendues, plus régionales, semblent plus anciennes que les roches crétacées à certains endroits et plus récentes que celle-ci en d'autres.

Parmi les problèmes d'ingénierie qu'on s'attend à rencontrer a l'intérieur de ces régions, il y a ceux qui proviennent de la tendance qu'ont plusieurs formations à subir des glissements sous l'effet de la pesanteur; il y a également le fait que les roches qui peuvent convenir à l'enrochement sont clairsemées.

Même s'il est possible qu'il y ait des métaux non précieux dans la région étudiée, le pétrole et le gaz n'en demeurent pas moins le plus important potentiel économique.

ONTARATUE RIVER (106J), TRAVAILLANT LAKE (106-O), AND CANOT LAKE (106P) MAP-AREAS, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

INTRODUCTION AND ACKNOWLEDGMENTS

Geological mapping of the three map-areas, Ontaratue River (106J), Travaillant Lake (106-O), and Canot Lake (106P), was carried out in 1968 with additional work in 1971, as part of Operation Norman, an airborne, regional geological reconnaissance by the Geological Survey of Canada. The authors together with H.R. Balkwill and M.E. Ayling were responsible for the bedrock mapping and structural interpretation. W.S. MacKenzie made surface studies of Middle and Upper Devonian strata and presently is conducting subsurface studies of Proterozoic to Upper Devonian rocks. C.J. Yorath examined Cretaceous strata, particularly in Ontaratue River map-area (106J). A.E.H. Pedder conducted field and laboratory studies of Devonian biostratigraphy. Fossil collections from the three map-areas were examined by W.W. Brideaux, T.P. Chamney, W.S. Hopkins, J.A. Jeletzky, A.E.H. Pedder and R. Thorsteinsson, all of the Geological Survey of Canada, and by W.W. Stewart, University of Alberta. The resultant reports are in Appendices I, II and III and Geological Survey of Canada permanent locality numbers are plotted on the geological maps 1408A, 1409A and 1410A (in pocket). Valuable bedrock information was obtained from seismic shot point samples donated by Chevron Standard Limited, Sigma Explorations Ltd., and Western Decalta Petroleum Ltd., and from samples from test drilling by the Department of Public Works along and adjacent to the proposed route for the Mackenzie Highway. Unpublished, non-confidential geological reports on file with the Department of Indian and Northern Affairs are acknowledged individually where called upon.

PHYSIOGRAPHY AND ACCESS

The three map-areas covered by this report lie within the Interior Plains (*see* Bostock, 1964), and are characterized by great expanses having low relief and containing abundant swamps, ponds and lakes linked by sluggish streams.

The Mackenzie River occupies part of a broad flood plain of pre-Quaternary age that has been modified by Pleistocene glaciation and extensively buried by Quaternary deposits. North and east of Little Chicago (106-O), the moraine-covered flood plain is bounded by a bedrock-supported escarpment 600 to 800 feet (180-240 m) high.

A similar escarpment south and southeast of Travaillant Lake (106-O) presumably extends through the intervening Thunder River area but appears to be buried there by thick morainal deposits, so that the change from moraine-covered flood plain to bedrock upland is indistinct. Thick upland morainal deposits obscure bedrock east and southwest of Carcajou Lake in the Canot Lake map-area (106P) and north of Tenlen Lake in the Travaillant Lake map-area (106-O). The Grandview Hills are a bedrock upland surrounded by drift-covered lowlands. Drift-covered lowlands occupy about three quarters of the Ontaratue River map-area and are distinguished by a northwest-trending linear belt of closely spaced small lakes. The lakes have been developed by thermokarst action in ice-rich proglacial lake clays (J. Pilon, pers. com., 1973).

Summer access to the area is provided by Mackenzie River, along which heavy equipment and fuel can be transported by barge. Access to those parts of the area removed from the river is primarily by helicopter or float-equipped fixed-wing aircraft. The Mackenzie Highway, currently being designed by the Department of Public Works, will cross Travaillant Lake map-area (106-O) and the southwest corner of Canot Lake map-area (106P), northeast of Mackenzie River.

PREVIOUS WORK

The exploration history of the Mackenzie River drainage basin prior to 1921 was summarized by Camsell and Malcolm (1921, p. 2-5). The first geological observations pertaining to the lower Mackenzie River appear to have been made by Dr. John Richardson (reprint, 1971) when he accompanied Captain John Franklin on his second expedition to the polar sea. Few geological maps pertaining to this area have been published. The earliest appear to be those produced by McConnell (1891) showing lithologies and ages of rocks exposed in the banks of the Mackenzie River and major tributaries. The map of Camsell and Malcolm (1921) is a regional compilation extending from Edmonton to the Mackenzie Delta, and the geology shown by them along the Mackenzie River from The Ramparts to the delta is largely that of McConnell with minor modifications.

Nauss (1944) mapped the area adjacent to the Mackenzie River from The Ramparts near Fort Good Hope to Point Separation, as part of the Canol Project; his geology was incorporated in maps compiled and published by Hume (1954).

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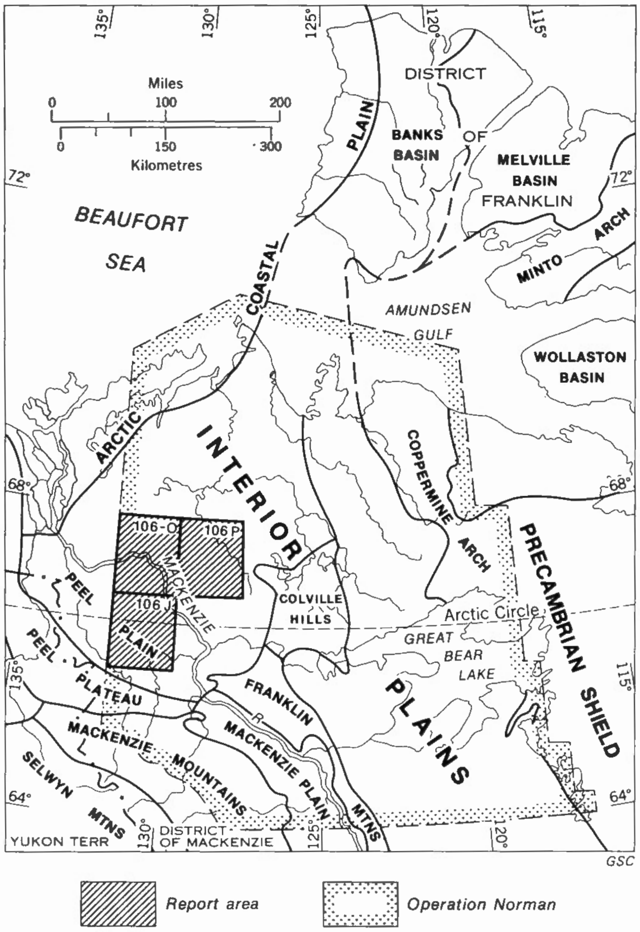

FIGURE 1. Index map showing position of report area with respect to total Operation Norman area, and with respect to regional tectonic elements (tectonic elements modified from Douglas *et al.*, 1963)

All published maps pertaining specifically to the report-areas show geology only along the shores of major rivers and lakes. Unpublished geological studies by oil companies and consultants, dealing with the upland areas away from the river, are on file with the Department of Indian and Northern Affairs. Douglas and MacLean (1963) compiled a small-scale map of the entire region from various sources, and Douglas *et al.* (1963) discussed geology and petroleum potential of all of northern Canada.

Tassonyi's (1969) regional subsurface study dealt with all wells drilled prior to March, 1961, and provided an important starting-point for the present study.

Map-areas 106J, O and P are adjoined by the following recent geological maps: a regional compilation by Norris *et al.* (1963) on the west, a map by Yorath and Balkwill (1969) on the north, and maps by Cook and Aitken (1969, 1971) on the east.

Paleozoic stratigraphic nomenclature used here evolved primarily from earlier work in the region to the south. Summaries of the history of exploration there are presented by Hume (1954) and Tassonyi (1969).

REGIONAL GEOLOGY

The three map-areas 106J, O and P lie entirely in the Interior Plains physiographic region. Their position within the total Operation Norman area and relationship to regional tectonic features are shown in Figure 1. Regionally, Paleozoic rocks form a gently westward-dipping homocline truncated by pre-Cretaceous erosion, so that Cretaceous rocks overlie Upper Devonian rocks in Peel Plateau southwest of the study area and overlie progressively older strata eastward toward the Coppermine Arch where they lie on Cambrian and Precambrian rocks.

The study area lies in a plains re-entrant bounded on the east, south and west by tectonically disturbed areas: the Colville Hills and Franklin Mountains to the east and southeast, the Mackenzie Mountains to the south, and the Richardson Mountains to the west. Localized folding and faulting occur in map-areas 106-O and P. These and more subtle structures appear to pre-date Cretaceous deposits.

STRATIGRAPHY

The oldest rocks exposed in the three map-areas are Middle Devonian Hume Formation limestones, but older strata down to and including Precambrian rocks have been encountered in exploratory wells. The stratigraphy of the three map-areas is summarized in Table 1.

Subsurface units are described here briefly. Descriptions of Precambrian and basal Cambrian strata are abstracted from the well reports on file with the Department of Indian and Northern Affairs. Descriptions of the Franklin Mountain Formation, Mount Kindle Formation, and a younger unnamed unit also are brief, but have been written in consultation with W.S. MacKenzie and are based primarily on his detailed examination of core from the Central Del Rio Tenlen A-73 well, which was cored between depths of 200 and 8,510 feet (61-2554 m). Description of the Gossage Formation is abstracted from Tassonyi (1969).

PROTEROZOIC

Unnamed Proterozoic rocks

Four wells have penetrated Proterozoic strata. In the two westernmost wells, Candel *et al.* Mobil Grandview Hills L-26 (map-area 106J) and Central Del Rio Tenlen A-73 (map-area 106-O), the Proterozoic beds are mainly cryptocrystalline to crystalline, commonly pink or red dolomite with minor shale, limestone, siltstone, and chert. In the easternmost well, Candel Mobil *et al.* Iroquois I-11 (map-area 106P), Proterozoic rocks are mainly microcrystalline to finely crystalline, grey and greyish brown dolomite with pink and red patches.

	Unit		Thickness
CRETACEOUS	*unnamed: marine and nonmarine shales and sandstones, undivided*		0-300+ ft (0-91+ m)
regional unconformity			
UPPER DEVONIAN	*Imperial Formation*		0-850+ ft (0-259+ m)
	Canol Formation		75-285 ft (23-87 m)
regional unconformity			
MIDDLE DEVONIAN	*unnamed unit D_4*		0-65 ft (0-20 m)
	Ramparts Formation		0-50 ft (0-15 m)
	Hare Indian Formation		500-800 ft (152-244 m)
	Hume Formation		225-340 ft (69-104 m)
LOWER AND MIDDLE DEVONIAN	*Gossage Formation (subsurface)*	*Upper limestone member*	750 ft (229 m)
		Middle dolomite member	660 ft (201 m)
		?unconformity?	
		Lower limestone, dolomite, and shale member	0-180 ft (29-55 m)
?unconformity?			
UPPER SILURIAN	*unnamed unit (subsurface) (Delorme equivalent)*		760± ft (232± m)
?unconformity?			
UPPER ORDOVICIAN TO LOWER SILURIAN	*Mount Kindle Formation (subsurface)*		790 ft (241 m)
regional unconformity			
UPPER CAMBRIAN TO LOWER ORDOVICIAN	*Franklin Mountain Formation (subsurface)*	*unnamed chert-free porous dolomite*	381 ft (116 m)
		Cherty unit	1,120 ft (341 m)
		Rhythmic unit	1,000 ft (305 m)
		Cyclic unit	226 ft (69 m)
UPPER CAMBRIAN	*Saline River Formation (subsurface)*		370-880 ft (113-268 m)
regional unconformity			
LOWER AND/OR MIDDLE CAMBRIAN	*Old Fort Island and Mount Cap Formation, undivided (subsurface)*		340-650 ft (104-198 m)
regional unconformity			
PROTEROZOIC	*unnamed (subsurface)*		1,458+ ft (444+ m)

GSC

Table 1. Table of stratigraphic units

In Mobil *et al.* Iroquois D-40 well (map-area 106P), about 16 miles (26 km) southwest of the Iroquois I-11 well, 1,458 feet (437 m) of Proterozoic beds were intersected. These are composed mainly of siltstone and silty shale, in part calcareous or dolomitic, with some sandstone and dolomite. The uppermost 300 feet (90 m) are mainly red, green and brown shale.

Differences in lithology presumably are related to truncation of units at the sub-Cambrian unconformity.

CAMBRIAN

Old Fort Island and Mount Cap Formations, undifferentiated (Norris, 1965; Williams, 1923)

Beds at the base of the Paleozoic sequence comprise mainly green, red, grey and brownish grey shale with some siltstone and microcrystalline dolomite, minor anhydrite and gypsum, and small amounts of fine-grained sandstone, in part glauconitic.

These strata occupy the same stratigraphic position as the Old Fort Island (Mount Clark) and Mount Cap Formations exposed in Mackenzie and Franklin Mountains to the south, and along the edge of the Canadian Shield to the east. Thickness of the interval varies between 341 feet (102 m) in the Iroquois I-11 well and 645 feet (193 m) in the Iroquois D-40 well. The basal Cambrian sandstone (Old Fort Island/Mount Clark) cannot be recognized with certainty from some of the well descriptions on file with the Department of Indian and Northern Affairs, and may be missing in some wells. Macqueen and MacKenzie (1973) draw attention to the discontinuous distribution of the basal sandstone, which they attribute tentatively to the control of deposition by Precambrian topography. The basal sandstone is best developed in Candel *et al.* Mobil Grandview L-26 well (106J), where 96 feet (29 m) of siltstone and sandstone occur.

Saline River Formation (Williams, 1923)

Evaporites of the Saline River Formation occur in the Candel *et al.* Grandview L-26, Mobil *et al.* Iroquois D-40, and Candel *et al.* Iroquois I-11 wells. The formation consists of a lower unit up to 645 feet (197 m) thick, composed mainly of halite, and an upper unit, up to 235 feet (72 m) thick, composed mainly of gypsum. No halite occurs in the CDR Tenlen A-73 well, where 370 feet (113 m) of mostly green, red, and grey shale with some dolomite and siltstone, and minor anhydrite overlie Precambrian beds and underlie the Franklin Mountain Formation. MacKenzie (1974) assigned these beds to the Saline River Formation. The western or northwestern edge of the halite deposits must pass between the Tenlen A-73 well and the three wells named above. The Saline River Formation extends southeastward into the Franklin Mountains and eastward to the flanks of Coppermine Arch (Fig. 1).

No fossils have been collected from the Saline River Formation but, in the Mackenzie Mountains to the south, it is considered to be Late Cambrian in age because there it has a gradational contact with overlying Upper Cambrian beds at the base of the Franklin Mountain Formation (*see* Macqueen, 1970) and overlies the regional sub-Upper Cambrian unconformity (*see* Aitken, Macqueen and Usher, 1973).

UPPER CAMBRIAN TO LOWER ORDOVICIAN

Franklin Mountain Formation (Williams, 1923)

W.S. MacKenzie (1974) recognized in the Tenlen A-73 well each of Macqueen's (1970) three subdivisions of the Franklin Mountain Formation and a fourth unit at the top of the formation. The lowermost "cyclic unit" consists mainly of grey and brown, finely crystalline dolomite, commonly argillaceous, with thin shale interbeds and beds of flat-pebble conglomerate. It is 226 feet (69 m) thick, and grades upward into pale and dark brown and dark grey, finely, medium and coarsely crystalline, partly argillaceous dolomite equivalent to Macqueen's "rhythmic unit". The "rhythmic unit" is 1,000 feet (305 m) thick and is overlain by 1,120 feet (341 m) of cherty dolomite beds equivalent to Macqueen's "cherty unit". MacKenzie described a "zone of floating sand grains", 302 feet (92 m) thick, occurring within the cherty unit. MacKenzie also described an uppermost porous, chert-free dolomite unit, 381 feet (116 m) thick, overlying the cherty unit. The porous dolomite unit has not been recognized in outcrops in Colville Hills, Franklin Mountains, or Mackenzie Mountains.

The contact with the overlying Mount Kindle Formation is known regionally to be unconformable (*see* Norford and Macqueen, in press).

No fossils have been reported from the Franklin Mountain Formation from within the three map-areas described here. Elsewhere, the Franklin Mountain Formation ranges in age from Late Cambrian at its base to Early Ordovician at its top (*see* Macqueen, 1970; Macqueen and MacKenzie, 1973). In most well reports, dolomites of the Franklin Mountain, the overlying Mount Kindle Formation, and younger beds have been designated as undivided Ronning Formation.

UPPER ORDOVICIAN TO LOWER SILURIAN

Mount Kindle Formation (Williams, 1923)

The Mount Kindle Formation comprises mainly dark brown, argillaceous and siliceous, microcrystalline dolomite, which commonly is fossiliferous. It is 787 feet (240 m) thick (MacKenzie, 1974) in the CDR Tenlen A-73 well. In exposures in the Colville Hills and Franklin Mountains (Fig. 1), the Mount Kindle is discontinuous due to pre-Devonian or pre-Late Silurian erosion. In well reports, the Mount Kindle commonly is lumped with the Franklin Mountain Formation as Ronning Formation or Group, and its distribution within the three map-areas is, therefore, not known completely.

