Geological Survey of Canada
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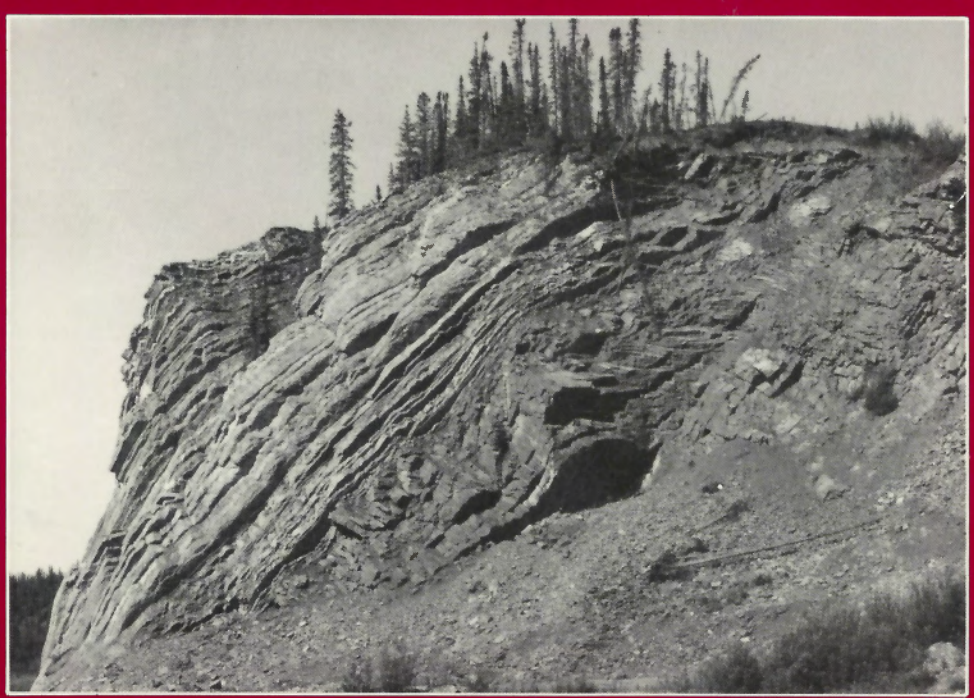
MEMOIR 410

STRATIGRAPHY OF DEVONIAN OUTCROP BELTS IN NORTHERN YUKON TERRITORY AND NORTHWESTERN DISTRICT OF MACKENZIE (OPERATION PORCUPINE AREA)

A.W. NORRIS



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Cover illustration

Contact between dark limestone beds of the Michelle Formation and overlying lighter coloured carbonate beds of the Ogilvie Formation, exposed in a roadcut on Dempster Highway at 212 km; on northern flank of Ogilvie Mountains. (Photograph by B.C. Rutley, July, 1983; ISPG Negative No. 2048-41.)

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PREFACE

This report describes the geology of the Devonian rocks of the most northwestern part of mainland Canada, in the northern Yukon Territory and adjacent District of Mackenzie, an area under study since 1962 by Geological Survey of Canada scientists under "Operation Porcupine". Sixteen geological maps covering this area, at a scale of 1:250 000, have been published recently. This report is intended to complement the information which they presented. This study of the stratigraphy, biostratigraphy, paleogeography, and economic geology of Devonian rocks will be an invaluable aid to future exploration and geological analysis.

Devonian sedimentary rock successions in the area consist of two main types: those deposited in basinal shale troughs, and those deposited on stable, shallow water, carbonate platforms. Igneous intrusions dated radiometrically as Devonian and older occur in the northwestern part of the area. Some of the stratigraphic units are known to have a good potential as host rocks for mineral concentrations, or as source and reservoir rocks for hydrocarbons. Information presented in this report as to the nature and distribution of the Devonian strata will help identify some of the more promising areas of economic interest.

OTTAWA, March 1984

R.A. Price
Director General
Geological Survey of Canada

PRÉFACE

Le présent rapport décrit la géologie des roches du Dévonien à l'extrémité nord-ouest de la partie continentale du Canada, dans le nord du Yukon et dans la partie adjacente du district de Mackenzie, région où les chercheurs de la Commission géologique du Canada exécutent des études depuis 1962 dans le cadre de l' "Opération Porcupine". Seize cartes géologiques couvrant cette région à l'échelle de 1/250,000 ont été publiées récemment. L'objectif du présent rapport est de compléter les renseignements qui sont consignés sur ces cartes. Cette étude de la stratigraphie, de la biostratigraphie, de la paléogéographie et de la géologie économique des roches du Dévonien apportera une aide inestimable à l'exécution d'analyses à des fins d'exploration et de géologie.

Dans la région, les roches sédimentaires du Dévonien consistent principalement en deux types de successions: celles qui se sont déposées dans les dépressions schistes argileux de bassins et celles qui se sont déposées en eau peu profonde, sur des plate-formes stables formées de roches carbonatées. Dans la partie nord-ouest de la région, il y a des intrusions ignées du Dévonien et du pré-Dévonien dont l'âge a été déterminé par des méthodes radiométriques. On sait que certaines unités stratigraphiques sont fort probablement des roches encaissantes favorables aux concentrations minérales, ou des roches mères et des roches réservoires où se sont formés des hydrocarbures. Les renseignements sur la nature et la distribution des strates du Dévonien qui sont fournies dans le présent rapport aideront à identifier certaines régions des plus prometteuses sur le plan économique.

OTTAWA, mars 1984

R.A. Price
Le Directeur général
Commission géologique du Canada

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STRATIGRAPHY OF DEVONIAN OUTCROP BELTS IN NORTHERN YUKON TERRITORY AND NORTHWESTERN DISTRICT OF MACKENZIE (OPERATION PORCUPINE AREA)

Abstract

This revised account of the Devonian geology of the Operation Porcupine area is based primarily on 49 outcrop sections measured in 1962, 1970 and 1982, and incorporates new biostratigraphic data from numerous workers who have published on the area since 1968. The report area lies between latitude 65°N and the arctic coast and between longitudes 132°W and 141°W (Yukon-Alaska boundary) and embraces an area of 207 200 square kilometres.

During Early and Middle Devonian time, carbonate successions were deposited on the Mackenzie Platform in the east, on the Yukon Stable Block in the west, and on two small isolated platforms, the White Mountains Platform in the north and Royal Mountain Platform in the south. During the same time interval, successions consisting largely of shale were deposited in the centrally located Richardson Trough and in the peripheral Blackstone, Selwyn, Hazen and Rapid troughs.