The Mount Kindle Formation has an abundant silicified fauna and ranges in age from Late Ordovician to Early Silurian (*see* Cook and Aitken, 1971; Macqueen, 1970; Norford and Macqueen, in press).

UPPER SILURIAN

Unnamed unit

Ziegler (1969) indicated that a unit of carbonate rocks, equivalent to the Delorme Formation of the southern Mackenzie Mountains, extends northward across the map-areas reported here. MacKenzie (1974) has identified tentatively this unit above the Mount Kindle Formation in the Tenlen A-73 well. The unit comprises mainly grey and brown, variably argillaceous dolomites, 758 feet (231 m) thick. From these beds, MacKenzie collected fish fragments which R. Thorsteinsson (Geological Survey of Canada) believes are no older than Late Silurian (Appendix I). The fossils are important evidence in confirming Ziegler's northward extension of rocks equivalent to the Delorme Formation. The unit was not observed in outcrop to the east in Colville Hills or to the southeast in Franklin Mountains. Its distribution in wells adjacent to Tenlen A-73 currently is being studied by MacKenzie.

It is not known whether the contact with the overlying Gossage Formation is conformable or unconformable.

LOWER TO MIDDLE DEVONIAN

Gossage Formation
(Tassonyi, 1969)

Tassonyi (1969) named the Gossage Formation and designated the Richfield *et al.* Grandview Hills No. 1 well (106-O) as the type section. He subdivided the formation into three informal members. In the type well, the basal member is 180 feet (55 m) thick and is composed mainly of light buff limestone, with thin partings of green waxy-appearing shale and minor dolomite. Elsewhere (*see* Tassonyi, 1969, p. 50), the member is as thin as 95 feet (29 m) and is mainly dolomite. The middle dolomite member, 657 feet (200 m) thick in the type well, is almost entirely brown and buff dolomite with rare thin limestone beds and waxy-appearing shale partings. The upper pellet limestone member is 752 feet (229 m) thick in the type well and consists mainly of buff to pale brown, dense limestone, commonly with pellets. For detailed lithologic descriptions and discussion of regional thickness variations, see Tassonyi (1969, p. 48-61). The three members are recognizable in the subsurface of all three map-areas (106J, O, and P) (Tassonyi, 1969; MacKenzie, pers. com., 1974).

Biostratigraphic control is poor, but the Gossage Formation appears to correlate with the Bear Rock Formation to the southeast, with which it is physically continuous.

The Gossage is overlain conformably by the Hume Formation.

MIDDLE DEVONIAN

Hume Formation (Dh)
(Bassett, 1961)

The Hume Formation over most of the three map-areas is a subsurface unit, but it is exposed along Carnwath and Andrew Rivers in the northeast part of map-area 106P. It was encountered in all exploratory wells in the three map-areas as well as in a number of seismic shot points. In outcrop, it consists of fossiliferous, brown, dense, thin- and medium-bedded limestone with partings and thin interbeds of brown shale, especially in the lower and middle parts of the formation. At a single locality only, a few miles east of Canot Lake map-area (map-area 106P) along Carnwath River, a number of small patch reefs, abundantly fossiliferous, were observed in calcareous shale at the top of the Hume Formation (MacKenzie, 1969; Cook and Aitken, 1971). Within the three map-areas, the formation ranges in thickness from 224 feet (67 m) in the Canada Southern Carnwath River No. 1 well in the north-central part of map-area 106P to 342 feet (104 m) in Atlantic Circle River No. 1 well (Map 1408A). Abundant fossils indicate an early to mid-Middle Devonian age [Eifelian with the exception of a few feet of Givetian beds at the top (Lenz and Pedder, 1972, p. 7)].

Hare Indian Formation (Dhi)
(Kindle and Bosworth, 1921; Bassett, 1961)

The Hare Indian Formation conformably overlies the Hume Formation. It is the surface bedrock unit over wide areas, especially in map-area 106P, but is recessive and consequently very poorly exposed. The best exposures occur in cut banks along the Iroquois River and its tributaries from the west.

Lower and upper members are identified readily in individual outcrops but could not be mapped separately. The basal spore-bearing member of Tassonyi (1969) consists of dark brown to black, fissile, bituminous shale with abundant *Tentaculites* and rare limestone beds, including one or more distinctive fibrous calcite beds a few inches thick (*see* MacKenzie, 1972). The basal member, observed locally along the Carnwath River, varies in the subsurface from 18 to 126 feet (6-38 m) in thickness (W.S. MacKenzie, pers. com., 1974). The upper member of the Hare Indian consists of grey, greenish grey, and pale brown shale with thin beds, especially near the top, of locally fossiliferous and partly silty limestone. The thickness of the upper member varies from between 395 and 695 feet (121-212 m) in the subsurface (MacKenzie, pers. com., 1974).

The total thickness of the formation also varies markedly across the region. Near Iroquois Syncline at Carnwath River in the northwestern part of map-area 106P, the thickness can be calculated to be about 500 feet (150 m) on the basis of shot point, outcrop, and measured dip data. West of Iroquois River in the Mobil *et al.* Iroquois D-40 well, the base of the Hare Indian Formation is at an elevation of about 175 feet (53 m) and the top, on the geological map, is at about 725 feet (220 m). The thickness of the Hare Indian in that vicinity, therefore, appears to be about 500 feet (168 m). In Mobil Inexco NCO Sun Manuel Lake J-47 well, it is 793 feet (242 m), a maximum observed for the study area. The minimum observed is 453 feet (138 m), in the CDR Tenlen A-73 well in the northern part of map-area 106-O. From there it thickens southward and is 746 feet (227 m) thick in the Atlantic Circle River No. 1 well in 106J, but thins westward to zero in wells just west of map-area 106P and in Decalta *et al.* Ontaratue I-38 in the southwest part of map-area 106J.

The Hare Indian Formation is overlain conformably by either the Ramparts Formation or map-unit D_4 where the Middle Devonian sequence is complete. To the west in the subsurface it has been truncated by pre-Late or Late Devonion erosion and is overlain by the Upper Devonian Canol Formation. To the northeast, over large parts of map-area 106P, the Hare Indian is unconformably overlain by Cretaceous sandstone and shale.

The fauna of the Hare Indian Formation indicates a Middle Devonian (Givetian) age (Bassett, 1961).

Ramparts Formation (Dr)
(Kindle and Bosworth, 1921; Caldwell, 1964)

The Ramparts Formation lies conformably on and is, in part, a lateral facies of the Hare Indian Formation. It has been observed in isolated outcrops near Yeltea Lake in 106P and on both sides of the Mackenzie River in the southern part of 106-O. It is considered to extend about 12 miles (19 km) north of Little Chicago (106-O) as a continuous mass, but outliers occur farther north. A small one lies about 50 miles (80 km) north of Little Chicago and a larger outlier is preserved in Iroquois Syncline in the north-central part of 106P. It is not known whether these are depositional outliers or erosional outliers isolated by pre-Canol erosion.

The Ramparts Formation of most of the region covered by this report, unlike the type Ramparts, consists mainly of thin- to medium-bedded, brown, fetid, partly argillaceous, rubbly-weathering limestone commonly formed of transported fragments of branching tabulate corals. It is poorly exposed and no complete section was observed within the three map-areas, but it appears generally to be no greater than 25 feet (8 m) thick. The strata exposed in Iroquois Syncline, however, resemble the type Ramparts Formation. There, the base is covered, but about 50 feet (15 m) of massive limestone with indistinct bedding occur. Stylolitic fractures with accumulation of bitumen are common. In contrast to the abundantly fossiliferous Ramparts elsewhere, in Iroquois Syncline only a few stromatoporoids and local thin bioclastic beds were observed.

The Ramparts Formation is overlain either conformably by the unnamed Devonian map-unit D_4, unconformably by the Upper Devonian Canol Formation, or unconformably by Cretaceous sandstone and shale. Sandstone of map-unit D_4 locally fills channels cut into the Ramparts, but regional stratigraphic and biostratigraphic studies (W.S. MacKenzie, A.E.H. Pedder, and T.T. Uyeno, pers. com., 1974) show that no significant hiatus exists at the contact. Considered regionally, the Ramparts is in part a lateral facies equivalent of both the underlying Hare Indian Formation and the overlying map-unit D_4.

Fossils in the Ramparts Formation are Middle Devonian (Givetian).

Unnamed map-unit D_4

An unnamed sandstone unit, designated "map-unit D_4", is restricted to a relatively small area, about 150 by 50 miles (240 x 80 km), extending from a few miles south of Ontaratue River (106J) to a few miles beyond the north boundaries of 106-O and 106P. It has a maximum recorded thickness of 65 feet (20 m) in the Richfield *et al.* Grandview Hills No. 1 well and thins both westward and eastward. It does not occur in wells west of map-areas 106J and 106-O (W.S. MacKenzie, pers. com., 1974). The eastern limit, in 106P, is controlled by pre-Cretaceous and Recent erosion, but probably corresponds closely to the depositional limit since the unit was not observed beneath the Canol Formation farther east in Iroquois Syncline.

The unnamed sandstone overlies Ramparts limestone in the southern part of its area of occurrence but extends beyond the northern limit of Ramparts development to overlie Hare Indian shale in the northern part of map-areas 106-O and 106P. It is believed to be a continuous sand body, but outcrops are poor and widely separated. At least one local area of non-deposition or removal occurred within the general area of deposition as the unit is missing between Canol and Hare Indian strata at two faulted sections about 6 and 10 miles (10 and 16 km) north of Little Chicago (Figs. 9, 10).

The unit is composed of fine- to very fine grained, grey, friable, quartzose sandstone, commonly calcareous and fossiliferous, with shale interbeds. It is generally thin bedded with irregular laminations and is flaggy when weathered but includes some more indurated, more massive beds up to 1 foot (0.3 m) thick. The most common fossil is a large brachiopod, *Leiorhynchus hippocastanea*; stromatoporoids, gastropods, corals, trilobites, and other brachiopods also occur.

The abundant fauna indicates a Middle Devonian, late Givetian age. Although local channelling into underlying Ramparts Formation strata suggests an unconformity at the base of the unit, regional litho- and biostratigraphic considerations (W.S. MacKenzie and A.E.H. Pedder, pers. com., 1974) indicate that it is in part a facies of the Ramparts Formation.

The contact between map-unit D_4 and overlying black shale of the Canol Formation is abrupt (Fig. 2). The contact appears conformable locally, but regionally the base of the Canol can be demonstrated to be unconformable (W.S. MacKenzie, pers. com., 1974). Locally, map-unit D_4 is overlain unconformably by Cretaceous sandstone or shale.

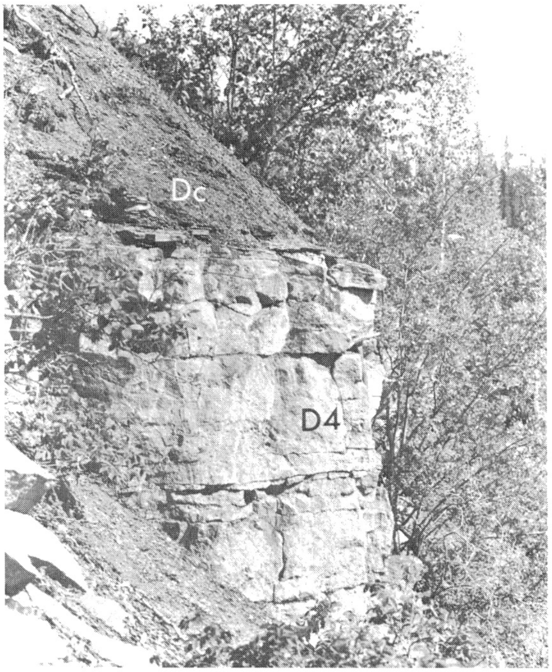

FIGURE 2. Contact between map-unit D_4 and Canol Formation (Dc). About 6 miles east of Little Chicago, 67°12'N, 130°01'30"W, NTS 106-O. GSC 199086

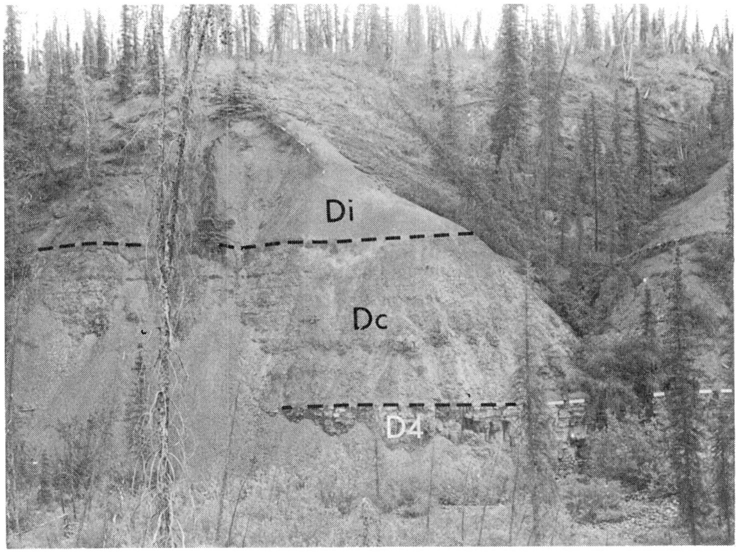

FIGURE 3. Stratigraphic section showing map-unit D_4, Canol Formation (Dc), and Imperial Formation (Di), part of section Mn 13-72; about 1.5 miles south of Charrue Lake, 67°21'N, 130°09'W, NTS 106-O. GSC 199088

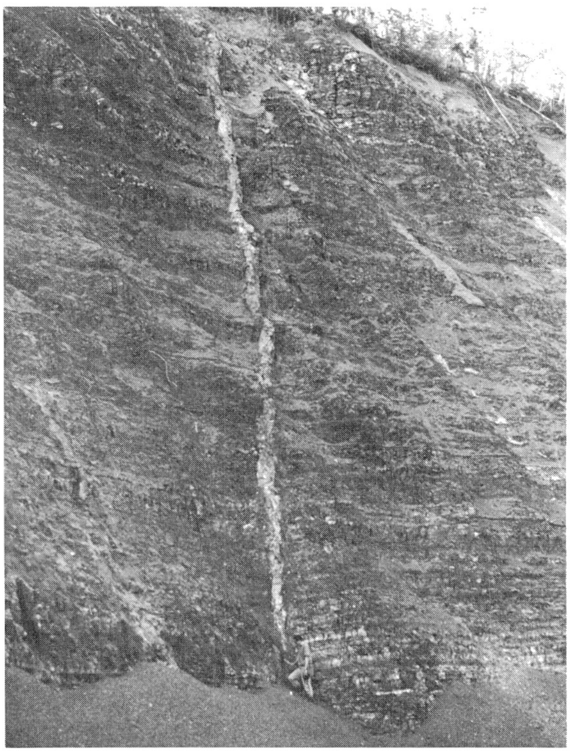

FIGURE 4. Sandstone dyke cutting Canol Formation shale; 67°58'30"N, 130°24'W, NTS 106-O. GSC 199083

FIGURE 5. Close-up of sandstone dyke in Figure 4, showing contraction faults in the dyke. GSC 199085

FIGURE 6. Ramparts Formation limestone; about 10 miles north-northwest of Little Chicago; 67°20'N, 130°22'W, NTS 106-O. GSC 199087

UPPER DEVONIAN

Canol Formation (Dc)
(Bassett, 1961)

The Canol Formation occurs throughout map-areas 106J and 106-O, and occurs along the western part of 106P, where it has been truncated by pre-Cretaceous erosion. It probably extended originally across most or all of map-area 106P, because an outlier is preserved in Iroquois Syncline in the north-central part of that map-area. One complete section (Fig. 3) is exposed near Lac Charrue in 106-O. It is about 100 feet (30 m) thick but measured thicknesses vary from 75 feet (23 m) in Atlantic *et al.* Ontaratue K-4 well to 285 feet (87 m) in CDR Tenlen A-73 well (W.S. MacKenzie, pers. com., 1974).

The Canol is composed of black, siliceous, bituminous shale with some silty beds, clay-ironstone beds and concretions, and pyrite nodules. It is generally a poorly exposed recessive unit but, in rare good exposures, closely spaced joints result in characteristic blocky fracture and vertical cliff faces. Exposures commonly are coated with yellow jarosite, and locally are oxidized and red.

In the northeast part of 106-O, the Canol is cut by a sandstone dyke (Figs. 4, 5) which has been shortened vertically by a large number of small contraction faults (Fig. 5). The faults indicate that the dyke was emplaced prior to compaction of the shales and that, as the shales compacted, the enclosed dyke was shortened vertically by displacement on the contraction faults.

The Canol Formation overlies Hare Indian Formation, Ramparts Formation, or map-unit D_4 in exposures, but its base cuts down-section westward in the subsurface to overlie Hume Formation and older rocks west of map-areas 106J and 106-O (W.S. MacKenzie, pers. com., 1974).

Conodonts from the Canol Formation in the Normal Wells region indicate a Late Devonian (Frasnian) age (Braun, 1966; Uyeno *in* Lenz and Pedder, 1972). A tree trunk from the Canol in the northeastern part of 106-O was assigned a probable Late Devonian age by W.M. Stewart, University of Alberta (GSC loc. C-2018, Appendix II).

Imperial Formation (Di)
(Hume and Link, 1945; Bassett, 1961)

The Imperial Formation forms a westward-thickening wedge truncated at its top by Cretaceous deposits. Because of pre-Cretaceous erosion, no complete section remains within the study area. The greatest recorded thickness is 850 feet (260 m) in the Atlantic *et al.* Ontaratue K-4 well in map-area 106J. It thins progressively eastward to a zero edge which lies a few miles east of the boundary between 106-O and 106P in the south and a few miles west of that boundary in the north.

In the northeastern part of map-area 106-O, a resistant sandstone unit, having topographic expression, permitted subdivision of the Imperial into lower shale, and upper sandstone and shale members. The lower shale member includes platy, dark grey to black, brown-weathering shale which, in poor exposure, is easily confused with the Canol Formation. Elsewhere, lower and upper subdivisions could not be mapped but, because of the westward dip, most beds of the Imperial Formation at surface probably belong to the upper member, which is composed of greenish brown, grey, and brown shale and silty shale with subordinate impure, brown, fine-grained sandstone and siltstone beds.

The Imperial is overlain unconformably by Lower Cretaceous sandstone and shale.

The Imperial Formation is Late Devonian (Frasnian and Famennian) in age (*see* Lenz and Pedder, 1972, p. 37, 38).

CRETACEOUS

Cretaceous, undivided (K)

Cretaceous strata comprise a variety of lithologies that have not been subdivided adequately to enable naming formations, and consequently they are mapped as one map-unit. Cretaceous rocks overlie a profound regional unconformity which cuts across progressively older underlying rocks from west to east. Figure 7, a structure contour map on the unconformity, shows relief greater than 900 feet (275 m).

At a number of localities, local channelling into underlying Devonian rocks can be seen or inferred in the field. At the east side of Yeltea

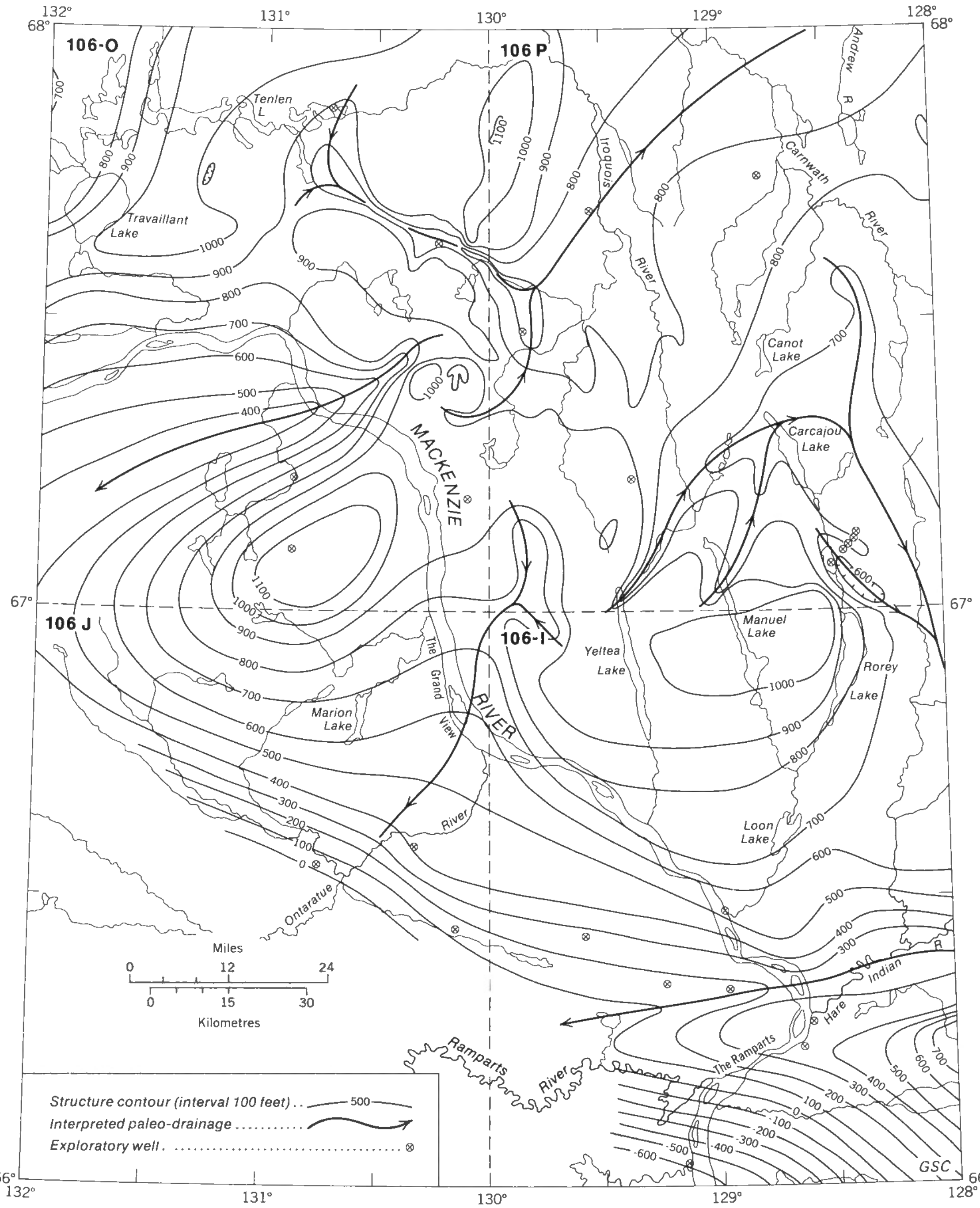

FIGURE 7. Structure contour map of sub-Cretaceous unconformity, showing interpreted paleo-drainage pattern

Lake (106P), for example, white nonmarine Cretaceous sand occurs at elevations corresponding with those of Ramparts limestone to the north and south, and a channel about 200 feet (61 m) deep can be inferred. Other small local channels, cut into Devonian rocks and filled with light grey weathering Cretaceous shale, can be detected near Latitude 67°24'N, Longitude 130°11'W, about 14 miles (22 km) north of Little Chicago, and near Latitude 67°44'N, Longitude 131°19'W, 9 miles (14.5 km) east of Travaillant Lake. A broader channel, one to two miles (1.5-3 km) wide occurs at about Latitude 67°37'N and near the east boundary of map-area 106-O. There, in a prominent valley, nonmarine Cretaceous sand and sandstone with carbonaceous clay occur at elevations at least as low as 700 feet (213 m), whereas to the north and south of the valley the Devonian-Cretaceous contact occurs at elevations of 900 to 1,000 feet (275-300 m). The present-day valley clearly follows a Cretaceous depression. Local relief occurs elsewhere but is obscured by overburden. For example, east of Rond Lake, a series of shallow wells drilled by Decalta *et al.* indicate a small hill of Hare Indian Formation strata flanked by Cretaceous sandstone.

In addition to local relief observable in the field, broader scale topography also can be detected on the geological maps. The sub-Cretaceous unconformity occurs at elevations of between 900 and 1,000 feet (275 and 300 m) west of Yeltea Lake and drops toward Rond Lake where it occurs commonly between 600 and 700 feet (180 and 210 m). Figure 7 shows generalized structure contours on the unconformity based on elevation control points from the geological maps, with additional control from wells and seismic shot points.

A prominent southwest-dipping homocline in map-area 106J is recorded on structure maps on the sub-Cretaceous unconformity (Fig. 7) and on the base of the Canol Formation (Fig. 13). The gradient on the sub-Cretaceous surface, there, is less than that on the Devonian surface; this is to be expected because of the wedge of Imperial Formation between the two. The homocline appears to mark the northeastern side of a Cretaceous marine trough underlying Peel Plain, Peel Plateau, and Mackenzie Plain (*see* Fig. 1). The southern side of the trough probably coincided more or less with the Mackenzie Mountain front.

The oldest Cretaceous rocks recorded in the trough are Albian (late Early Cretaceous) suggesting that the area occupied by the trough was emergent through most of Early Cretaceous time up to and including the Aptian. The trough began to subside in the Albian and continued to subside as it was filled with Cretaceous, mainly marine shale and sand that resulted in the accumulation of at least 7,000 feet (2135 m) of mainly marine clastic rocks including Upper Cretaceous strata (C.J. Yorath, pers. com., 1974).

In contrast to the homocline, sub-Cretaceous structure contours over the remainder of the study area (Fig. 7) show very little correspondence with structures in the underlying Devonian rocks (Figs. 9, 10), resulting in the conclusion that most of the relief on the unconformity represents Early Cretaceous paleotopography which subsequently has been buried by Cretaceous sediments. Figure 7 is based on control points picked from the geological maps. Because the control points themselves are based on assumed contacts over most of the region, the structure contours represent second-order assumption and must be considered with reservations. However, at least two generalized drainage systems can be suggested. One has its "headwaters" east of Tenlen Lake in map-area 106-O, and drains south and southeast across map-area 106-O and into map-area 106P where it swings northeast across the northern part of 106P (Fig. 7). A localized basin seems to be defined by the 700-foot (213 m) structure-contour, but that contour is controlled, in part, by assumed contacts on the geologic map and is not reliable. Another broad drainage valley is thought to head east of Canot Lake, to drain southward parallel to present-day Bluefish River, to swing westward to coincide with Hare Indian River and to empty into the marine trough to the southeast. In map-area 106P, along the west side of the broad valley, two small tributary valleys have been interpreted but control for these is poor.

A deep depression on the sub-Cretaceous unconformity, north of Grandview Hills and south of Mackenzie River, is shown as opening to the southwest but outcrop control is poor and the geometry shown is largely interpretive. The deep depression is believed to exist because C.J. Yorath (pers. com., 1974) found rusty brown shale overlying dark grey silty shale at an elevation of less than 400 feet (122 m) near Latitude 67°19'N, Longitude 130°59'30"W. Yorath detected an unconformity with slight angular discordance, and microfossils determined by T.P. Chamney (GSC locs. C-5548-50, Appendices II and III) indicate that Lower Cretaceous rocks overlie rocks of Devonian age (Imperial Formation). The Cretaceous rocks there appear to have been derived locally from the Devonian Imperial Formation, because W.W. Brideaux and A.R. Sweet found only Devonian pollen and megaspores (GSC loc. C-5549, Appendix II).

Cretaceous rocks have not been studied in enough detail to permit definition of formations, but three generalized facies can be related to paleotopography. A nonmarine, dominantly sandstone facies occurs in paleotopographic depressions in the northern and eastern parts of the study area. A marine siltstone and shale facies occurs on paleotopographic uplands and apparently oversteps the nonmarine deposits. Marine shale with subordinate sandstone occurs south and west of Mackenzie River in or adjacent to the marine trough noted above.

Nonmarine sandstone

A broad sandstone belt extends eastward from Travaillant Lake across the northern parts of map-areas 106-O and 106P to Canot and Carcajou Lakes. From there the belt extends southward into map-area 106I (*see* Cook and Aitken, 1969) following the Bluefish and Hare Indian River valleys. Nonmarine, white, very fine to fine-grained, commonly crossbedded sandstones occupy depressions on the sub-Cretaceous unconformity. No statistical study of paleocurrent directions has been made by the writers. The sandstone is friable and porous and

FIGURE 8. Unconsolidated Cretaceous sand and dark grey clay; about 3 miles northeast of north end of Carcajou Lake, 67°21'30"N, 128°40'30"W, NTS 106P. GSC 199090

weathers readily to form disaggregated piles of white sand. A few exposures of grey shale were observed. In the same general area, but having an uncertain relationship to the crossbedded sandstone, is unconsolidated brown, fine sand interlaminated with dark grey to black, partly carbonaceous clay (Fig. 8). These interlaminated beds are even more recessive than other Cretaceous strata and were observed in only three places: in the valley previously described near the eastern boundary of map-area 106-O; east of Canot Lake; and northeast of Carcajou Lake. These laminated beds, at least in part, overlie crossbedded sandstone more typical of the belt. Their age is late Early Cretaceous, probably Aptian based on palynology by W.S. Hopkins (GSC loc. C-10072, Appendix III). If they are Aptian, they are the oldest Cretaceous deposits recorded in the study-area; all other Cretaceous determinations are Albian or possibly Albian. Similar unconsolidated laminated deposits south of Lac des Bois, about 160 miles (260 km) to the east (Cook and Aitken, 1971, p. 39), also are probably Aptian.

The sandstones of this belt appear to be contiguous with those mapped as basal Cretaceous sandstone in map-areas to the east and southeast (NTS sheets 96L, 96M) (Aitken and Cook, 1969; Cook and Aitken, 1971). Nonmarine sandstone also occurs west of Mackenzie River and south of Ontaratue River in map-area 106J, and probably dip westward beneath black marine shale. Their extent in the subsurface has not been studied, but nonmarine beds occur in Triad BP Arco CC Hume River A-53 well in the south-central part of map-area 106I where 2 feet (0.6 m) of coal occur near the base of the Cretaceous sequence (W.S. MacKenzie, pers. com., 1974).

Marine siltstone and shale

East of Mackenzie River and east and southeast of Little Chicago, Cretaceous rocks are poorly exposed, but samples from seismic shot points show them to be composed of friable, white siltstone or very fine sandstone interlaminated with dark grey shale and silty shale, and overlain by dark grey to black shale. Rare surface exposures are characterized by blocks of one-foot thick, very silty or sandy limestone, tan to yellow weathering, bearing Albian (late Early Cretaceous) pelecypods (GSC loc. C-10070, Appendix III). Poorly developed cone-in-cone structure was observed. A few miles north of Little Chicago, an outcrop of pale grey, soft, silty shale weathers into miniature badlands topography. The beds are basal Cretaceous at that point and are Early Cretaceous (Albian) based on microfossils studied by T.P. Chamney (GSC loc. C-10069, Appendix III). Brown calcareous siltstone in a paleotopographic or structural depression north of Mackenzie River and south of Thunder River (106-O) has been recovered from seismic shot point samples and Department of Public Works test holes.

The laminated siltstone and shale beds east of Little Chicago are about 200 feet (61 m) thick and have yielded Early Cretaceous palynomorphs (Appendix III). They are marine deposits yet are topographically high relative to nonmarine rocks to the north and east which they apparently overstep, since similar topographically high siltstone or fine sandstone units occur in the northeast corner of map-area 106P and in the northern part of map-area 106-O. The outcrop in 106P contains a pelecypod coquina bed dated as of probable Albian age (GSC loc. C-5439, Appendix III). Outcrops in the northern part of map-area 106-O are more or less continuous with rocks mapped by Yorath and Balkwill (1969) as "Silty Zone" (Langton Bay Formation - new name, Yorath *et al.*, in press) in NTS map-area 107A to the north.

Marine shale and sandstone

Marine Cretaceous rocks south and west of Mackenzie River consist dominantly of brown shale with local clay-ironstone beds and concretions. Near Marion Lake (*see* Map 1408A), prominent beds of brown laminated sandstone occur containing well-preserved pelecypods. Sandstone was encountered also in shot point samples from the south flank of Grandview Hills. Paucity of exposure precludes establishing an internal stratigraphy but all age determinations are Albian or probable Albian (*see* Appendix III). Rocks of this facies were deposited in or adjacent to the subsiding marine trough discussed earlier.

In the Grandview Hills area, relief on the sub-Cretaceous unconformity may be in part structurally controlled, because the topographic high (Fig. 17) beneath Grandview Hills is reflected in structure contours drawn on the top of the Devonian Canol Formation (Fig. 13). The deep trough on the north side of Grandview Hills (Fig. 7), although considered to be paleotopographic, could be a structural syncline developed in conjunction with the Grandview Hills high. Devonian rocks are poorly exposed along the axis of the depression and it cannot be determined whether or not they have been structurally depressed.