The Lower and Middle Devonian successions on the Mackenzie Platform consist of the Unnamed carbonate unit, together with the Cranswick, Hume, and Hare Indian formations. Slope deposits comprising a tongue of the Road River Formation and Mount Baird Formation (new name) are transitional between the Mackenzie Platform and Richardson Trough. On the Yukon Stable Block in the west, the carbonate succession consists of the Kutchin (new name) and Ogilvie formations and an unnamed shale unit. A succession showing a fluctuation between basinal shale and carbonate platform deposits comprises the Road River and Michelle formations in the Blackstone Trough, and the Ogilvie Formation and the Unnamed shale unit on the Yukon Stable Block. Deep water sediments of the Road River Formation were deposited in the troughs.

The uppermost Middle and Upper Devonian succession was characterized by a completely different sedimentary regime. Stratigraphic units comprise the Canol, Imperial, and Tuttle (new name introduced by Pugh, 1983) formations. The upper Middle Devonian Canol Formation is a dark euxinic shale that was deposited over a large part of the area and which is locally separated by an unconformity from underlying rock units. The succeeding Upper Devonian Imperial and Tuttle formations consist of fine to very coarse grained, clastic rocks. A small part of the Imperial Formation in the east is of shallow marine origin, but throughout most of the report area these two formations consist largely of flysch-like sediments and turbidites derived from an uplifted area in the north. The Tuttle Formation is uppermost and is dated by spores as latest Late Devonian and Early Carboniferous.

Résumé

Cette contribution à la géologie du Dévonien dans la région de l'Opération Porcupine a pris appui primitivement sur quarante-neuf coupes d'affleurements mesurées en 1962, 1970 et 1982 et on a apporté de nouvelles données biostratigraphiques à partir d'études de nombreux chercheurs dans cette région et dont les résultats sont publiés depuis 1968. Ce levé géologique couvre une région comprise entre 65° de latitude nord et la côte Arctique et entre 132° et 141° de longitude ouest (frontière Yukon-Alaska); la surface est de 207 200 km^2.

Au cours du Dévonien inférieur et moyen, les sédiments carbonatés se sont déposés sur la plate-forme Mackenzie à l'est, sur le môle du Yukon à l'ouest et sur deux petites plate-formes isolées, la plate-forme White Mountain au nord et la plate-forme Royal Mountain au sud. Au cours du même intervalle, les successions constituées, en grande partie, de schistes argileux, se sont déposés dans le sillon Richardson situé au centre et dans les sillons périphériques Blackstone, Selwyn, Hazen et Rapid.

Les successions du Dévonien inférieur et moyen situées sur la plate-forme Mackenzie comprennent le groupe de Bear Rock et les formations de Cranswick, Hume et Hare Indian. Les sédiments de versants comprennent la langue de Road River et la formation de Mount Baird (nouvelle appellation); ils formaient une transition entre la plate-forme Mackenzie et le sillon Richardson. Sur le môle du Yukon à l'ouest, la succession carbonatée comprend les formations de Hutchin (nouvelle appellation), Ogilvie et la langue de McCann. Une succession montrant une fluctuation entre les dépôts de schistes argileux de bassins à sédimentation et la plate-forme carbonatée comprend les formations de Road River et Michelle dans le sillon Blackstone et la formation d'Ogilvie et la langue de McCann Hill sur le môle du Yukon. Des sédiments d'eau profonde appartenant à la formation de Road River ont pris place dans les sillons.

La succession de niveau le plus élevé du Dévonien supérieur et moyen etait caractérisée par un régime sédimentaire entièrement différent. Les unités stratigraphiques comprennent les formations suivantes: Canol, Impérial et Tuttle (nouvelle appellation introduite par Pugh, 1983). La formation supérieure, du Dévonien moyen, est constituée de schiste argileux euxinique foncé, s'est déposée sur une surface importante de la région et se trouve localement séparée par une discordance due à des unités rocheuses sous-jacentes. Les formations de Tuttle et Impérial du Dévonien supérieur sont constituées de roches clastiques à grains fins à grossiers. Une petite partie de la formation d'Impérial à l'est est d'origine marine d'eaux peu profondes, mais pour une bonne partie de la région étudiée, ces deux formations sont constituées majoritairement de sédiments flyschoïdes et turbidiques provenant d'une zone soulevée au nord. La formation de Tuttle, de niveau le plus élevé, se situe chronologiquement à la toute fin du Dévonien supérieur et au Carbonifère inférieur; cette datation relative a été obtenue à partir de spores.

INTRODUCTION

Location and present work

This report comprises a revision and synthesis of the Devonian geology of the area covered by Operation Porcupine, the preliminary mapping of which was done in 1962 (see Geological Survey of Canada, Map 10-1963). The report area lies mainly between latitude 65°N and the arctic coast, and between longitudes 132°W and 141°W (Yukon-Alaska boundary), encompassing an area of about 80 000 square miles (207 200 square kilometres) within the northern Yukon Territory and northwestern District of Mackenzie (figs. 1, 2). Preliminary accounts of the Devonian geology of the Operation Porcupine area were presented by A.W. Norris (1967, 1968a, b) based on 36 sections measured by members of the operation. The present report incorporates data from 13 new sections measured by the writer in 1970 and 1982, as well as biostratigraphic information that has been published since 1968. Three sections, one of which is new, immediately east of the Operation Porcupine area are included to tie in with the more accessible and better known Devonian sequence of the Norman Wells area. In addition, three new sections south of the Operation Porcupine area are included to show the relationship of the richly fossiliferous Devonian sequences of the Road River and other formations in the Royal Creek area studied by Lenz (1966, 1968, 1977a, b), Lenz and Pedder (1972), Green (1972), and others.

It is unfortunate that part of the field data acquired in 1970, including some vertical air photographs showing precise locations of sections, all exposed 35 millimetre film, and part of the field notes covering some of the described sections were consumed in a fire that destroyed our office tent at the end of that field season. However, much of the descriptive data was recovered by careful copying of charred pages of the field notebooks and by piecing together data recorded on labels accompanying fossil and lithological samples.

Recently (September, 1982), in attempting to locate topotypic material of the coral, *Spongonaria filicata* Crickmay, a new section, 2a, in the Arctic Red River area was measured by A.E.H. Pedder and A.W. Norris. This section provides new outcrop data on the Unnamed carbonate unit and Cranswick Formation from an area just within the Mackenzie Mountain front immediately east of that covered by Operation Porcupine.

Supplementing the text in the present report are the following: a map showing the main belts of Devonian outcrops and locations of measured sections (Fig. 1); a map showing the tectonic subdivisions of the report area, control points, and lines of sections (Fig. 2); a chart showing the Devonian formational nomenclature, main faunas and floras, and correlation with other areas (Fig. 3); and five lines of measured columnar sections schematically depicting the lithology and distribution of some of the main fossils (figs. 4-8).

Also included are the following: a map (Fig. 9) showing the paleophysiographic subdivisions of the area, and a series of maps (figs. 10-16) showing the paleogeography and lithofacies for seven intervals of time covering the Late Silurian, through the Devonian, to Early Carboniferous.

Acknowledgments

During the field phase of this project in 1970, helicopter support and base camp facilities were shared with D.K. Norris, who later facilitated preparation of this report by providing access to unpublished geological and tectonic maps of the area.

The writer is grateful to Mr. C.H. Riddell of Inexco, who kindly provided helicopter support for measuring Devonian sections out of a base camp on the Ogilvie River, in 1970, while our own camp was being moved from the arctic coast to Mile 103 on the Dempster Highway.

The writer acknowledges with thanks the following workers who provided paleontological data for inclusion in this report: D.E. Jackson, who identified a large number of graptolites collected by the writer from the Road River Formation; D.C. McGregor, for re-examining the spores from the Imperial and Tuttle formations on Trail River; A.E.H. Pedder, for identifying and dating the rich coral fauna from the type Ogilvie Formation on Mount Burgess; and T.T. Uyeno, for providing new information on the distribution of conodonts in the lower part of the Hume Formation on Powell Creek.

D.K. Norris and T.T. Uyeno critically read a draft of the report. Their comments are appreciated and have been incorporated in the text.

Main geological contributions since Operation Porcupine in 1962

A summary of early exploration and geological work on Devonian formations of the report area up to about 1964 was presented by A.W. Norris (1968b). The following résumé will present the highlights of contributions made since that date, and will be concerned primarily with the Devonian stratigraphy and biostratigraphy of the report area. Some of the more significant contributions on Devonian geology, particularly in the central and southern Mackenzie Valley areas and in east-central Alaska also will be mentioned.

Studies of Devonian faunas arising out of collections made by members of Operation Porcupine in 1962 include the following: Collins (1969), Jackson and Lenz (1969), Stearn and Mehrota (1970), Lenz and Jackson (1971), and Ormiston (1971). Collins (1969) described three nautiloids from several collections made by B.S. Norford (1964, p. 40) from a 519-foot (158 m) interval of Unit 6 of his Royal Creek section. This interval was later included in the Lower member of the type section of the Prongs Creek Formation of A.W. Norris (1968b, p. 23, Fig. 3, Sec. 8). The three species of nautiloids comprise *Leurocycloceras superplenum* Collins, *Ormoceras* sp., and *Rayonnoceras*? sp., which were dated as late Siegenian to Emsian in age (Collins, 1969, p. 34). Jackson and Lenz (1969, p. 20), in a paper describing latest Silurian graptolites from the Yukon Territory, indicated that the uppermost part of a shale section on lower Porcupine River (Sec. 13 of Norris, 1968a, b) between 219 and 238 feet (66.8 and 72.5 m) above the base of the section contained monograptids and tentaculitids suggestive of the *Monograptus yukonensis* Zone of Early Devonian age. Stearn and Mehrota (1970), in their study of the Devonian stromatoporoids from the Operation Porcupine area,

identified three stromatoporoid species from the Gossage Formation, four species from the Michelle Formation, two species from the Cranswick Formation, one species from the Prongs Creek Formation, sixteen species from the Ogilvie Formation, and five species from the Hume Formation. Lenz and Jackson (1971) described or listed Lower Devonian monograptids from the upper part of a section on Prongs Creek (65°18'N, 135°40'W) that corresponds to Section 10 of Norris (1967; 1968a, Fig. 3) and to Section 7 of Norford (1964); and from the upper part of a section on Hart River (65°34'N, 136°55'W) that corresponds to Section 15 of Norris (1968a, Fig. 4). In the same report, Lenz and Jackson (1971, p. 3, 4) summarized the occurrences and other data pertaining to the Lower Devonian monograptid zones and beds comprising the following: *Monograptus uniformis*, *M. hercynicus*, beds with *M. thomasi* and *M. yukonensis*. Ormiston (1971) described a distinctive trilobite assemblage from the Michelle Formation of the Ogilvie-Hart rivers area collected by L.H. Green, A.J. Jenik, D.J. McLaren and A.W. Norris of the Geological Survey of Canada. Ormiston (1971, p. 29) assigned these trilobites to the Lower Devonian (Emsian) and indicated that they had affinity to forms in the Canadian Arctic Islands and, to a lesser extent, with forms in the McCann Hill Chert of Alaska.

Dineley (1969) described the heterostracan ostracoderm *Corvaspis* from a section located directly west of Snake River at 65°22'N, 133°30'W, occurring in an orange weathering rock unit here assigned to the Unnamed carbonate unit. The fish-bearing beds were considered to be of marine origin and dated as Late Silurian.

The report by Tassonyi (1969) dealing with the "Subsurface Geology, lower Mackenzie River and Anderson River area, District of Mackenzie", includes the most thorough and detailed account of the subsurface Devonian stratigraphy to that date. The area covered by his report lies between 64°N latitude and the arctic coast, and between the edge of the Canadian Shield in the east and the Yukon Territory-District of Mackenzie boundary in the west and, thus, overlaps the eastern limit of the Operation Porcupine area. His report was based on an examination of well samples, cores and mechanical logs of the more important exploratory wells drilled up to March, 1961.

Fåhraeus (1971, p. 669, 670) showed that the Michelle Formation contains a rich conodont fauna assigned to twenty-five species. He concluded (Fåhraeus, 1971, p. 670-671) that this conodont fauna belongs in the upper part of the *Polygnathus dehiscens* Zone (=*P. lenzi* fauna of Klapper, 1969), which he dated as late Pragian. The Michelle Formation was shown to be correlative with at least part of the Buchan Caves Limestone of Victoria, Australia; questionably with the *Acrospirifer kobehana* Zone, and more definitely with the lower part of the *Eurekaspirifer pinyonensis* Zone of Nevada; and with the lowermost part (d4a∝) of the Mariposas Beds of the Iberian Chains, northeastern Spain.