Black fissile shale occurs in the Ontaratue River area. It overlies, in part at least, nonmarine

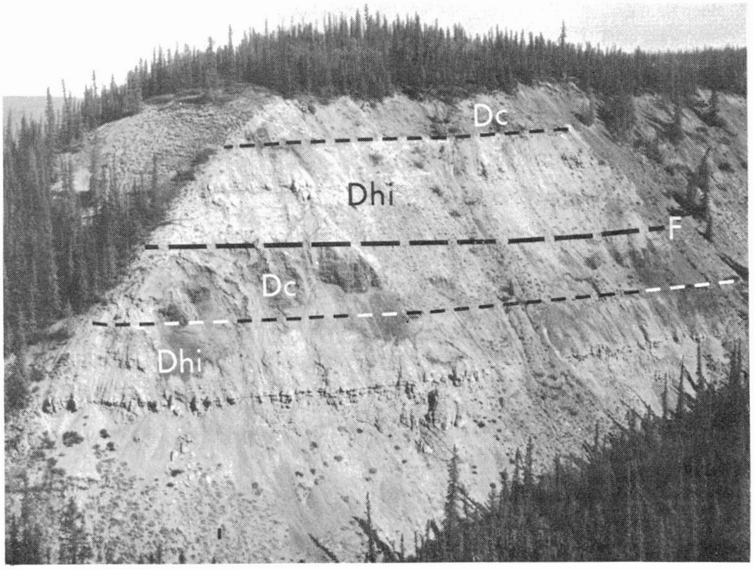

FIGURE 9. Thrust fault (F) placing Hare Indian Formation (Dhi) on Canol Formation (Dc); 10 miles north of Little Chicago, 67°20'30"N, 130°17'W, NTS 106-O. GSC 199092

FIGURE 11. Tilted Canol Formation shale; on Thunder River, 67°36'N, 130°39'W, NTS 106-O. GSC 199089

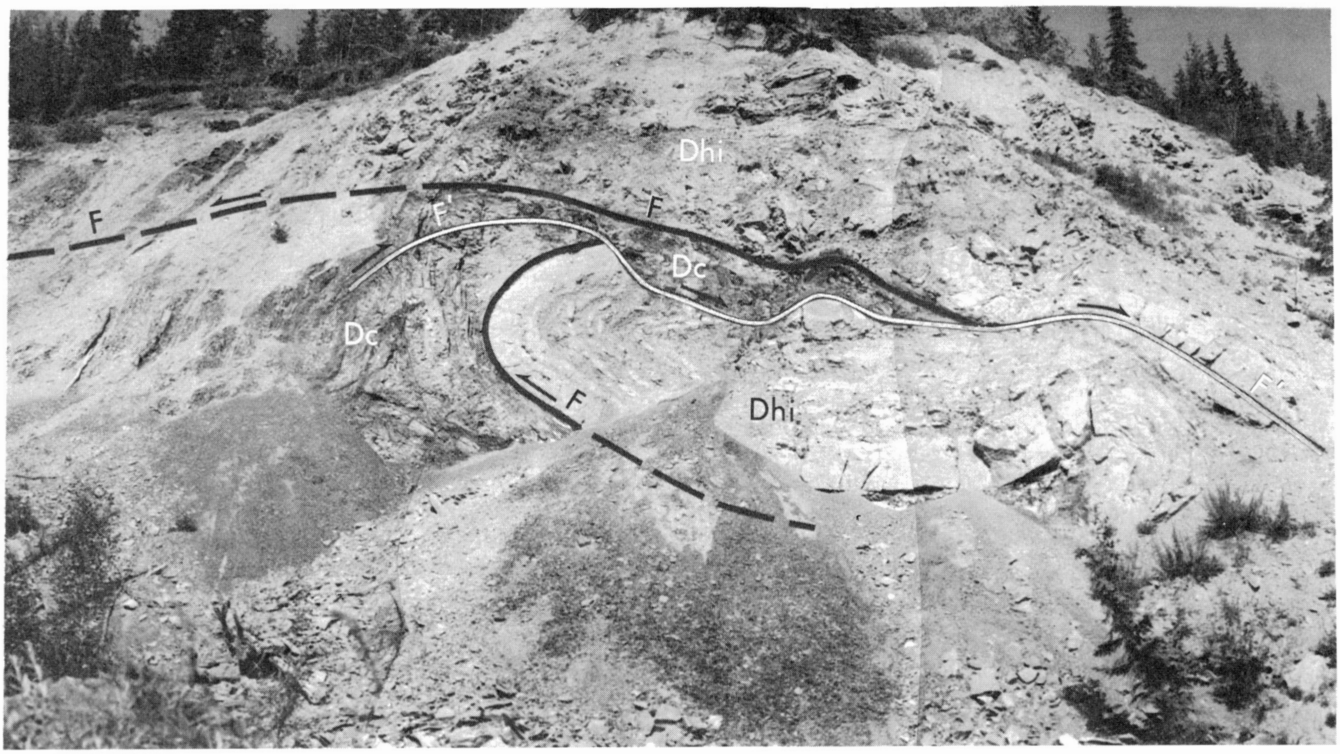

FIGURE 10. Folded and faulted thrust. An early fault (F) placing Hare Indian Formation (Dhi) on Canol Formation (Dc) is cut off and displaced by a later fault (F'). Displacement on the later fault (F') is opposite to the apparent displacement on the early fault (F). About 6.5 miles north of Little Chicago, 67°17'N, 130°14'W, NTS 106-O. GSC 199084

basal sandstone. Its relationship to the brown shale and sandstone in the Grandview Hills is unknown.

STRUCTURAL GEOLOGY

Epeirogenesis

At least five Phanerozoic periods of regional uplift and erosion have affected the geological history of these map-areas. Regional unconformities occur at the bases of the Cambrian, Upper Ordovician, (?)Upper Silurian, (?)Lower Devonian, Upper Devonian, and Cretaceous successions. The sub-Cambrian, sub-Upper Ordovician, sub-Upper Silurian, and sub-Lower Devonian unconformities are not exposed and have not been studied adequately. The sub-Upper Devonian (sub-Canol) unconformity is exposed at the surface but is documented best in the subsurface where it cuts downsection westward (Tassonyi, 1969; W.S. MacKenzie, pers. com., 1974). The most striking unconformity is that at the base of the Cretaceous succession.

In addition to regional tilting and bevelling, there has been local folding and faulting (described below), which apparently preceded Cretaceous deposition in part or entirely.

Orogenesis

Local folding and faulting has affected Devonian rocks in the eastern part of map-area 106P.

North of Little Chicago, at two localities about 4 miles (6.4 km) apart, older rocks have been thrust onto younger. The strata at these localities are interpreted here as two exposures of a single thrust surface. At the northernmost locality, the fault is a bedding plane feature placing Hare Indian Formation shale and silty limestone on Canol Formation shale (Fig. 9). No truncation of bedding and no small-scale folds were seen in the exposure. At the other locality (Fig. 10), in contrast to the first, silty limestone and shale assigned to the Hare Indian Formation are faulted onto Canol shale as at the other section, but successive deformation has resulted in the fault surface itself being refaulted and drag-folded. The primary fault appears to be a bedding-plane fault as at the northern locality, whereas the secondary, minor fault intersects bedding at a large angle. The folds trend approximately north-south with essentially horizontal axes, implying that displacement on the fault(s) was in an east-west direction. The main fault plate appears to dip to the east implying that displacement on the larger thrust was from east to west, whereas the geometry of the drag fold (Fig. 10) requires that displacement on the secondary fault be from west to east. Apparently the secondary fault is conjugate to the primary fault and, therefore, has the opposite sense of displacement. The eastward dip of the main plate is admittedly largely interpretative.

The fault cannot be unequivocally dated, but no Cretaceous strata were seen to be involved. Moreover, at the northern locality, the sub-Cretaceous unconformity cuts through the Canol Formation so that Cretaceous shale overlies Hare Indian calcareous siltstone a few hundred feet south of the exposure shown in Figure 9, giving the impression that the hanging wall plate has been eroded after emplacement. If so, the deformation predates late Early Cretaceous (Albian) time. The Iroquois Syncline, described later in this report, also appears to be pre-Cretaceous.

Another fault can be inferred on Thunder River, at Latitude 67°36'N, Longitude 130°39'W. Deformed Canol Formation shale (Fig. 11) is tilted and occupies a higher structural position than shale mapped as Imperial Formation a short distance upstream to the southeast; a thrust fault is indicated.

About 4.5 miles (7.2 km) upstream from that locality (about Lat. 67°33'N, Long. 130°33'W), a flat thrust fault truncates Canol Formation beds in its hanging wall and map-unit D_4 in its footwall. Mudstone and cross-laminated calcareous sandstone and siltstone in map-unit D_4 are contorted, in part brecciated, and locally overturned. The degree of distortion in the footwall and the thrusting of younger onto older beds indicate a substantial and complex fault that unfortunately cannot be traced into the surrounding overburden-covered terrain. The assumed contacts shown on the map consequently are oversimplified.

About 10.5 miles (17 km) north of that locality, Canol Formation exposed west of an elongate unnamed lake (Lat. 67°37'N, Long. 130°35'W) has been folded to form two anticlines with an intervening syncline. Fold plunges of 35 degrees at 064 degrees azimuth and 37 degrees at 250 degrees azimuth were recorded. Fold amplitudes of 70 to 100 feet (21-30 m) are great enough to expose sandstone of map-unit D_4 in the core of one of the anticlines, but the resultant "eye" of sandstone could not be shown at the scale of the geological map.

The four structures described above all occur in a narrow northerly trending belt less than 3.5 miles (5.6 km) wide and about 30 miles (48 km) long and may define a zone of structural disturbance. Conversely, the alignments of fold axes and resultant inferred direction of transport is inconsistent from locality to locality suggesting that these structures are not directly related and the alignment is fortuitous.

Iroquois Syncline

The most striking structure in the study-area is the Iroquois Syncline (Iroquois River Syncline of Williams and Peterson, 1959) in the north-central part of map-area 106P. It trends 055 degrees azimuth, and is outlined in its northeastern part by massive limestone of the Ramparts Formation which dips about 12 degrees (Fig. 12) on either limb. A prominent plunge depression coincides with Carnwath River valley where outcrops of Ramparts limestone outline a small doubly plunging syncline. Other plunge culminations and depressions along the fold axis are interpreted on the presence or absence of Ramparts outcrops and could be in error if beds of this formation are locally buried by

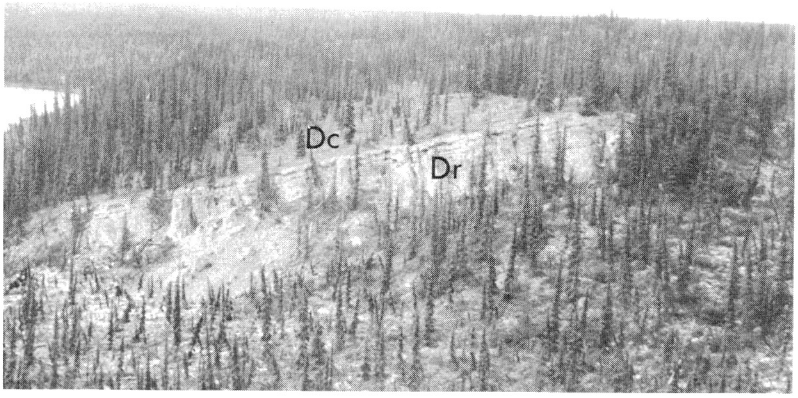

FIGURE 12.

Southward-dipping north limb of Iroquois Syncline. Ramparts Formation (Dr) limestone overlain by Canol Formation (Dc) shale (not exposed). View west, 67°40'20"N, 128°56'W, NTS 106P. GSC 199091

overburden. The axis of the syncline was extended to the southwest across Iroquois River because rocks of the Canol Formation were encountered in shot point holes. The shot point samples are from the bottom of drill holes which penetrate a thin veneer of Cretaceous rocks. Two shot points producing samples of Canol Formation shale coincide with the extended axis of the Iroquois Syncline and are flanked to the east and to the west by shot point holes where Hare Indian shale was encountered. The samples from these shot points are important in two respects: first, they permit the otherwise undocumented extension southwestward of the Iroquois Syncline; and second, because the syncline, at that locality, appears to be overlapped by Cretaceous deposits, a pre-late Early Cretaceous age for the syncline is indicated.

Cretaceous rocks in the vicinity of the two shot points were not visited during reconnaissance mapping, and are mapped entirely on the basis of airphoto expression. Consequently, contacts are subject to revision with more detailed examination.

Other factors also point to a pre-Cretaceous age for the syncline. If the rocks were folded and then truncated by pre-Cretaceous erosion, the preservation of Ramparts and Canol strata is to be expected only in a syncline. Conversely, if the Ramparts and Canol Formations were buried by Cretaceous strata and subsequently folded, then Ramparts and/or Canol Formations beds would be expected to underlie Cretaceous rocks elsewhere in the immediate region. Such does not appear to be the case. Moreover, structure contours on the base of the Cretaceous (Fig. 7) do not reflect the syncline.

The weight of evidence points to a phase of compressive deformation in post-Late Devonian, pre-Albian (late Early Cretaceous) time as it does with the Little Chicago thrust fault. This could have important implications in analyzing the tectonic history of the Franklin Mountains and Colville Hills where a variety of structural trends occur. The documentation of pre-Cretaceous deformation raises the possibility that some Franklin Mountain Laramide (*sensu lato*) structures were localized, and their orientation controlled, by the presence of older structures.

Broad structures

Structure contours representing two surfaces have been drawn (Fig. 13); one on the top of the Hume Formation for the northeast part of map-area 106P, and the other on the base of the Canol Formation for map-areas 106I, J, O, and most of P. They are based on surface data (much of it inferred) and on shot point and well data. Parts of the Hume surface are based on subtracting assumed Hare Indian Formation thicknesses from mapped base-of-Canol control points. Similarly, the base-of-Canol surface is based, in part, on adding assumed Hare Indian thicknesses to mapped top-of-Hume control points. The structure portrayed, therefore, should be considered as a relatively crude approximation of the true structure. Both the Hume Formation and the Canol Formation structure surfaces comprise a complex of gentle arches and sags that are superimposed on a westward-dipping homocline. The most prominent feature is the northeast-trending Iroquois Syncline described above. Immediately north of Iroquois Syncline is a small dome with about 200 feet (60 m) of relief. This dome has been outlined in more detail by Meyers (1961) on the basis of seismic data.

A north-trending elongate dome about 30 miles (50 km) long and about 10 miles (16 km) wide near the boundary between NTS map-areas 106-O and 106P appears to have about 200 feet (60 m) of closure. The westward-dipping flank of this structure is obvious on the geological map, because the Canol Formation is at elevations of up to 1,000 feet (305 m) near the crest of the structure and drops progressively westward to 100 feet (30 m) at the mouth of Thunder River. Closure on the east flank, on the other hand, is interpretive and is based on the assumption that the Hare Indian Formation is about 600 feet (180 m) thick and calculating from this a theoretical elevation for the base of the Canol Formation in two control points near Iroquois River (the Candel Mobil *et al.* Iroquois I-11 well, and a deep shot point which intersected the Hume Formation north of the well). A sub-Cretaceous topographic high (Fig. 7) corresponds with the Devonian structural high (Fig. 13).

A third arch, underlying Grandview Hills, also is indicated on the geological maps. The base of the Canol Formation has an elevation of less than 100 feet (30 m) at Ontaratue River in 106J, climbs northward to above 200 feet (61 m) at Gossage River in 106-O, and to above 300 feet (91 m) at an unnamed stream (Lat. 67°07'N, Long. 130° 25'W) north of Gossage River, and drops to less than 100 feet (30 m) again at the mouth of Thunder River. No data are available across the wide Mackenzie Valley but the structure appears to plunge to the southwest with no closure to the northeast. Cretaceous rocks occupy a deep depression on the north flank of Grandview Hills (Fig. 7). The depression is thought to be paleotopographic but Devonian rocks are unexposed along the trough axis and

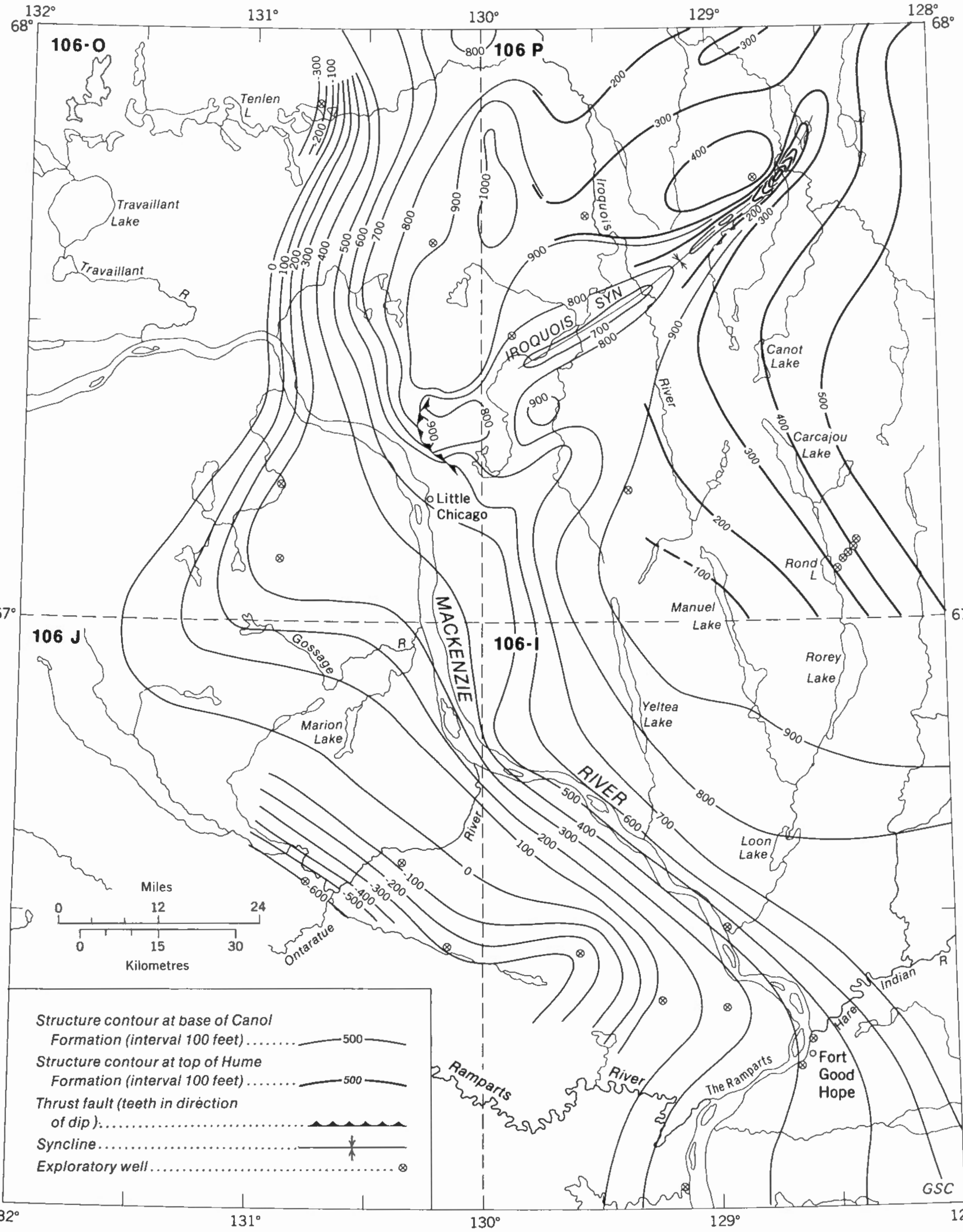

FIGURE 13. Structure contour map of top of Hume Formation and base of Canol Formation

98768—4½

the depression may well be structural. If so, it would represent post-Cretaceous deformation unlike other structures in the study area.

One notable structure that affects Cretaceous strata is the prominent westward-dipping homocline in the southwestern part of the study area. The homocline is recorded on both the sub-Cretaceous and base-of-Canol structure maps and, as noted earlier, appears to mark the northeastern side of a narrow Cretaceous marine trough underlying Peel Plain and Peel Plateau to the southwest. This trough developed and was filled between Albian and Turonian time, possibly as a foredeep to orogeny in the Mackenzie Mountains to the south. Cretaceous strata to the south and southeast within the basin subsequently were deformed themselves during formation of the Franklin Mountains and Imperial Anticline.

The earlier pre-Cretaceous structures in the three map-areas are not as readily understood. At least two structural trends, northeast-southwest and north-south, are represented. The structures described all may be construed to occur near the northwestern limit of the Saline River basin and may be related to adjustments on the detachment zone in the Saline River evaporites.

The Iroquois Syncline appears to be a compressional feature, but may in fact be due to salt solution at depth with resultant collapse of overlying rocks. Under such conditions, the Franklin Mountain and Mount Kindle Formations would collapse by block faulting, whereas higher and younger rocks (e.g. Ramparts Formation) might collapse by drape, resulting in the syncline. If so, the syncline marks a narrow zone of salt solution and resultant collapse brecciation of the Franklin Mountain Formation. The collapse model is attractive because it accounts for the apparent in-folding of strata in a region where isolated structures typically are narrow anticlines.

ENGINEERING GEOLOGY

No laboratory tests for engineering properties of rocks have been conducted as part of this study, and the comments presented below are very general conclusions drawn entirely from field observations of bedrock.

Hume Formation

The Hume Formation is composed of shaly limestone and could be used as fill or surfacing material for highway construction. It is commonly thin to medium bedded and should rip easily. It is exposed only in the extreme northeastern part of the study area. Bridge or pipeline-crossing foundations in the study area should be in Hume strata rather than in the rocks of the overlying Hare Indian Formation.

Hare Indian Formation

The Hare Indian's soft, waxy-appearing shales probably would not make good construction material. These shales maintain steep cliff faces up to 150 feet (48 m) high along Iroquois River but, about 12 miles (20 km) north of Little Chicago, a number of rotational slumps have developed in Hare Indian shales in the north wall of a broad valley.

Ramparts Formation

The Ramparts, like the Hume, is primarily thin- to medium-bedded limestone which may rip easily and could be used for road construction or surfacing material. The Ramparts Formation in Iroquois Syncline in the northeastern part of map-area 106P is massive and could not be ripped. This constitutes the only locality in the three map-areas from which large blocks suitable for riprap could be obtained. At Norman Wells, limestone from the upper reef part of the Ramparts Formation has been used for sub-grade fill for the airfield, road surfacing and for asphalt aggregate.

Map-unit D_4

Sandstones of map-unit D_4 could be used for road construction but might break down under heavy traffic and, therefore, should not be used as a surfacing material. In any event, the limited thickness of the unit would make quarrying expensive.

Canol Formation

The hard, siliceous shale of the Canol Formation should be excellent material for road-fill or road surfacing. Because of bedding fissility and blocky jointing, it should be easily ripped and quarried. Canol shales have been used as surfacing material at Norman Wells and appear to stand up well to traffic. The Canol Formation commonly maintains near-vertical cliff faces (*see* Fig. 3) but is closely jointed and such cliffs would provide very poor foundation rock for bridge abutments or the like. Furthermore, concrete foundations on Canol Formation bedrock probably would be subject to sulphate attack.

Imperial Formation

Imperial Formation shales and sandstones have been used extensively for sub-grade fill in the construction of the Demster Highway between Fort McPherson and Arctic Red River and on the Mackenzie Highway south of Inuvik. Imperial shale quarried at Fort McPherson proved unsatisfactory for road surfacing material because it disintegrated to mud under weathering and traffic. Imperial Formation sandstone used locally at Norman Wells appeared to have broken down very quickly under moderate traffic (O.L. Hughes, pers. com., 1975). Rotational slumps are developed widely in Imperial shales, but sandstone exposures might provide suitable bridge foundations.

Cretaceous rocks

Cretaceous shales are soft, easily eroded, subject to slumping, and generally would not be suitable as construction material. Cretaceous sandstones and siltstones are very fine grained and friable, and would break down under traffic. Cretaceous rocks have low ground ice content compared to glacial deposits (O.L. Hughes, pers. com., 1975) and have some potential as road fill material.

Quaternary deposits

The most critical engineering problems in the report-areas will pertain to Quaternary deposits, especially with regard to permafrost and ground ice. Quaternary deposits have not been examined by the writers, but have been studied recently by the Terrain Sciences Division of the Geological Survey of Canada. The interested reader is referred to the report by Hughes *et al.* (1973).

ECONOMIC GEOLOGY

No metallic minerals of economic significance were noted in the three map-areas.

Limestone of the Ramparts Formation occurs at shallow depths, is more or less surrounded by laterally equivalent shales, and could be the host rock for lead-zinc mineralization. Lead-zinc mineralization has been reported in the Headless Formation (equivalent to lower Hume) west of Wrigely, some 350 miles (563 km) southeast of map-area 106P (Canada DIAND, 1973). The Hume Formation is exposed in low-amplitude anticlines in map-area 106P but offers a very small exploration target.

Continental Cretaceous sandstone and carbonaceous shale occur widely in map-areas 106-O and P, but appear to have low potential for uranium deposits because of the absence of volcanic or granitic source rocks.

The greatest economic potential of the area is for oil and gas. A number of oil and gas seeps within the study area have been reported in unpublished reports on file with the Department of Indian and Northern Affairs. Two additional small gas seeps were observed by the writers. One, at the east shore of Travaillant Lake, occurred in beach sands with Imperial Formation bedrock forming the bank a few tens of feet from the shore. A sample was analysed by L.R. Snowdon and the only hydrocarbon detected was methane. The other, a small flammable gas seep seen in Thunder River (about Lat. 69° 36'N, Long. 130°39'W) was not sampled for analysis.

Reported oil and gas seeps noted above have been located on the geological maps accompanying this report although only one, east of Rond Lake, has been observed by the writers. The oil at the Rond Lake seep comes up through overburden. The underlying bedrock could be either Cretaceous sandstone or Devonian shale of the Hare Indian Formation. Cretaceous sandstone about half a mile (0.8 km) south of the seep is oil-stained. If the oil is moving up-dip, then it originated to the west and neither the Hare Indian shale nor the Cretaceous strata can be the source beds because both have been eroded from the Rond Lake valley. Decalta *et al.* Rond Lake No. 1, an exploratory well at the edge of Rond Lake, encountered Hume Formation beneath overburden. The oil, therefore, probably comes from strata older than the Hume. Only No. 1 of the series of holes drilled by Decalta *et al.* near Rond Lake penetrated beds older than Hume. For a detailed description of the seep, the reader is referred to Patterson and Kirker (1958).

If structures defined on the basis of surface and near-surface Devonian rocks (Fig. 13) persist to depth, then exploration targets exist in basal Paleozoic clastic rocks (Old Fort Island/Mount Cap, undifferentiated), in Ordovician/Silurian carbonate rocks (Franklin Mountain and Mount Kindle Formations and Delorme equivalents), and in Devonian carbonate rocks (Gossage and Hume Formations). All of the structures outlined appear to have been tested by wells, with the exception of a small high northeast of Tutsieta Lake. The potential of the basal Paleozoic sandstones has been enhanced by the recent report of significant flows of natural gas from the "Basal Paleozoic" in the Ashland *et al.* Tedji Lake F-24 well (Oilweek, 1974). In the basal sandstone, stratigraphic traps associated with basement "highs" may be anticipated; such traps need have no surface expression.

Potential for stratigraphic traps exists at the sub-Devonian unconformity.

The Hume Formation is exposed in the eastern part of map-area 106P but elsewhere is capped by Hare Indian shales. Small biohermal reefs, up to 45 feet (14 m) in diameter by 30 feet (9 m) in thickness (MacKenzie, 1969) occur on top of the Hume Formation along the Carnwath River a few miles east of map-area 106P, and suggest the possibility of stratigraphic traps in Hume Formation limestone. The overlying black, basal Hare Indian strata (shale) from the Tenlen A-73 well in 106-O are potential source beds (L.R. Snowdon, pers. com., 1974) because they are 1.4 to 6.3 per cent organic carbon and are thermally mature (high wet gas to total gas ratio)[1].

The presence of outliers of the Ramparts Formation (e.g. Iroquois Syncline) raises the possibility of small Ramparts targets capped by Canol Formation shale occurring farther north. They are unlikely to occur at depth to the west because the basal Canol unconformity cuts downsection westward (W.S. MacKenzie, pers. com., 1974) to place Canol Formation strata on rocks of the basal Hare Indian and Hume Formations.

Map-unit D_4, a porous sand that locally is oil-stained, is widely exposed over its area of occurrence and does not appear to have economic hydrocarbon potential.

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[1] For an explanation of the determination of organic carbon, and hydrocarbon gas content and their usefulness in identifying petroleum source rocks, the reader is referred to Snowdon and McCrossan (1973).

The Canol Formation in the Shell Tree River H-57 well, about 11 miles (17 km) west of map-area 106-O is a potential source rock because it is 4 to 6 per cent organic carbon and is thermally mature (high wet gas to total gas ratio) (L.R. Snowdon, pers. com., 1974). Conversely, the Canol Formation in the CDR Tenlen A-73 well appears to have lower potential because the mechanically extractable gas content is lower (Snowdon, pers. com., 1974). If the characteristic, closely spaced fractures of the Canol Formation are open at depth, the formation has reservoir potential. One well at Norman Wells produced oil from the Canol Formation (Boggs, 1974, p. 17).

Sandstone beds in the Imperial Formation might form reservoirs in structural traps in the western part of map-areas 106J and O or in stratigraphic pinch-outs at the sub-Cretaceous unconformity in the southwest part of map-area 106J but the porosity and permeability of Imperial sandstone is characteristically poor.

Cretaceous beds to the north and east of the Mackenzie River are exposed and dissected and have no direct potential for hydrocarbon reservoirs. Channels in pre-Cretaceous topography have been filled in and buried largely by porous quartz sand, and similar sand-filled channels may occur in the subsurface underlying the marine trough to the southwest. The sub-Cretaceous structure map (Fig. 7) contains suggestions of a paleo-drainage system, and a few valleys open into the marine trough. The best example is the broad paleo-valley (Fig. 7) which has its head east of Canot Lake in map-area 106P, and extends southward to merge with another that parallels the modern Hare Indian River and finally opens into the marine trough to the southwest. The Cretaceous fill in the valley outlined is characterized by porous, crossbedded, nonmarine sandstone with some laminated sand and shale. If the topography predates subsidence of the marine trough, similar porous channel sands capped by marine shale may occur on the floor of the trough in the subsurface. Alternatively, the drainage system may have developed contemporaneously with subsidence of the trough and, in that event, a small delta might be expected west of the mouth of Hare Indian River. Either model, submerged channel sands or local deltas, provides targets for hydrocarbon exploration.

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APPENDICES

I - Report on Silurian fossils

II - Reports on Devonian fossils

III - Reports on Cretaceous fossils

INDEX TO GSC LOCALITY NUMBERS

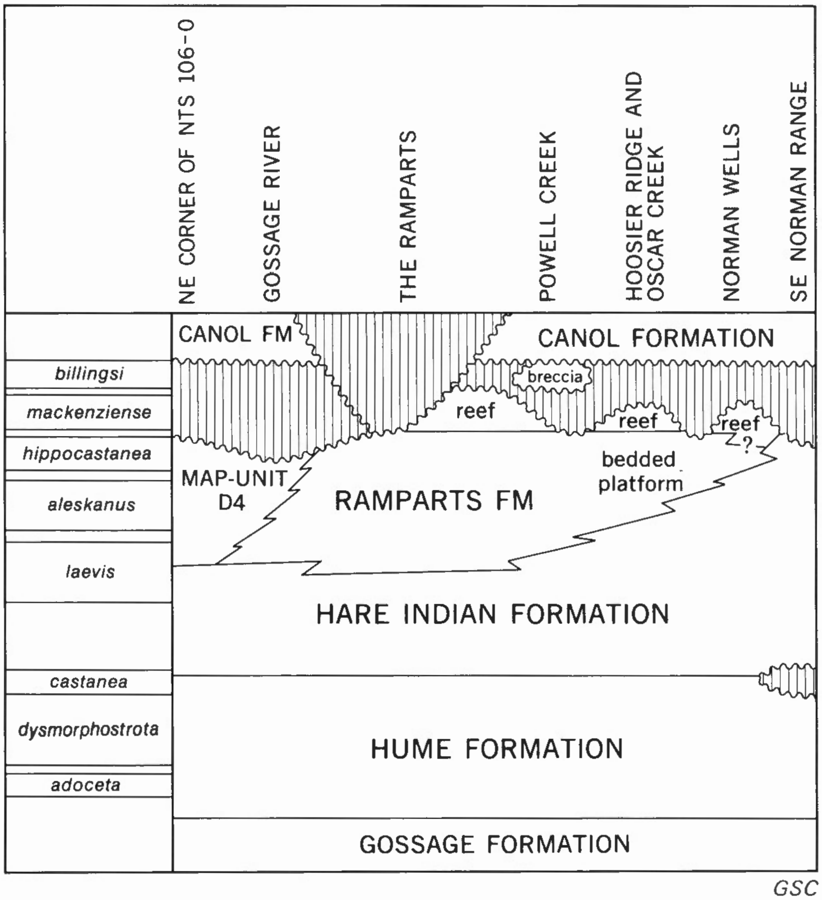

FIGURE 1A

Diagrammatic representation of the relationship between rock units, named and unnamed, and megafossil zones in the central Mackenzie Valley. The figure is not to scale and is simplified. Certain carbonate units, such as were encountered between the Ramparts and Hume Formations in the Atlantic Col. Can. Manitou Lake L-61 well, are omitted.

APPENDIX I

REPORT ON SILURIAN FOSSILS

Report by R. Thorsteinsson on fossils collected by W.S. MacKenzie, from core from Central Del Rio Tenlen Lake A-73 well, District of Mackenzie (NTS 106-O).

Stratigraphic position	Locality, fauna and age	GSC loc.
Unnamed unit above Mt. Kindle Fm., depth 3,517, 313 ft. above base of unit	C.D.R. Tenlen Lake A-73 well, Lat. 67°52'07"N, Long. 130°43'21"W fish fragments, of the Family Cyathaspididae, genus and species indet. age: family ranges Wenlockian to Gedinnian, but age of these fragments probably Late Silurian, Ludlovian or Pridolian	C-28116

APPENDIX II

REPORTS ON DEVONIAN FOSSILS

Report by W.W. Brideaux on palynologic reconnaissance study of samples from seismic shot holes, Department of Public Works test holes, exploratory wells, and surface outcrops from NTS map-areas 106J, 106-O, and 106P. Samples were examined only to differentiate Devonian from Cretaceous strata, and miospore species lists for most Devonian samples were not established. Location numbers are included here to show Brideaux's conclusions.