Lenz (1966, 1968a, b, 1977a, b) and Lenz and Pedder (1972) have described the stratigraphy and listed or described the brachiopod faunas of the upper Upper Silurian and Lower Devonian shale and carbonate sequences which are well exposed in the vicinity of the headwaters of Royal Creek. These sections (near secs. 36, 37 and 38 of the present report; see Fig. 6) are immediately south of the area covered by Operation Porcupine. The brachiopod faunas from sections RC-1, RC-2 and RC-3 of Lenz (1977a, Fig. 2, p. 40) for the Pridolian, Lower and Upper Lochkovian, Pragian and Zlichovian of the Lower Devonian are undoubtedly the best documented for this interval of any so far discovered in northwestern Canada. The summary and final reports on the brachiopods of the Royal Creek area by Lenz (1977a, b) include discussion on the age, correlation and paleoecology of the enclosing beds.

Ludvigsen (1970), in a study of the faunas of the Michelle Formation, based on four measured sections in the Hart-Blackstone rivers area and three spot-sampled localities in the Ogilvie River area, contributed the following: the brachiopod fauna of the Michelle Formation was correlated with the *Eurekaspirifer pinyonensis* Zone (Emsian) of Nevada; the dacryoconarid tentaculitid fauna was tentatively correlated with the *Guerichina strangulata* Zone (late Pragian, early Emsian) of Bohemia; the conodonts were assigned to the *Polygnathus lenzi* fauna (=*P. dehiscens* Zone; early Emsian); and the trilobites and ostracodes indicated an undifferentiated Emsian age.

Ludvigsen (1972), in a more detailed study of the dacryoconarid tentaculitid fauna of the Michelle Formation and the upper part of the Road River and part of the Prongs Creek Formation, presented the following results. He indicated that the dacryoconarid tentaculitid fauna in the upper part of the Road River Formation is dominated by *Turkestanella acuaria* (Richter), and in the overlying Michelle Formation the main forms are *T. acuaria* and *Nowakia parabarrandei* Churkin and Carter. He dated the upper part of the Road River Formation as Pragian, based on graptolites and dacryoconarids, and the overlying Michelle Formation as late Pragian based on the dacryoconarids. In addition, he showed that some species of *Nowakia* appear considerably earlier in the northern Yukon than in Bohemia.

In 1969, MacKenzie (1970a) spent two months on Devonian stratigraphic studies working in the McConnell Range and Mackenzie Mountains near Norman Wells. Devonian stratigraphic units tentatively recognized by MacKenzie in the Mackenzie Mountains included the Delorme, Camsell, Arnica, Landry, Bear Rock, Hume, Canol, Fort Simpson and Imperial formations. All of these rock units, with the exception of the Hume, Canol and Imperial formations, were extended northward from the Camsell Bend and Root River map areas of Douglas and Norris, D.K. (1961).

MacKenzie (1970b) described allochthonous reef debris-limestone turbidites of Late Devonian age that outcrop in the Powell Creek area, located about 50 miles (80 km) west-northwest of Norman Wells. In a later paper, MacKenzie (1973) described somewhat similar Upper Devonian echinoderm debris beds showing graded texture in core from the McDermott Canada GSC South Maida Creek G-56 well, located 2.5 miles (4 km) southeast of the Carcajou Ridge outcrop section.

Caldwell (1971) reviewed the stratigraphy and faunas of some Middle and Upper Devonian successions in several key areas of the Northwest Territories, and concentrated on those developed in the Great Slave Lake and lower and upper Mackenzie Valley areas. The well studied reference sequence of Devonian faunas, occurring in the lower Mackenzie Valley area between Norman Wells in the south and Fort Good Hope in the north, is the nearest to that of the Operation Porcupine area.

In an M.Sc. thesis that he wrote in 1971, Perry studied the Ogilvie Formation of the northern Yukon Territory. The results of this study were later published by Perry, Klapper and Lenz (1975), and included brachiopods, conodonts, corals and trilobites. Perry et al. (1975) concluded that the affinities of the brachiopods were with the Cordilleran Subprovince of the Old World Province and with forms of similar age described from Nevada. Five informal conodont faunal units, ranging in age from Emsian to Eifelian

were proposed for the Michelle-Ogilvie sequence. The *Polygnathus varcus* Zone was recognized in the *Stringocephalus*-bearing beds on Mount Burgess. The Emsian tetracoral fauna showed similarities to that of the Emsian of eastern Australia, and the Eifelian fauna to that of other parts of northwestern Canada. The trilobites of the Ogilvie Formation are similar to forms from the Arctic Islands, eastern Alaska, and Nevada.

Broad and Lenz (1972) described two species of *Vernonaspis* (Heterostraci) collected from an orange weathering dolomitic limestone unit of a section in the Snake River area, located 3.75 miles (6 km) north of the locality of fossil fish remains reported on by Dineley (1965). There also, the fish remains are dated as Late Silurian and the host beds are here included in the Unnamed carbonate unit.

Green (1972) described the geology of three map areas, located immediately south of the Operation Porcupine area, and comprising from west to east: Dawson (116B-116C, E½), Larsen Creek (116A), and Nash Creek (106D). Green's (1972) report describes and shows the distribution of four Devonian rock units in the three map areas, some of which are obviously continuous with or closely related to Devonian units in the present study area.

Lenz (1972) described the Ordovician to Devonian history of northern Yukon Territory and adjacent District of Mackenzie based on data taken from eighty-four control points. Paleophysiographic features discussed include the Mackenzie Platform, Richardson Trough, Bonnet Plume High, Cordilleran Trough, Yukon Stable Block, Blackstone Trough, Dave Lord High, and British-Barn Mountains Trough. Accompanying the discussion of the Devonian are five lithofacies maps and three geological cross-sections based on data from the control points.

Martin (1972), in his subsurface study of "Upper Paleozoic stratigraphy of the Eagle Plain Basin, Yukon Territory", based on data from eight drillholes, included a discussion on parts of the Devonian succession comprising the Unnamed shale unit of Norris (1968a, b) and the Imperial Formation.

Martin (1973), in a later paper on the Eagle Plain Basin, Yukon Territory, summarized the geology and petroleum potential of the stratigraphic succession and incorporated data from both surface and subsurface sections. Particularly useful are illustrations (Martin, 1973, figs. 2, 4 and 5) showing isopachs and distribution of the Devonian Road River, Gossage, Michelle, Ogilvie, Unnamed shale, Canol and Imperial formations within the area.