Stratigraphic position	Locality, fauna and age	GSC loc.
Cretaceous outcrop	Lat. 67°19'N, Long. 130°59'30"W; 106-O age: Paleozoic, Devonian, based on palynomorphs present (*see* GSC loc. C-5549 in Appendix III)	C-5549
Seismic shot hole, depth 20 ft.	Lat. 67°32'45"N, Long. 128°15'00"W; 106P age: Paleozoic	C-23946
Seismic shot hole, depth 20 ft.	Lat. 67°55'30"W, Long. 128°16'00"W; 106P age: Paleozoic, ?Devonian	C-23947
Seismic shot hole, depth 60 ft.	Lat. 67°11'45"N, Long. 124°21'30"W; 106P age: Paleozoic, ?Carboniferous	C-23949
Seismic shot hole, depth 20 ft.	Lat. 67°49'30"N, Long. 128°14'30"W; 106P age: Paleozoic, ?Devonian	C-23951
Seismic shot hole, depth 60 ft.	Lat. 67°24'30"N, Long. 130°18'00"W; 106-O age: Paleozoic, ?Devonian	C-24086
Seismic shot hole, depth 60 ft.	Lat. 67°40'40"N, Long. 131°06'20"W; 106-O age: Paleozoic, Devonian	C-24087
Seismic shot hole, depth 60 ft.	Lat. 67°24'30"N, Long. 130°16'20"W; 106-O age: Paleozoic	C-24088
Seismic shot hole, depth 60 ft.	Lat. 67°43'30"N, Long. 131°05'40"W; 106-O age: Paleozoic, Devonian	C-24089
Seismic shot hole, depth 60 ft.	Lat. 67°36'00"N, Long. 130°49'45"W; 106-O age: Paleozoic, Devonian	C-24090
Seismic shot hole, depth 60 ft.	Lat. 67°24'10"N, Long. 130°13'45"W; 106-O age: Paleozoic, Devonian	C-24091

Stratigraphic position	Locality, fauna and age	GSC loc.
Seismic shot hole, depth 60 ft.	Lat. 67°37'15"N, Long. 130°20'15"W; 106-O age: Paleozoic, Devonian	C-24093
Seismic shot hole, depth 60 ft.	Lat. 67°49'10"N, Long. 130°03'15"W; 106-O age: Paleozoic, Devonian	C-24095
Seismic shot hole, depth 60 ft.	Lat. 67°23'20"N, Long. 130°07'15"W; 106-O age: Paleozoic, ?Devonian	C-24096
Seismic shot hole, depth 60 ft.	Lat. 67°23'45"N, Long. 130°09'15"W; 106-O age: Paleozoic, ?Devonian	C-24097
Seismic shot hole, depth 60 ft.	Lat. 67°31'45"N, Long. 129°20'20"W; 106P age: Paleozoic, ?Devonian	C-24099
Seismic shot hole, depth 60 ft.	Lat. 67°22'00"N, Long. 129°54'00"W; 106P age: Paleozoic, Devonian	C-24103
Seismic shot hole, depth 60 ft.	Lat. 67°57'00"N, Long. 129°37'15"W; 106P age: Paleozoic, Devonian	C-24104
Seismic shot hole, depth 60 ft.	Lat. 67°32'30"N, Long. 129°57'15"W; 106P age: Paleozoic, Devonian	C-24108
DPW test hole, depth 16 ft.	Lat. 67°38'00"N, Long. 130°56'30"W; 106-O age: Paleozoic, Devonian	C-26512
DPW test hole, depth 6-9 ft.	Lat. 67°38'30"N, Long. 131°13'00"W; 106-O age: Paleozoic, Devonian	C-26515
DPW test hole, depth 19-24 ft.	Lat. 67°35'18"N, Long. 131°44'30"W; 106-O age: Paleozoic, Devonian	C-26516
DPW test hole, depth 6 ft.	Lat. 67°30'48"N, Long. 131°52'30"W; 106-O age: Paleozoic, Devonian	C-26517
DPW test hole, depth 7 ft.	Lat. 67°38'18"N, Long. 131°59'18"W; 106-O age: Paleozoic, Devonian	C-26518
DPW test hole, depth 18 ft.	Lat. 67°38'18"N, Long. 131°59'18"W; 106-O age: Paleozoic, Devonian	C-26519
Seismic shot hole, depth 70-80 ft.	Lat. 66°50'00"N, Long. 131°23'06"W; 106J age: Paleozoic, Devonian	C-26524
Cuttings, depth 30-80 ft.	Richfield Grandview Hills Core Hole No. 1, Lat. 67°13'40"N, Long. 130°51'16"W; 106-O age: Paleozoic, Devonian	C-26528
Cuttings, depth 180 ft.	Richfield *et al.* Grandview Hills No. 1 well, Lat. 67°06'12"N, Long. 130°52'30"W; 106-O age: Paleozoic, Devonian	C-26529
Cuttings, depth 40-50 ft.	Candel *et al.* Grandview L-26 well, Lat. 66°35'32"N, Long. 130°20'21"W; 106J age: Paleozoic, Devonian	C-26530
Cuttings, depth 500 ft.	As above age: Paleozoic, Devonian	C-26531
Cuttings, depth 800 ft.	As above age: Paleozoic, Devonian	C-26533
Cuttings, depth 270-330 ft.	Atlantic Circle River No. 1 well, Lat. 66°26'38"N, Long. 130°08'50"W; 106J age: Paleozoic, Devonian	C-26534

Stratigraphic position	Locality, fauna and age	GSC loc.
DPW test hole, depth 20-22 ft., Imperial Fm.	14 miles NW of Little Chicago, Lat. 67°26'00"N, Long. 130°29'00"W; District of Mackenzie *Ancyrospora* spp. *Retusotriletes* sp. *Punctatisporites* sp. *Hymenozonotriletes* sp. *Spinozonotriletes* spp. *Endosporites* sp. unidentified trilete spores age: Paleozoic, Devonian, (?)Middle, or Late Devonian comment: The spores are highly carbonized.	C-30072
DPW test hole, depth 40-42 ft., Imperial Fm.	As above *Retusotriletes* sp. *Verruretusispora* spp. *Ancyrospora* sp. *Endosporites* sp. *Hymenozonotriletes* spp. age: Paleozoic, Devonian, (?)Middle, or Late Devonian comment: Morphologic form species are identical to those in GSC loc. C-30072.	C-30073

Report by T.P. Chamney on Devonian microfossils from shale samples taken by J.D. Aitken, M.E. Ayling, D.G. Cook, and C.J. Yorath from NTS map-areas 106J, 106-O, and 106P.

Hare Indian Fm.	Lat. 67°33'20"N, Long. 130°33'00"W ambulacral segment sp. 5, rare (crinoid calyx) pyrite, euhedral dodecahedrons, abundant age: Paleozoic	C-5537
Hare Indian Fm.	W bank of Iroquois River, Lat. 67°33'00"N, Long. 129°18'00"W *?Reophax (Proteonina)* sp. P-15, rare cricoconarids: *Styliolina* sp. 9, very abundant *Tentaculites* sp. 11, common conodonts: sp. 10, rare sp. 6A, rare megaspores: P-1C sp. 2, common P-1A spp., few brachiopod shell fragments, few pyrite "grape shot", abundant age: Devonian, Middle (Givetian)	C-5541
Imperial Fm.	NE of Trading Post on Mackenzie River, Lat. 67°29'30"N, Long. 131°23'00"W megaspores: P-IV B sp. 5, abundant = *Archaeozonotriletes* sp. P-II A sp. 3, common = *?Lophozonotriletes* sp. P-II A sp. 5, abundant = *Triletes* spp. *?Haplophragmoides* sp. P-5, rare Ostracoda spp., few pyrite replacement, common age: Devonian, ?Upper	C-5543
Imperial Fm.	Lat. 67°17'30"N, Long. 129°40'00"W axons ?Radiolaria - sponge sp. P-2A, common spicules ?Radiolaria - sponge: sp. P-6, abundant sp. P-5A, few productid spine sp., few age: Devonian, ?Upper	C-5546

Stratigraphic position	Locality, fauna and age	GSC loc.
Imperial Fm.	Creek opposite Thunder River junction with the Mackenzie River, Lat. 67°19'N, Long. 131°00'W *?Jonesina* sp. 2 *Primitia* sp. 2 brachiopod umbo (pyritized) megaspores: predominantly *Triletes* spp. age: Devonian, Upper-Middle Devonian boundary interval	C-5548
Imperial Fm.	As above *Endothyra* sp. *?Reophax* sp. encrusting Foraminifera megaspores: predominantly *Triletes* spp. Ostracoda spp. age: Devonian to Mississippian	C-5550
Hare Indian Fm.	Lat. 67°44'N, Long. 129°42'W; 106P, lithology similar to GSC loc. C-10084 Gastropoda sp. (high spiral), few *Styliolina* sp., few *?Haplophragmoides* sp. P-6, few Ostracoda sp. (giant), rare age: Middle Devonian (Givetian)	C-10075
Imperial Fm.	Lat. 67°43'N, Long. 131°38'W; 106-O Ostracoda, *?Cavellina* sp., few plant remains megaspore P-IIA sp. 1, few black (?carbonized) spheres, few age: Devonian undifferentiated	C-10079
Hare Indian Fm.	Lat. 67°42'N, Long. 129°10'W; 106P Gastropoda: sp. 7, abundant sp. 8, few sp. 9, few Ostracoda spp., abundant *?Haplophragmoides* sp. P-6, few crinoid columnals: sp. 10, few sp. 8A, few crinoid ambulacral segments sp. 5C, common ?productid spines spp., common *?Styliolina* sp., few age: Devonian (Givetian)	C-10080
Hare Indian Fm.	Lat. 67°46'N, Long. 128°26'W; 106P cricoconarids: *Tentaculites* sp., common *Styliolina* sp., few Ostracoda sp., few megaspore spp., few age: Devonian (Givetian)	C-10084
Hare Indian Fm.	Lat. 67°31'N, Long. 128°20'W; 106P *Styliolina* spp., abundant megaspore P-IC sp. 1, very abundant age: Middle Devonian (Givetian)	C-10085
Imperial Fm.	Lat. 67°28'N, Long. 130°32'W crinoid ambulacral segments sp. 5C, few megaspores: carbonized "trilete" sp., common ?faecal pellets (ferruginous), few ?Ostracoda sp., few ?conodont fragment, rare age: Devonian (Frasnian to Givetian)	C-10086

Palynology report by W.S. Hopkins on a sample collected by J.D. Aitken from NTS map-area 106-O.

Stratigraphic position	Locality, fauna and age	GSC loc.
Map-unit D_4	Along Thunder River, Lat. 67°33'20"N, Long. 130°33'W; 106-O cf. *Retusotriletes* sp. age: probably Devonian comments: This preparation contained very few palynomorphs and, with the exception of the genus named above, none was well enough preserved to be identified. Abundant carbonaceous trash present in this specimen "looks older" than Mesozoic trash. *Retusotriletes* is a Devonian form and I see no reason to suggest that this is reworking. I feel quite confident in assigning a Paleozoic, and probably Devonian, age to this specimen.	C-5537

Report by A.E.H. Pedder on Devonian megafossils collected by J.D. Aitken, M.E. Ayling, D.G. Cook, W.S. MacKenzie, A.E.H. Pedder and W. Savigny from NTS map-areas 106J, 106-O, and 106P. The ranges of biostratigraphic zones used in this report and their relationship to Middle Devonian lithostratigraphy in the lower Mackenzie Valley region are discussed by A.E.H. Pedder in Geological Survey of Canada Open File Report 220.

Stratigraphic position	Locality, fauna and age	GSC loc.
Hume Fm., 92 ft. below top	Andrew River (south), Lat. 67°59'N, Long. 128°12'W; 106P *Favosites* sp. undet. *Alveolites* sp. undet. *Radiastraea* sp. nov. *Mesophyllum rectum* (Meek) *Variatrypa arctica* (Warren) age: Late Eifelian, *dysmorphostrota* Zone	C-1839
Hume Fm., 86 ft. below top	As above *Mesophyllum rectum* (Meek) *"Spinulicosta" stainbrooki* Crickmay *Variatrypa arctica* (Warren) age: Eifelian, *adoceta* or *dysmorphostrota* Zone	C-1840
Hume Fm., 80 ft. below top	As above *Alveolites* sp. undet. *Radiastraea* sp. nov. *Mesophyllum* sp. undet. *"Spinulicosta" stainbrooki* Crickmay *Variatrypa arctica* (Warren) *Spinatrypa andersonensis* (Warren) *Carinatrypa dysmorphostrota* (Crickmay) *Undispirifer compactus* (Meek) *Straparollus (Philoxene)* sp. undet. age: Late Eifelian, *dysmorphostrota* Zone	C-1841
Hume Fm., 73 ft. below top	Andrew River (south), Lat. 67°59'N, Long. 128°12'W; 106P *Mesophyllum* sp. undet. *Variatrypa arctica* (Warren) *Spinatrypa andersonensis* (Warren) age: Eifelian, *adoceta* or *dysmorphostrota* Zone	C-1842
Hume Fm., 65 ft. below top	As above *Mesophyllum rectum* (Meek) *"Spinulicosta" stainbrooki* Crickmay *Variatrypa aperanta* (Crickmay) *V. arctica* (Warren) *Spinatrypa andersonensis* (Warren) age: Eifelian, *adoceta* or *dysmorphostrota* Zone	C-1843

Stratigraphic position	Locality, fauna and age	GSC loc.
Hume Fm., 40 ft. below top	As above *Favosites* sp. undet. *Alveolites* sp. undet. *Aulopora* sp. undet. *Radiastraea* sp. nov. *Mesophyllum rectum* (Meek) *Variatrypa aperanta* (Crickmay) *V. arctica* (Warren) *Spinatrypa andersonensis* (Warren) age: Late Eifelian, *dysmorphostrota* Zone	C-1844
Hume Fm., 26 ft. below top	As above *Alveolites* sp. undet. *Thamnopora* sp. undet. *Mesophyllum rectum* (Meek) *"Spinulicosta" stainbrooki* Crickmay *Variatrypa aperanta* (Crickmay) *Spinatrypa andersonensis* (Warren) *Undispirifer compactus* (Meek) age: Eifelian, *adoceta* or *dysmorphostrota* Zone	C-1845
Hume Fm., 12 ft. below top	Andrew River (south), Lat. 67°59'N, Long. 128°12'W; 106P *Thamnopora* sp. undet. *Spinulicosta* sp. undet. *Variatrypa arctica* (Warren) *"Atrypa" borealis* Warren *"Emanuella" meristoides* (Meek) *Undispirifer compactus* (Meek) age: Late Eifelian *dysmorphostrota* Zone, or early Givetian *castanea* Zone	C-1846
Hare Indian Fm., 20 ft. above base	As above *Styliolina fissurella* (Hall) *Tentaculites* sp., broad sense age: probably Givetian	C-1848
Map-unit D_4	20 miles ENE of Tenlen Lake, Lat. 67°56'15"N, Long. 130°23'W; 106-O *Leiorhynchus hippocastanea* Crickmay *L.* sp. indet. age: late Givetian or early Frasnian *hippocastanea* Zone	C-2017
Map-unit D_4, 2 ft. below top	6 miles E of Little Chicago; Lat. 67°12'N, Long. 130°01'30"W; 106-O *Leiorhynchus hippocastanea* Crickmay ambocoeliid, indet. age: late Givetian or early Frasnian *hippocastanea* Zone	C-2042
Hume Fm., upper 3 ft.	Carnwath River, Lat. 67°57'N, Long. 128°52'W; 106P *Schizophoria* sp. undet. *Leiorhynchus castanea* (Meek) *Undispirifer compactus* (Meek) age: early Givetian, *castanea* Zone	C-3084
Hare Indian Fm.	6.5 miles N of Little Chicago, Lat. 67°17'N, Long. 130°14'W; 106-O bivalve, indet. mould conspecific with form occurring in GSC loc. C-3109 ambocoeliid, indet. age: probably Middle Devonian	C-3104

Stratigraphic position	Locality, fauna and age	GSC loc.
Hare Indian Fm.	6.5 miles N of Little Chicago, Lat. 67°17'N, Long. 130°14'W; 106-O *Alveolites* sp. indet. loxonematid gastropod? *Productella* sp. indet. *Rhyssochonetes* sp. cf. *R. aurora* (Hall) *Emanuella* sp. indet. *Cyrtina* sp. indet. age: Givetian	C-3105
Hare Indian Fm.	As above *Moravophyllum* sp. indet. *Rensselandia?* sp. nov. age: Givetian	C-3106
Hare Indian Fm.	As above *Rensselandia?* sp. nov. age: Givetian	C-3107
Hare Indian Fm.	As above *Spinatrypa?* sp. indet., fragments *Dechenella?* sp. indet., fragments age: Devonian, almost certainly Middle Devonian	C-3108
Hare Indian Fm.	As above bivalve, indet. mould conspecific with form occurring in GSC loc. C-3104 *Spinatrypa?* sp. indet., fragments *Dechenella?* sp. indet., fragments of pygidia age: Devonian, almost certainly Middle Devonian	C-3109
Hare Indian Fm.	As above *Alveolites* sp. indet. *Rhyssochonetes* sp. cf. *R. aurora* (Hall) atrypoid, indet., possibly *Spinatrypa* sp. age: Givetian	C-3110
Hare Indian Fm.	6.5 miles N of Little Chicago, Lat. 67°17'N, Long. 130°14'W; 106-O *"Schuchertella"?* sp. indet., fragmentary *Schizophoria?* sp. indet., fragmentary *Atrypa* sp. indet., broad sense *Spinatrypa* sp. indet., broad sense *Cyrtina* sp. undet. *Ectorensselandia laevis* (Meek)? age: Givetian, questionably *laevis* Zone	C-3112
Hare Indian Fm., 20 ft. above exposed base, 55 ft. below top	10.75 miles N of the centre of Mackenzie River opposite Little Chicago, Lat. 67°20'30"N, Long. 130°17'W; 106-O *Stachyodes* sp. undet. stromatoporoid, not studied *Alveolites* sp. undet. *Grypophyllum* sp. indet. *Tabulophyllum* sp. nov. *Schizophoria* sp. indet. *Spinatrypa* sp. indet. *Emanuella* sp. undet. *Cyrtina* sp. undet. trilobites, fragments of more than one species age: Givetian, *laevis* Zone	C-3256

Stratigraphic position	Locality, fauna and age	GSC loc.
Hare Indian Fm., 65 ft. below top and immediately above a fault	As above *Stachyodes* sp. undet. *Grypophyllum aquilonium* Pedder atrypoid, indet. trilobite fragment age: Givetian, *laevis* or *aleskanus* Zone	C-3257
Ramparts Fm., base of a 35-ft. exposure	Section MN-34-68, near S end of Rond Lake, Lat. 67°01'28"N, Long. 128°31'37"W; 106P *Favosites* sp. undet. *Stringophyllum* or *Sociophyllum* sp. undet. *Mesophyllum* sp. undet. *Hederella (Parahederella)* sp. undet. gastropod moulds age: Middle Devonian	C-3258
Ramparts Fm., 8 ft. above base of a 35-ft. exposure	As above *Actinostroma tyrrelli* Nicholson *Alveolites* sp. undet. *Cystiphyllum* sp. undet., broad sense gastropod mould age: Middle Devonian, probably Givetian	C-3259
Ramparts Fm., 12 ft. above base of a 35-ft. exposure	As above *Stringocephalus* sp. undet. age: Givetian, *laevis* or *aleskanus* Zone	C-3260
Ramparts Fm., 33 ft. above base of a 35-ft. exposure	As above *Actinostroma tyrrelli* Nicholson *Spinatrypa* sp. indet. *Stringocephalus aleskanus* Crickmay age: Givetian, *aleskanus* Zone	C-3261
Map-unit D_4, 10 ft. below top	Gossage River, Lat. 66°57'N, Long. 130°24'W; 106J *Stachyodes* sp. undet. stromatoporoid, not studied *Temnophyllum?* sp. undet. stropheodontid, indet. *Spinatrypa* sp. undet. orthoconic nautiloid trilobite age: Eifelian to Frasnian	C-3262
Map-unit D_4, 10 ft. below top	As above *Favosites* sp. undet. orthoconic nautiloid age: Silurian to Givetian	C-3263
Hare Indian Fm., top of formation	As above *Productella* sp. atrypoid, indet. *Cyrtina* sp. undet. age: Givetian or Frasnian	C-3264
Map-unit D_4	Ontaratue River, Lat. 66°37'N, Long. 130°02'W; 106J *Leiorhynchus hippocastanea* (Crickmay) *L.* sp. ex gr. *L. rhabdotum* Crickmay *Emanuella* sp. undet. age: late Givetian or early Frasnian *hippocastanea* Zone	C-3278
Map-unit D_4, top of unit	Mouth of Thunder River, Lat. 67°28'N, Long. 130°52'30"W; 106-O *Leiorhynchus* sp. age: probably late Givetian or early Frasnian	C-5536

Stratigraphic position	Locality, fauna and age	GSC loc.
Ramparts Fm.	Approx. 12 miles NE of Little Chicago, Lat. 67°21'N, Long. 130°03'W; 106-O *Emanuella* sp. undet. *Rensselandia* or *Ectorensselandia* sp. nov. age: Givetian	C-10063
Ramparts Fm.	Scarp 10 miles NNW of Little Chicago, Lat. 67°20'N, Long. 130°22'W; 106-O stromatoporoids, not studied *Caliapora* sp. infested with *Chaetosalpinx* sp. *Temnophyllum* sp. nov. *Moravophyllum?* sp. undet., young specimen *Spinatrypa* sp. undet. *Stringocephalus* sp. indet., fragment age: Givetian, probably *aleskanus* Zone	C-10064
Ramparts Fm.	Approx. 29 miles N of Little Chicago, Lat. 67°36'N, Long. 130°15'W; 106-O stromatoporoids, not studied *Temnophyllym* sp. indet., fragment *Grypophyllum subtile* Pedder atrypoid, indet. *Spinatrypa* sp. indet. broad sense age: Givetian, *laevis* or *aleskanus* Zone	C-10065
Map-unit D_4	Approx. 11 miles N of Little Chicago, Lat. 69°21'N, Long. 130°09'W; 106-O *Leiorhynchus hippocastanea* Crickmay *L.* sp. cf. *L. rhabdotum* Crickmay ambocoeliid, undet. age: late Givetian or early Frasnian, *hippocastanea* Zone	C-10066
Map-unit D_4	Approx. 11 miles N of Little Chicago, Lat. 67°21'N, Long. 130°09'W; 106-O *Buechelia tyrrelli* (Whiteaves) *Paracyclas antiqua* (Goldfuss) bivalve, indet. mould *Leiorhynchus* sp. nov. *Emanuella* sp. age: Givetian	C-10067
Map-unit D_4	As above bivalve, indet. mould ambocoeliid, indet. *Cyrtina* sp. undet. *Dechenella* sp. undet. age: Middle Devonian, probably Givetian	C-10068
Map-unit D_4	Approx. 11 miles NE of Tutseita Lake, Lat. 67°25'N, Long. 129°44'W; 106P ambocoeliid, indet. age: probably Devonian, but cast and mould preservation does not allow generic identification that might eliminate the possibility of a late Paleozoic age.	C-10071
Hare Indian Fm.	W of Yatage River, near its headwaters, Lat. 67°42'N, Long. 129°10'W; 106P *Hadrorhynchia?* sp. undet. *Emanuella?* sp. indet. age: Devonian, probably Givetian	C-10081
Rampart Fm.	SE of the headwaters of Yatage River, Lat. 67°38'N, Long. 129°01'W; 106P stromatoporoids, not studied *Moravophyllum* sp. nov. age: Givetian, *laevis* or *aleskanus* Zone	C-10082

Stratigraphic position	Locality, fauna and age	GSC loc.
Ramparts Fm.	Approx. 1 mile E of Carnwath River, Lat. 67°48'N, Long. 128°36'W; 106P *Thamnopora* sp. undet. indet. shell fragments age: Silurian to Devonian	C-10083
Ramparts Fm., upper 2 ft.	Creek bank approx. 1.5 miles S of Lac Charrue, Lat. 67°20'45"N, Long. 130°09'15"W; 106-O stromatoporoids, not studied *Pachyfavosites* sp. undet. *Thamnopora* sp. undet. *Alveolites* sp. undet. *Grypophyllum aquilonium* Pedder *G. subtile* Pedder *G.* sp. nov. cf. *Cyathophyllum* sp. nov. *Tabulophyllum* sp. nov *Spinatrypa* sp. indet., fragmentary *Cyrtina* sp. undet. *Scutellum* sp. cf. *S. costatum* (Pusch) age: Givetian, *laevis* Zone	C-19853
Map-unit D_4, 14-18 ft. above base, 27-31 ft. below top	As above cf. *Cyathophyllum* sp. nov. bivalves, not studied orthoconic nautiloid *Pedinodechenella* sp. nov. *Dechenella* sp. indet. age: Givetian, *laevis* or *aleskanus* Zone	C-19854
Map-unit D_4, 33-34 ft. above base, 11-12 ft. below top	As above *Thamnopora* sp. indet. *Alveolites* sp. indet. *Argutastrea arguta* Crickmay subsp. nov. *Temnophyllum decaeni* Pedder *T. richardsoni* (Meek) stropheodontid, indet. *Rhyssochonetes* sp. indet., fragments *Stringocephalus* sp. nov. bellerophontinid, indet. *Dechenella* sp. indet. age: Givetian, *aleskanus* Zone	C-19858
Map-unit D_4, 33-34 ft. above base, 11-12 ft. below top	As above, but about 200 feet upstream *Alveolites* sp. undet. *Aulopora* sp. indet. *Argutastrea arguta* Crickmay subsp. nov. *Schizophoria mcfarlanei* (Meek) *Desquamatia?* sp. ex gr. *D.(?) hormophora* (Crickmay) *Cyrtina* sp. indet. *Stringocephalus aleskanus* Crickmay *Buechelia* sp. indet., small sp. or immature specimen bivalve moulds, not studied age: Givetian, *aleskanus* Zone	C-19859
Map-unit D_4, 37-38 ft. above base, 7-8 ft. below top	Creek bank approx. 1.5 miles S of Lac Charrue, Lat. 67°20'45"N, Long. 130°09'15"W; 106-O *Devonoproductus* sp. cf. *D. minimus* Crickmay *Leiorhynchus* sp. nov. age: late Givetian	C-19860
Map-unit D_4, 38-39 ft. above base, 6-7 ft. below top	As above new solitary rugose coral *Tabulophyllum* sp. undet. *Cystiphyllum* sp. nov., broad sense age: Givetian	C-19862

Stratigraphic position	Locality, fauna and age	GSC loc.
Map-unit D4, 43-44 ft. above base, 1-2 ft. below top	As above *Leiorhynchus hippocastanea* Crickmay *L.* sp. cf. *L. rhabdotum* Crickmay *Warrenella occidentalis timetea* Crickmay ambocoeliid, indet. age: late Givetian or early Frasnian, *hippocastanea* Zone	C-19863
Hare Indian Fm., 32 ft. below top	Gossage River, approx. 4.5 miles (direct) SW of mouth, Lat. 66°57'N, Long. 130°24'W; 106J *Dicricoconus* sp. nov. *Rhyssochonetes aurora solox* Johnson *Cyrtina panda* Meek trilobite fragments, indet. age: Givetian, probably lower *laevis* Zone	C-19867
Hare Indian Fm., 10 ft. below top	As above *Dicricoconus* sp. nov. *Cyrtina panda* (Meek) trilobite fragments, indet. age: Givetian, probably lower *laevis* Zone	C-19869
Ramparts Fm., 1-11 ft. above base, 0-10 ft. below top	As above stromatoporoids, not studied *Thamnopora* sp. undet. *Alveolites* sp. undet. *Caliapora* sp. cf. *C. battersbyi* Milne-Edwards and Haime *Temnophyllum* sp. *Grypophyllum* sp. nov. *Stringophyllum* sp. *Tabulophyllum* sp. *Cystiphyllum* sp., broad sense atrypoid, indet., fragments *Spinatrypa* sp., broad sense, fragmentary trilobite fragments age: Givetian, probably *laevis* Zone	C-19872
Talus from map-unit D4	Gossage River, approx. 4.5 miles (direct) SW of mouth, Lat. 66°57'N, Long. 130°19'W; 106J *Stringocephalus* sp. indet. age: Givetian	C-19873
Map-unit D4 29-31 ft. above base, 0-2 ft. below top	As above *Devonoproductus* sp. cf. *D. minimus* Crickmay *Leiorhynchus* sp. nov. age: late Givetian	C-19874
Ramparts Fm., 3-10 ft. above base of exposure, 19-26 ft. below top of exposure	Scarp 2.5 miles SSW of S end of Rond Lake, Lat. 67°01'28"N, Long. 128°31'37"W; 106P stromatoporoids, not studied *Heliolites* sp. undet. *Moravophyllum?* sp. undet. *Grypophyllum subtile* Pedder *G.* sp. undet. *Spinatrypa* sp. undet., broad sense *Stringocephalus aleskanus* Crickmay age: Givetian, *aleskanus* Zone	C-19876
Ramparts Fm., 14-29 ft. above base of exposure, 0-15 ft. below top of exposure	As above stromatoporoids, not studied *Thamnopora* sp. undet. *Tabulophyllum* sp. nov. *Temnophyllum richardsoni* (Meek) *Grypophyllum* sp. undet. *Stringocephalus aleskanus* Crickmay age: Givetian, *aleskanus* Zone	C-19878

Stratigraphic position	Locality, fauna and age	GSC loc.
Ramparts Fm., 0-4 ft. above base of exposure, 26-32 ft. below top of exposure	Ridge on N side of syncline, 14.5 miles NNW of the N end of Canot Lake, Lat. 67°40'31"N, Long. 128°56'37"W; 106P *Amphipora* sp. undet. *Thamnopora* sp. undet. cf. *Cyathophyllum* sp. nov. *Stringocephalus* sp. indet. *Conomimus?* sp. indet., fragment age: Givetian, *laevis* or *aleskanus* Zone	C-19880
Ramparts Fm., 21-24 ft. above base of exposure, 8-11 ft. below top of exposure	As above *Stachyodes* sp. undet. *Thamnopora* sp. undet. *Temnophyllum* sp. nov. cf. *Cyathophyllum* sp. nov. *Grypophyllum* sp. undet. *Stringocephalus* sp. cf. *S. axius* Crickmay age: Givetian, *laevis* or *aleskanus* Zone	C-19883
Ramparts Fm., 24-29 ft. above base of exposure, 3-8 ft. below top of exposure	As above stromatoporoids, not studied *Stachyodes* sp. undet. *Thamnopora* sp. undet. *Moravophyllum* sp. nov. *Grypophyllum subtile* Pedder *Spinatrypa* sp. indet., fragments ambocoeliid, indet. *Cranaena* sp. undet. *Stringocephalus* sp. indet., fragmentary age: Givetian, *laevis* or *aleskanus* Zone	C-19884
Map-unit D4, 19-25 ft. below top	Right bank of Mackenzie River, 1.7 miles above the mouth of Thunder River, Lat. 67°27'30"N, Long. 130°52'W; 106-O *Leiorhynchus* sp. age: probably late Givetian or early Frasnian	C-19886
Ramparts Fm.	South face of Iroquois Syncline, Lat. 67°38'N, Long. 129°01'W; 106P *Stringocephalus* sp. undet. age: Givetian	C-26465
Ramparts Fm.	Near mouth of a tributary of Carnwath River, Lat. 67°45'30"N, Long. 128°41'W; 106P stromatoporoid, not studied *Thamnopora* sp. undet. *Moravophyllum?* sp. undet. *Disphyllum* 2 spp. undet. *Rensselandia* or *Ectorensselandia* sp. indet. *Dechenella?* 2 spp. undet. age: Givetian, possibly *laevis* Zone	C-26464

Report by W.N. Stewart, Professor of Botany, University of Alberta, on a specimen of fossil wood collected by J.D. Aitken from the Canol Formation.

Stratigraphic position	Locality, fauna and age	GSC loc.
Canol Fm.	Lat. 67°58'30"N, Long. 130°24'W; 106-O The wood belongs to the genus *Callixylon* Zalessky, 1911. There are several species that are recognized by the number of vertical rows of pits on the radial walls. I doubt if this is an important characteristic. *Callixylon* is a common genus of the Upper Devonian of North America. It is especially abundant in the New Albany Shales of Indiana and New York. Here some trunks are reported to be 1.5 m in diameter and 26 m long. Specimens of *Callixylon* have been reported from the upper Middle Devonian but this is rare. The genus extends into the Lower Cretaceous of Europe.	C-2018

Stratigraphic position	Locality, fauna and age	GSC loc.
	The wood represents the trunk of a large, arborescent, progymnosperm with foliage of the *Archaeopteris* type. Most of the recent work on the two genera and the progymnosperms has been done by C.A. Arnold and Charles Beck, both of the University of Michigan. I would suggest that the wood specimen is probably Late Devonian in age.	

Report by A. Sweet on one field sample, collected by C.J. Yorath from NTS map-area 106-O.

Stratigraphic position	Locality, fauna and age	GSC loc.
Cretaceous	Lat. 67°19'N, Long. 130°59'30"W; 106-O *Hystricosporites* spp. *Ancyrospora* spp. *Lagenicula* sp. *L. devonica* Chaloner, 1959 *Ocksisporites* spp. *Biharisporites* spp. *Nikitinsporites canadensis* Chaloner, 1959 *Triangulatisporites rootsii* Chaloner, 1959 age: Late Devonian, Frasnian (based on megaspores present) comments: Sample very prolific with well-preserved Frasnian spores (*see* GSC loc. C-5549 in Appendix III).	C-5549

Report by T.T. Uyeno on Devonian conodont samples from NTS map-areas 106J, 106-O, and 106P.

Stratigraphic position	Locality, fauna and age	GSC loc.
Ramparts Fm., 0-2 ft. below top of limestone member	Creek bank, about 1.5 miles S of Lac Charrue, Lat. 67°20'45"N, 130°09'15"W; 106-O *Polygnathus decorosus* Stauffer sensu lato of Ziegler, 1966 *P. xylus* Stauffer *?Ancyrognathus* sp. (highly fragmentary) age: Givetian-Frasnian	C-19853
Map-unit D_4, 28-29 ft. above base, 16-17 ft. below top	As above *Icriodus eslaensis* van Adrichem Boogaert *Polygnathus xylus* Stauffer *P. decorosus* Stauffer sensu lato of Ziegler, 1966 age: late Givetian, *Polygnathus varcus* Zone	C-19855
Map-unit D_4, 30.4-30.6 ft. above base, 14.4-14.6 ft. below top	As above *Icriodus eslaensis* van Adrichem Boogaert *Pelekysgnathus* sp. *Polygnathus decorosus* Stauffer sensu lato of Ziegler, 1966 *P. xylus* Stauffer age: late Givetian, *Polygnathus varcus* Zone	C-19856
Map-unit D_4, 31.4-32.0 ft. above base, 13.0-13.6 ft. below top	As above *Icriodus eslaensis* van Adrichem Boogaert *Polygnathus linguiformis* Hinde *P. varcus* Stauffer age: late Givetian, *Polygnathus varcus* Zone	C-19857
Hare Indian Fm. 21 ft. below top	Gossage River, about 4.5 miles SW of mouth, Lat. 66°57'N, Long. 130°19'W; 106J *Icriodus eslaensis* van Adrichem Boogaert *Nothognathella* sp. *Polygnathus linguiformis* Hinde *P. pennatus* Hinde sensu lato of Seddon, 1969 *P.* prob. n. sp. age: late Givetian, *Polygnathus varcus* Zone	C-19868

Stratigraphic position	Locality, fauna and age	GSC loc.
Ramparts Fm., 1-11 ft. above base, 0-10 ft. below top	As above *Ligonodina* sp. *Polygnathus* sp. (highly fragmentary) indet. cone pyritized ostracodes and charophyta(?) age: Devonian-Mississippian	C-19872
Ramparts Fm.	Near mouth of tributary of the Carnwath River, Lat. 67°45'30"N, Long. 128°41'W; 106P *Icriodus eslaensis* van Adrichem Boogaert indet. O_1 element (1) belodellid (1) age: Middle Devonian (Givetian), *Polygnathus varcus* Zone	C-26464

Weights of samples etched:

GSC loc.	Weight (g.)
C-19853	8255
C-19855	4090
C-19856	4130
C-19857	4157
C-19860	4040
C-19866	4030
C-19868	4059
C-19870	4009
C-19871	4011
C-19872	4098
C-26465	2155

Comments

In Belgium, the range of *Icriodus eslaensis* is from Givetian (Gic) to Frasnian (Fla) (Bultynck, 1972, p. 72, 82). This corresponds to a large part of the *Polygnathus varcus* Zone which ranges from Givetian (Gic) to Frasnian (Fla). In North America, *I. eslaensis* has been reported previously from the *P. varcus* Zone (Tully Fm. of New York, Dawson Bay Fm. of Manitoba), together with *Rhyssochonetes aurora* (Hall).