Berdan and Copeland (1973) described and illustrated ostracodes from the Lower Devonian parts of the McCann Hill Chert of east-central Alaska, from three sections (II, IV and I of Ludvigsen, 1970) of the Michelle Formation, and from one section (V of Ludvigsen, 1972) of the Prongs Creek Formation in the Yukon Territory. Berdan and Copeland (1973) dated the ostracode faunas from the three formations as Emsian, Early Devonian in age, based on associated conodonts and dacryoconarid tentaculites. The ostracodes were considered to represent a provincial assemblage.

Miall (1973), in his paper on the regional geology of northernmost Yukon Territory, included a discussion of Devonian rocks in the British and Barn Mountains, Old Crow Plain, Dave Lord Ridge, and Richardson Mountains. He pointed out that a major tectonic episode, the Ellesmerian Orogeny, affected the northern Yukon, northern Alaska and the Arctic Islands in several separate phases during the Devonian.

Kunst (1973) included a summary of the Devonian stratigraphy of the Peel Plateau area in his assessment of the hydrocarbon potential of that area. Devonian formations discussed included the Gossage, Prongs Creek, Hume, Hare Indian, Canol and Imperial.

Chi and Hills (1973) described and illustrated the megaspores, described the sediments, and interpreted the depositional environment of the type section of the Imperial Formation located on Imperial River at the front of the Mackenzie Mountains (65°07'N, 127°51'W). They recognized three megaspore zones in the Imperial Formation ranging from Frasnian (but not lowermost Frasnian) at the base, to low-middle Famennian at the top. Fluctuations in total megaspore counts in the Imperial Formation indicate that the lower 1335 feet (407 m) of the formation are dominantly of nearshore marine origin but contain three, thin, offshore, marine intervals. The interval between 1335 and 1970 feet (407-600 m) is essentially offshore marine in origin.

Macqueen (1974, p. 325-326, Fig. 1, Loc. MQl-9) investigated and described a series of small carbonate masses occurring in the upper one third of a sequence of shale approximately 2000 feet (610 m) thick in the Prongs Creek Formation (=Road River Formation) that outcrops on the east flank of Knorr Range. The same carbonate masses have been mentioned by Lenz (1972, p. 328), who referred to them as "small reef developments".

MacKenzie (1974a) reported radiolaria from several levels within the Canol Formation from both outcrop and subsurface sections distributed over a wide area of the lower Mackenzie River region. Five genera of radiolaria were listed, two of which are of possible importance in zonation of the upper Paleozoic.

MacKenzie (1974b) reported that the lower Spore-bearing member of Tassonyi (1969, p. 71) of the Hare Indian Formation contains algal spore cases referred to the genus *Leiosphaeridia*. These are abundant in the Spore-bearing member in the eastern area, but are absent in the western area of distribution of the formation.

Ludvigsen and Perry (1975), in their study of the brachiopod *Warrenella* in the Lower and Middle Devonian formations of northwestern Canada, included five forms from the present report area. These are as follows: *Warrenella transversa* Ludvigsen and Perry from the Michelle Formation; *W. quadrata* Ludvigsen and Perry and *W. kirki* (Merriam) from the Ogilvie Formation; and *W. weigelti meeki* Ludvigsen and Perry and *W. crickmayi* Ludvigsen and Perry from the upper part of a rock unit here named the Mount Baird Formation.

Macqueen (1975), in his study of lower and middle Paleozoic sediments, northern Yukon Territory, included new data on the Road River Formation exposed on Royal Creek (Sec. 6 of Norford, 1964; Sec. 8 of Norris, 1968a, b) and on the Unnamed carbonate unit exposed immediately to the east on the west flank of Royal Mountain. Of unusual interest in these two sections is the apparent absence, or very thin sequence, of Silurian shale on Royal Creek, and the relatively thick Silurian carbonate sequence on Royal Mountain.

The megafossil zonation of the Middle and lowest Upper Devonian strata of the central Mackenzie Valley area was revised by Pedder (1975a). The revised zones and the rock units in which they occur are as follows in ascending sequence: the *adoceta* and *dysmorphostrota* Zones in the Hume Formation; the *castanea* Zone in the uppermost Hume and lowermost Hare Indian formations; the *laevis* Zone in the uppermost Hare Indian Formation and lowermost platform beds of the Ramparts Formation; the *aleskanus* and

hippocastanea Zones in the bedded platform beds of the Ramparts Formation; the *mackenziense* Zone in the upper reefal part of the Ramparts Formation; and the *billingsi* Zone in the unnamed allochthonous beds unconformably overlying the Ramparts Formation. Elements of three of these zones can be traced westward into the report area.

Pedder (1975b) described and illustrated coral faunas from three levels in the Lower Devonian, mainly from the three sections (RC-1, RC-2 and RC-3 of Lenz and Pedder, 1972) at the headwaters of Royal Creek; but also from a section of the Michelle Formation at 65°40'30"N, 136°57'00"W; and from an unnamed carbonate unit on the west flank of Royal Mountain at 65°03'N, 135°05'W. The three coral faunas are associated with conodont elements that suggest alignment with the *pesavis*, *kindlei*, and *dehiscens* Zones.

Uyeno and Mason (1975), in their paper on "New Lower and Middle Devonian conodonts from northern Canada", described forms from two localities within the report area as follows: a section of the Road River Formation on Road River on the east flank of the Richardson Mountains (66°35'N, 135°35'W); and a section of the Cranswick Formation in the Campbell Lake Uplift (68°10'N, 133°28'W).

MacKenzie, Pedder and Uyeno (1975) described a Middle Devonian sandstone unit developed in the Grandview Hills area, and illustrated some of its main faunal elements. The sandstone unit overlies shale of the Hare Indian Formation in the west and bedded limestone of the Ramparts Formation in the east, and is unconformably overlain by shale of the Canol Formation. Faunas from the sandstone unit were assigned to *Stingocephalus aleskanus* and *Leiorhynchus hippocastanea* Zones of Pedder (1975) that are typically developed in the Ramparts Formation south of Fort Good Hope.

Miall (1976), in a paper on the Devonian geology of Banks Island, which incorporated new information from the subsurface, showed the relationship of the Devonian rock units on that island to those on the mainland of northwestern Canada, including the Yukon Territory.