Reference

Bultynck, P.
1972: Middle Devonian *Icriodus* assemblages (Conodonta); Geol. Palaeont., v. 6, p. 71-86.

APPENDIX III

REPORTS ON CRETACEOUS FOSSILS

Palynologic report by W.W. Brideaux on samples of Cretaceous rock from seismic shot holes, Department of Public Works test holes, and exploratory wells from NTS map-areas 106J, 106-O, and 106P. Samples were examined primarily to differentiate Devonian from Cretaceous and species lists for many samples were not established. Location numbers for such samples are included in this appendix to show Brideaux's conclusions (the interested reader may contact him for more specific information).

Stratigraphic position	Locality, fauna and age	GSC loc.
Seismic shot hole, depth 60 ft.	Lat. 67°11'45"N, Long. 129°26'00"W; 106P age: Early Cretaceous (marine environment, dinoflagellates)	C-23945
Seismic shot hole, depth 45 ft.	Lat. 67°19'10"N, Long. 128°09'30"W; 106P age: Early Cretaceous	C-23952
Seismic shot hole, depth 60 ft.	Lat. 67°25'00"N, Long. 130°23'15"W; 106-O age: Early Cretaceous	C-24092
Seismic shot hole, depth 60 ft.	Lat. 67°24'00"N, Long. 130°13'00"W; 106-O age: Mesozoic, ?Cretaceous	C-24094
Seismic shot hole, depth 60 ft.	Lat. 67°36'00"N, Long. 129°57'15"W; 106P age: Early Cretaceous, Aptian-Albian (marine environment, dinoflagellates)	C-24098
Seismic shot hole, depth 60 ft.	Lat. 67°31'45"N, Long. 129°25'10"W; 106P age: Early Cretaceous	C-24100
Seismic shot hole, depth 60 ft.	Lat. 67°35'30"N, Long. 129°57'15"W; 106P age: Cretaceous, probably Early Cretaceous	C-24101
Seismic shot hole, depth 60 ft.	Lat. 67°21'15"N, Long. 129°46'30"W; 106P age: problematic, a few rare dinoflagellates belonging to assemblages of Early Cretaceous age are associated with an abundant Devonian palynomorph assemblage	C-24102
Seismic shot hole, depth 60 ft.	Lat. 67°20'30"N, Long. 129°17'30"W; 106P age: Early Cretaceous (Hauterivian-Albian)	C-24105
Seismic shot hole, depth 60 ft.	Lat. 67°19'45"N, Long. 129°32'45"W; 106P age: Early Cretaceous (Aptian-Early Albian)	C-24106
Seismic shot hole, depth 60 ft.	Lat. 67°18'20"N, Long. 129°32'20"W; 106P age: Early Cretaceous	C-24107
Seismic shot hole, depth 60 ft.	Lat. 67°11'20"N, Long. 129°45'30"W; 106P age: Early Cretaceous	C-24109
DPW test hole, depth 17 ft.	Lat. 67°40'18"N, Long. 131°13'30"W; 106-O *Oligosphaeridium* sp. *Cleistosphaeridium?* sp. AE *Cyclonephelium compactum* Deflandre and Cookson *Gonyaulacysta auctifica* Brideaux *"Broomea" jaegeri* Alberti trilete spores bisaccate pollen *Cicatricosisporites* sp. age: Early Cretaceous (Albian, probably Early or Middle)	C-26513

Stratigraphic position	Locality, fauna and age	GSC loc.
DPW test hole, depth 28 ft.	Lat. 67°40'18"N, Long. 131°13'30"W; 106-O *Scriniodinium* sp. *Odontochitina operculata* (Deflandre) Deflandre *Gardodinium eisenackii* Alberti *Oligosphaeridium albertense* (Pocock) Davey and Williams *Tenua hystrix* Eisenack *Oligosphaeridium* sp. *Cleistophaeridium?* sp. AE *Antulisporites* sp. bisaccate pollen age: Early Cretaceous (Albian, probably Early)	C-26514
Seismic shot hole, depth 22 ft.	Lat. 66°22'12"N, Long. 130°27'06"W; 106J *Stereisporites antiquasporites* (Wilson and Webster) Dettmann *Cleistosphaeridium polypes* Davey subsp. *polypes* trilete spores bisaccate pollen *Microdinium* "spinosum" (MS name, McIntyre and Brideaux) age: Early Cretaceous (probably Albian)	C-26520
Seismic shot hole, depth 60 ft.	Lat. 66°29'36"N, Long. 130°35'42"W; 106J trilete spores *Cicatricosisporites* sp. *Stereisporites antiquasporites* (Wilson and Webster) Dettmann bisaccate pollen *Muderongia* sp. A *Odontochitina operculata* (Deflandre) Deflandre age: Early Cretaceous (Aptian or Early Albian)	C-26521
Seismic shot hole, depth 20 ft.	Lat. 66°54'42"N, Long. 131°20'06"W; 106J *Oligosphaeridium asterigium* Gocht *O.* spp. *O. totum* Brideaux subsp. *totum* trilete spores bisaccate pollen *Lunatadinium dissolutum* Brideaux and McIntyre *Astrocysta cretacea* Pocock ex Davey *Exesipollenites tumulus* Balme age: Early Cretaceous (Hauterivian-Middle Albian)	C-26522
Seismic shot hole, depth 40-50 ft.	Lat. 66°50'N, Long. 131°23'06"W; 106J trilete spores bisaccate pollen *Gleicheniidites senonicus* Ross *Cycadopites* spp. *Gonyaulacysta* sp. *Oligosphaeridium* sp. *Coronatispora valdensis* (Couper) Dettmann *Tenua* sp. A (MS name, McIntyre and Brideaux) *Oligosphaeridium anthophorum* (Cookson and Eisenack) Davey and Williams age: Early Cretaceous (probably Aptian-Middle Albian)	C-26523
Cuttings, depth 90 ft.	Atlantic *et al.* Ontaratue K-4 well, Lat. 66°33'37.5"N, Long. 130°46'10.3"W; 106J dinoflagellate cysts *Gonyaulacysta* sp. bisaccate pollen age: Early Cretaceous	C-26532

Report by T.P. Chamney on Cretaceous microfossils from shale samples taken by M.E. Ayling, D.G. Cook, and C.J. Yorath from NTS map-areas 106J, 106-O, and 106P.

Stratigraphic position	Locality, fauna and age	GSC loc.
Cretaceous	Lat. 67°25'N, Long. 129°13'W; 106P megaspore: ID sp. 8, common = *?Selaginellites* sp. wood, carbonized, few plant rootlets, common iron pellets, black, common age: indet. Pleistocene to ?Maastrichtian	C-5542
Cretaceous	Travaillant Lake, Lat. 67°40'40"N, Long. 131°57'30"W *Haplophragmoides* sp. G 95, rare *Verneuilinoides* sp., rare *Ammodiscus* sp. G 13, rare megaspores: I C var. sp. 1, rare I D var. sp. 1, rare Recent cases III A sp. 5, few age: Cretaceous, Early	C-5545
Cretaceous	Grandview Hills, Lat. 66°59'N, Long. 131°20'W *Spiroplectinata bettenstaedti* Grabert, very abundant *Ammobaculites* cf. *A. fragmentarius* Cushman, few *Gaudryina* ex gr. *G. canadensis* Cushman, few *Hyperammina* sp. 16, abundant *Glomospirella parammodiscus* McGill and Loranger, common *G.* cf. *G. eucalla* McGill and Loranger, few *G.* cf. *G. obesa* McGill and Loranger, few *G.* sp. 4, abundant *Jaculella* sp. 2, rare *Reophax* sp. 11B, common *Verneuilinoides* sp. 18B, few *Ammodiscus* sp. 8, few *Saccammina lathrami* Tappan, few *S.* sp., abundant *Hippocrepina* sp. 4, few *Haplophragmoides* sp. G122, very abundant *H.* cf. *H. volubilis* Romanova, few *H.* ex gr. *H. spissus* Stelck and Wall, common *Trochammina* ex gr. *T. canningensis* Tappan, abundant age: Albian, Middle	C-5547
Cretaceous	Lat. 67°19'N, Long. 131°59'30"W; 106-O *Glomospira* sp. *Glomospirella* sp. *Haplophragmoides* sp. *Microcarpolithes* sp. ostracode spp., ?derived megaspores: *Triletes* spp., ?derived age: youngest possible age is Early Cretaceous (Albian). The sample also contains Late Devonian pollen and megaspores (*see* GSC loc. C-5549 in Appendix II) which must have been derived from the underlying Imperial Formation	C-5549
Cretaceous	Lat. 67°21'N, Long. 130°15'W; 106-O *?Gaudryina* ex gr. *G. nanushukensis* Tappan, rare plant remains: roots sp. 5A, common ?faecal pellets sp. 4, common age: Early Cretaceous (Albian, undifferentiated) biostratigraphic equivalent: Sans Sault-Slater River Formations	C-10069

Palynology report by W.S. Hopkins, Jr., on samples collected by J.D. Aitken, M.E. Ayling, and D.G. Cook from NTS map-areas 106-O and 106P.

Stratigraphic position	Locality, flora and age	GSC loc.
Cretaceous	3 miles NE of N tip of Carcajou Lake, Lat. 67°21'30"N, Long. 128°40'30"W; 106P *Tsugaepollenites* cf. *T. mesozoicus* Couper ?*Araucariacites* sp. *Gleicheniidites senonicus* Ross small, circular, unidentified trilete spore ??tricolpate pollen comments: GSC loc. C-4315 was essentially barren, but contained several *Gleicheniidites* spores. Assuming these are indigenous to the rock, it would suggest an age of Jurassic or Cretaceous for the sample.	C-4315
Cretaceous	Lat. 67°25'N, Long. 129°13'W; 106P *Deltoidospora* sp. *Densoisporites* sp. *Gleicheniidites* sp. *Murospora* sp. *Sphagnum* sp. *Lycopodium* cf. *L. novomexicanum* Anderson *L.* sp. *Acanthotriletes* sp. *Laevigatosporites* sp. ?*Klukisporites* sp. *Pinus* - type *Tsugaepollenites* sp. *Larix* - type Cupressaceae - Taxodiaceae types *Alnus* sp. cf. *Betula* sp. Chenopodiaceae tetraporate pollen, very small, unidentified age: *see* comments comments: Preservation of the angiosperm pollen appears much better than that of the spores or gymnosperm pollen. This suggests contamination of the sample either from the overlying Pleistocene or recent vegetation. If all the pollen and spores are indigenous to the sample, we would be forced to conclude that we are dealing with a Pleistocene or Tertiary unit. However, if we conclude that the angiosperm pollen are contaminants, as seems likely, an Early Cretaceous age is suggested. The lack of small, simple tricolpate pollen grains characteristic of the Upper Albian suggests a pre-Late Albian age. Furthermore, the lack of more typical Early Cretaceous spores would suggest a post-Aptian age. Therefore, the indicated age is most likely Early or Middle Albian. A complete lack of phytoplankton suggests a continental origin for this unit.	C-5542
Cretaceous	Lat. 67°37'N, Long. 130°05'W *Gleicheniidites senonicus* Ross *Cyathidites minor* Couper *C. australis* Couper *Densoisporites* cf. *D. velatus* Weyland and Krieger cf. *Hymenozonotriletes* sp. *Osmundacidites wellmanii* Couper *Lycopodiumsporites* cf. *L. austroclavatidites* (Cookson) Pocock	C-10072

Stratigraphic position	Location, flora and age	GSC loc.
	Lycopodiumsporites marginatus Singh *Deltoidospora junctum* (Kara-Murza) Singh *D.* sp. *Sphagnum antiquasporites* Wilson and Webster cf. *Cicatricosisporites* sp. *Cingutriletes* sp. cf. *Murospora* sp. *?Trilobosporites* sp. *Trilites* spp. *Alisporites* sp. *Podocarpidites* sp. assorted bisaccate pollen grains (conifers) *Spheripollenites* sp. *Tsugaepollenites mesozoicus* Couper *T.* sp. *Cycadopites* sp. *Monosulcites* sp. cf. *Araucariacites* sp. age: Early Cretaceous (probably Aptian)	
Cretaceous	Lat. 67°37'N, Long. 130°05'W *Lycopodiumsporites austroclavatidites* (Cookson) Pocock *Cyathidites minor* Couper *Spheripollenites* sp. *Tsugaepollenites* spp. *Podocarpidites* sp. assorted bisaccate pollen grains (conifers) *Monosulcites* sp. age: Cretaceous comments: GSC locs. C-10072 and C-10073 are undoubtedly Cretaceous in age. The lack of typical earliest Cretaceous spores as well as a lack of typical Late Cretaceous spores and pollen suggest a late Early Cretaceous age for these samples. I would consider Aptian as a reasonable interpretation. A complete lack of phytoplankton suggests that these are continental sediments.	C-10073

Report by J.A. Jeletzky on fossils collected by J.D. Aitken, H.R. Balkwill, and D.G. Cook from NTS map-areas 106J, 106-O, and 106P.

Stratigraphic position	Location, fauna and age	GSC loc.
Cretaceous shale	Lat. 67°03'N, Long. 131°07'30"W; 106-O *Arcthoplites* cf. *A. belli* (McLearn) var. *Beaudanticeras (Grantziceras) affine* (Whiteaves) age and correlation: Some part of the generalized *Arcthoplites* and *Beaudanticeras affine* zone (*see* Jeletzky, 1968) and of the late Early Albian age in terms of the international standard stages. In the Mackenzie Basin, *Arcthoplites* zone apparently occurs within the Sans Sault Group (*see* Hume, 1953, p. 47-49). Its stratigraphic position within the Sans Sault Group remains obscure but it must be stratigraphically higher than the *Sonneratia?* ex aff. *kitchini* fauna which was collected by C.J. Yorath at Sans Sault Rapids (GSC loc. 84792, unpubl). *Arcthoplites* and *Beudanticeras affine* zone also is represented in the middle and upper portion of the "Bentonitic zone" (Horton River Formation, *see* Yorath *et al.*, in press). GSC	C-2019

Stratigraphic position	Location, fauna and age	GSC loc.
	loc. C-2019 is therefore equivalent to some parts of the Sans Sault Group of the Mackenzie Plain and the "Bentonitic zone" of Anderson Plain.	
Cretaceous	East side of Marion Lake, Lat. 66°48'45"N, Long. 130°32'30"W; 106J *Tancredia* cf. *T. stelcki* McLearn indeterminate pelecypods age and correlation: Possibly some part of the Albian Stage of the international standard and from the equivalents of Sans Sault Group. However, cannot be dated definitively because of poor preservation of all pelecypods available.	C-2049
Approximately 100 ft. above base of Cretaceous	Tributary of Andrew River, Lat. 67°44'N, Long. 128°05'W; 106P *Arctica* cf. *limpidiana* McLearn cf. *Psilomya* sp. indet. cf. *Thracia* sp. indet. (juvenile) pelecypods, gen. et sp. indet. age and correlation: *Arctica limpidiana* McLearn is a prominent member of the late Early Albian Clearwater fauna of the Lower Athabasca area in the Canadian Western Interior region. This species, furthermore, was never reported outside of the Albian rocks in Canada or northern Alaska. A general Albian (late Early Cretaceous) age, therefore, is suggested for GSC loc. C-5439. It cannot be overstressed, however, that the genus *Arctica* is a long-ranging, facies-bound type which cannot be treated as a reliable index fossil.	C-5439
Cretaceous	Lat. 67°19'N, Long. 130°03'W; 106-O *Tancredia kurupana* Imlay, 1961 indeterminate pelecypods age and correlation: *Tancredia kurupana* Imlay appears to be restricted to the Albian rocks in northern Alaska (Imlay, 1961) and Arctic Canada. A general Albian age is suggested for GSC loc. C-10070.	C-10070

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