The report on the geological component of the Lower Mackenzie Energy Corridor Study by AGAT Consultants Ltd. and Geochem Laboratories (Canada) Ltd. (1977), includes information on the Peel Plain and Peel Plateau areas immediately east of the Richardson Mountains. The report is based on data from 141 wells, 34 of which were selected for detailed geo-chemical analysis. Also included in the report is new information on a coarse clastic rock unit of Late Devonian and Early Carboniferous age, which Pugh (1983) has named the Tuttle Formation.

Copeland (1977), in his paper on early Paleozoic Ostracoda from southwestern District of Mackenzie and Yukon Territory, included descriptions and illustrations of thirty-one species of ostracodes from two Siluro-Devonian sections (RC-I and RC-II of Lenz, 1968) located in the Royal Creek area. A relatively complete ostracode succession of late Ludlovian to Emsian ages was obtained from the two sections (Copeland, 1977, Fig. 4, p. 5).

Braun (1966, 1971, 1977, 1978), in a series of papers, has differentiated progressively the ostracode faunas and currently recognizes twenty-two or more ostracode assemblages in the Eifelian to Frasnian rock sequences of western Canada. These assemblages have proven to be exceedingly useful in regional correlations and in deciphering facies relationships. Some of these papers by Braun (notably 1966, 1977, 1978), refer to sections in the southeastern part of the present report area, as well as to nearby sections on Hume and Gayna rivers and on Bell and Powell creeks.

Pedder and Klapper (1977) studied the megafaunas and conodonts of the type section of the Cranswick Formation (Sec. 6, this report). They concluded that the Cranswick Formation could be correlated with the lower part of the Ogilvie Formation of the northern Yukon Territory; the lower part of the Blue Fiord Formation as developed at Sor Fiord in southwestern Ellesmere Island; the Stuart Bay Formation on Bathurst Island; the Disappointment Bay Formation on Lowther Island; the Fitzgerald Formation of northeastern Alberta; and the McColley Canyon Formation of Nevada.

Jackson, Lenz and Pedder (1978) have summarized the tectonic setting and paleogeography, and have illustrated the main graptolite, brachiopod and coral faunas of the Upper Silurian and Lower Devonian occurring in northwestern Canada. About half of the illustrated fossils are from localities in the northern Yukon Territory.

Chatterton (1979) proposed informal conodont faunal units for correlating strata of Emsian, Eifelian and Givetian ages over a wide area of northwestern Canada, based on collections from outcrop sections in southern District of Mackenzie, and subsurface sections in northeastern British Columbia and Saskatchewan. Recently, the informal faunal units have been aligned with formal conodont zones by Klapper (in Klapper and Johnson, 1980). Chatterton's (1979) study is particularly useful in providing more precise datings for many of the Devonian rock units in the southern Mackenzie Mountains, and in showing the relationship of these rock units to those in the Norman Wells area to the north.

Sedimentary structures of the Imperial Formation were summarized by Hills and Braman (1978), based on a study of sections at Imperial River, Powell Creek, Mountain River-Imperial Hills, Arctic Red River and Trail River. The last two sections are within the area covered by this report.

Perry and Lenz (1979), in their paper on Emsian paleogeography and shelly fauna biostratigraphy of Arctic Canada, included a discussion of some of the more important Lower Devonian sections in the northern Yukon Territory and adjacent areas. Their generalized lithofacies maps (Perry and Lenz, 1979, figs. 3, 4) for the early Pragian and "late" Emsian time intervals are important contributions. New information on the upper beds of the Road River Formation at the headwaters of Royal Creek is included.

D.K. Norris and Calverley (1978), in a description of three bedrock quarries in the Inuvik area, presented a geological sketch map and structure section of the Campbell Uplift (modified after Dyke, 1975). Included in this report are identifications of Devonian fossils by T.T. Uyeno and A.W. Norris from beds, here assigned to the Cranswick Formation, exposed in a limestone quarry near the Mackenzie Highway (Site 4).

Using conodonts, Uyeno (1979) dated parts of the well known Devonian sequence exposed at Powell Creek and located near the Mackenzie River, about 122 miles (196 km) east of Section 3 of this report. Conodont datings were provided for parts of the Gossage, Hume, Hare Indian, and Ramparts formations, allochthonous beds, and the Canol Formation.

Lane and Ormiston (1979) studied the conodonts and megafaunas of the Salmontrout Limestone at its type locality on the Porcupine River in east-central Alaska. They established the presence of all described Lower and lower Middle Devonian conodont zones up to the *kockelianus* Zone,

except the *inversus* Zone, and recognized eight megafossil zones and faunal units.

As a Ph.D. thesis project, Braman (1981) studied the miospores of the Imperial Formation, based on five sections at the following localities: Imperial River, Powell Creek, Mountain River, Arctic Red River, and Trail River. The last two of these sections are within the area of the present report. He recognized seven miospore biozones within the Imperial Formation. He noted abrupt changes between some miospore assemblages that suggest two unconformities; one within the Upper Frasnian, and the other between the Middle and Upper Famennian.

Morrow and Meijer-Drees (1981) investigated several sections of the Bear Rock Formation at and near the type section located near Fort Norman on the Mackenzie River. Included in their paper are discussions on problems of stratigraphic nomenclature, regional variations in the lithology, origin of the Bear Rock breccias, as well as a descriptive classification of breccia fabrics.

The most recent comprehensive and detailed work covering the Devonian stratigraphy in the subsurface of the report area is that by Pugh (1983). This work covers the "Pre-Mesozoic geology in the subsurface of the Peel River map area, Yukon Territory and District of Mackenzie". The area covered by the Peel River map area lies between 64°N and 68°N latitude and 128°W and 141°W longitude. Pugh's study is based on an examination of the radioactivity well logs and drill cuttings of 132 wells that were available up to 1976. The Devonian formational nomenclature of Bassett (1961) and Tassonyi (1969), used in the Norman Wells area, has been modified considerably by Pugh and the new nomenclature has been extended westward into the area of the present report, where it conflicts with the terminology used by Norris (1967, 1968a, b) and other workers.

Geological mapping at a scale of 1:250 000 of the area immediately east of the Operation Porcupine area was recently completed by Aitken, Cook and Yorath (1982). Rock units of Devonian age mapped in the Upper Ramparts River map area (NTS 106G) comprise the following: a Silurian or Devonian unnamed unit designated as SD; the Lower Devonian Arnica and Landry formations; the Middle Devonian Hume and Hare Indian formations; and the Upper Devonian Canol and Imperial formations. In the present report, the unnamed SD unit and Arnica Formation are assigned to the Unnamed carbonate unit, and the name Cranswick Formation is used in place of the Landry Formation.

Geological maps at a scale of 1:250 000 covering the area studied by members of Operation Porcupine were recently completed by D.K. Norris, the coordinator of this operation. These Geological Survey of Canada maps are as follows in numerical sequence: Herschel Island and Demarcation Point (1514A), Mackenzie Delta (1515A), Blow River-Davidson Mountains (1516A), Aklavik (1517A), Old Crow (1518A), Bell River (1519A), Fort McPherson (1520A), Arctic Red River (1521A), Porcupine River (1522A), Eagle River (1523A), Trail River (1524A), and Martin House (1525A) (Norris, D.K., 1981a-l); and Ogilvie River (1526A), Hart River (1527A); Wind River (1528A) and Snake River (1529A) (Norris, D.K., 1982a-d). For a detailed distribution of Devonian and associated rocks in the Operation Porcupine area, the reader is referred to the above indicated geological maps. The relationships between Devonian stratigraphic units and map units are discussed under the descriptions of the formations of this report.

STRATIGRAPHY

Main Devonian outcrop belts

Sedimentary rocks of the Devonian System are widespread and well exposed in the Operation Porcupine area (Fig. 1), especially in the folded mountain belts in the southern half of the area. The Lower and Middle Devonian Series are represented by both carbonate platform and basinal shale facies that outcrop mainly in the folded belts of the Mackenzie, Richardson and Ogilvie mountains. Smaller scattered outcrop areas of Lower and Middle Devonian rocks are present also in the Keele Range, Porcupine Plain, and in the cores of the White and Campbell uplifts. The Upper Devonian Series consists largely of recessive clastic rocks that outcrop in the plateau and lowland areas flanking the Mackenzie, Wernecke, Ogilvie, and Richardson mountains. These rocks also underlie a large, drift-covered area on the east and west sides of the Mackenzie River immediately south and east of the upper part of the delta.

Lower and Middle Devonian carbonate platform successions occur in the eastern (Mackenzie Platform) and western (Yukon Stable Block) parts of the area, separated by equivalent basinal marine shale deposits that occupy the north-northwest trending Richardson Trough, now marked approximately by the Richardson Anticlinorium (see Fig. 9). The carbonate successions on each side of the Richardson Trough are similar in gross features, but distinctively different in detail.

The Lower and Middle Devonian carbonate succession in the White Uplift appears to be closely related to that of the Yukon Stable Block to the southwest. The Lower and Middle Devonian carbonate sequence in the Campbell Uplift was probably a part of the Mackenzie Platform succession. A sequence showing a transition between a typical carbonate platform succession and a shale basin succession is present in the Snake River area near the junction of the Mackenzie Platform and the Richardson Trough, in the southeastern part of the report area. In the part of the Yukon Stable Block lying west of the Richardson Trough and east of the Dave Lord High, the Lower and Middle Devonian succession consists of a lower carbonate platform sequence succeeded by a basinal shale sequence. To the south, in the area marked approximately by the Blackstone Trough of Lenz (1972, Fig. 3, p. 328), the lower and upper parts of the Lower and Middle Devonian succession consist of basinal shale with a middle part of platform carbonate.

The uppermost Middle and Upper Devonian succession in the report area, beginning with the black shale of the Canol Formation and followed by clastic rocks of the Imperial and Tuttle formations, was deposited under an entirely different sedimentary regime. The relatively coarse flysch-like sediments of the Imperial and Tuttle formations appear to have been derived from the north or northwest. Uplift and orogenic activity in the northwestern part of the report area are indicated by the presence of igneous plutons of Devonian and older ages. These occur mainly in the Old Crow Range, but smaller intrusions are present at Ammerman Mountain, Mount Fitton and Mount Sedgwick (Norris, D.K., and Yorath, 1981, Table II, p. 47).

The Devonian succession outcropping in the Mackenzie Mountain front in the southeastern part of the report area consists of the following, in ascending sequence: Unnamed carbonate unit, Cranswick, Hume, Hare Indian, Canol and Imperial formations. It is this sequence that shows the closest relationship to the sequence in the Norman Wells area to the east. A sequence in the Snake River area, showing a transition between platform carbonates to the east and basinal shale to the west, consists of the following rock units in ascending order: Unnamed carbonate unit, Cranswick Formation, Tongue of Road River Formation, and Mount Baird, Canol and Imperial formations. The basinal shale and clastic sequence of the Richardson Trough, which is exposed within and on the flanks of the Richardson Anticlinorium, consists of the following in ascending sequence: Road River, Canol, Imperial and Tuttle formations. The Devonian sequence outcropping in the southwestern part of the area, marked approximately by the Blackstone Trough of Lenz (1972, Fig. 3, p. 328), consists of the following, in ascending order: Road River and Michelle formations, Ogilvie Formation with dolomite beds in the lower part, and an unnamed shale unit. The middle third of this sequence consists of platform carbonate, whereas the lower and upper thirds of the sequence consist of basinal shale. It is this sequence that shows the closest resemblance to that in the Nation River area of east-central Alaska. In the Yukon Stable Block lying west of the Richardson Trough, north of the Blackstone Trough, east of the Dave Lord High, and outcropping in the north-south trending part of the Ogilvie Mountains, the Devonian succession consists of the following in ascending order: Kutchin and Ogilvie formations and an unnamed shale unit. The parts of this sequence represented by the Kutchin and Ogilvie formations are similar to those in the White Uplift.

The lithology, distribution, thickness, and relationship of the Devonian sedimentary rock units in the report area are summarized in the Table of Devonian Formations (see page 8).

Kutchin Formation

The name Kutchin Formation is here introduced to apply to the succession of dolomite and dolomitic limestone underlying limestone of the Ogilvie Formation and overlying a variety of carbonate and other rocks of Ordovician and Silurian ages. It is named for the Kutchin Indians who have long occupied the central part of the Yukon Territory (Swanton, 1952, p. 575). The type section selected is at locality 30 in the southeastern part of the White Uplift. The more recently measured Section 47 (see Fig. 8 of this report) is located in the northeastern part of the White Uplift and provides supplementary information on this rock unit. The rocks exposed at Section 30 have been described by A.W. Norris (1968b, p. 232-235, Fig. 5, Sec. 30) and by Norford (1964, p. 10, 111-118, Fig. 3, Sec. 23). The part of the sequence selected as the type section of the Kutchin Formation comprises units 3 and 4, 1187 and 625 feet (361.8 and 190.5 m) thick, respectively, which were considered formerly to be a part of the Gossage Formation by Norris (1968b, p. 235-236). Rocks formerly assigned to the Gossage Formation by Tassonyi (1969) have been revised by Pugh (1983) who considers the name Gossage obsolete.

Rocks of the Kutchin Formation outcrop in western and northern Ogilvie Mountains (Taiga - Nahoni Fold Belt of D.K. Norris, this report), and in the White Uplift. In the subsurface these rocks underlie approximately the western half of the Eagle Plain (Eagle Fold Belt of D.K. Norris, this report). On the 1:500 000 geological map of the report area by D.K. Norris (in press) rocks of the Kutchin Formation have been included in a map unit designated as SDu.

The thickness of the Kutchin Formation at the type section (Loc. 30) in southeast White Uplift is 1812 feet (553 m) thick. At Section 47 located 4.2 miles (6.7 km) to the north, in northeast White Uplift, it is 2684 feet (818.1 m) thick. The only other section where the formation is completely exposed is at Mount Burgess (Loc. 24) in northern Ogilvie Mountains, where it is 352.2 feet (107.4 m) thick, and where it is lithologically atypical. At all other localities throughout the western and northern Ogilvie Mountains, only the upper part of the Kutchin Formation is exposed. In this area, the thickest, although incomplete, section of the formation is at Locality 28, where 1250.3 feet (381.1 m) of beds were measured. In the subsurface of the Eagle Plain, beds assigned to the Kutchin Formation in the Peel Plateau Eagle Plains Y.T. No 1 (N-49) well (66°48'54"N, 138°08'31"W) are 2032 feet (619.4 m) thick between 4770 and 6802 feet (1453.9 and 2073.3 m) depths.

The lithology of the Kutchin Formation in the outcrop area consists of evenly thin- to thick-bedded, light grey to black, fine grained to aphanitic dolomite, dolomitic limestone and limestone. The beds commonly weather a banded light to dark grey and generally are more resistant where they have not been altered to dolomite. Some of the beds are slightly argillaceous and silty, and an occasional dolomite bed exhibits brecciation. Some of the limestone beds in the upper part of the formation in the northern Ogilvie Mountains are finely pelletoidal.

An atypical lithological development of the Kutchin Formation occurs at Mount Burgess (Loc. 24). There, the formation consists of a basal unit of chert-pebble conglomerate in a matrix of reddish brown, silty shale; overlain by hematitic red, silty and sandy shale; and capped by recessive, thin bedded, dark grey, fine grained dolomite, weathering orange-brown.

The lower contact of the Kutchin Formation in the type area in the White Uplift (locs. 30 and 47) is with a unit of dark, fine grained, thin bedded limestone bearing some stromatoporoids, a few cup corals, and abundant *Atrypella* brachiopods of Late Silurian (Ludlow) age. This unit, in turn, is separated by an erosional unconformity, showing about 20 feet (6.1 m) of relief, at Locality 47, from underlying limestone beds named the Vunta Formation by Norford (1964). At Section 24 in the Mount Burgess area, conglomerate beds of the Kutchin Formation unconformably overlie dolomite beds of Middle Ordovician (Llandeilian or lowest Caradoc) age. This dating is based on trilobites recently described by Ludvigsen (1980) from a limestone unit 9.8 feet (3 m) thick, some 278.8 feet (85 m) below the unconformity. At all other localities throughout the western and northern Ogilvie Mountains, the lower contact of the Kutchin Formation with underlying rocks is not exposed.

The upper contact of the Kutchin Formation is with more resistant and generally thicker bedded limestone of the Ogilvie Formation. This contact is paraconformable and probably is isochronous from place to place, as indicated by fossils present over a wide area in lower Ogilvie beds.

Table of Devonian Formations

ERA–THEM	SYSTEM OR SERIES	FORMATION OR MEMBER	THICKNESS FEET (METRES)	LITHOLOGY AND DISTRIBUTION
PALEOZOIC	Unconformably overlain by Permian, Cretaceous or Recent deposits			
	LOWER CARBONIF–EROUS	*TUTTLE FORMATION*	2866 (873.6) to 4659 (1420)	Alternating succession of chert pebble conglomerate, very poorly sorted quartz and chert sandstone, siltstone, and dark greyish brown shale. Pebbles consist of white, buff, grey, yellow, orange and green chert. Kaolinite filling pore spaces and sericite along separation planes. Contains plant fragments and spores. Crops out on eastern and western flanks of Richardson Anticlinorium; probably present also on northern flank.
	UPPER DEVONIAN	Paraconformable on Trail River, but it is not known if hiatus is of local or regional extent		
		IMPERIAL FORMATION	1763 (537.4) to 5520 (1682.5)	Argillaceous and silty quartzose sandstone, sandy and silty shale, some sandy and ferruginous mudstone; some sandstone beds are cross-laminated and exhibit flow cast structures. Marine fossils in upper part of formation immediately east of Arctic Red River; plant fragments in scattered beds in remainder of area.
	MIDDLE DEVONIAN	*CANOL FORMATION*	360 (109.7) to 740 (225.6)	Dark grey to jet black, hard to soft, non-calcareous, in part siliceous shale and mudstone; weathered surfaces commonly coated with a bright yellow, orange and apple green patina; orange weathering, clay ironstone nodules present in scattered beds. Well developed in eastern part of area; becoming silty and more difficult to recognize in western part of area where it is included in upper part of Unnamed shale unit. Sparsely fossiliferous.
	Disconformity of variable magnitude at base of Canol Formation in eastern part of report area			
	MIDDLE DEVONIAN	*HARE INDIAN FORMATION*	500 (152.4) to 600 (182.9) 2 (0.6) in southeast part of report area	Upper member in type area consists of dark grey calcareous shale with generally less than 10 per cent of interbedded calcareous siltstone and argillaceous or silty limestone. Lower member in type area consists of dark brownish grey or black, bituminous, in part non-calcareous and calcareous shale (Bluefish Member or Spore-bearing member). Erosional remnant in southeast part of report area consists of dark grey, evenly and irregularly thin bedded, argillaceous and richly fossiliferous limestone.
		HUME FORMATION	398 (121.3) to 757 (230.7)	Dark, rubbly, thin to thick bedded, richly fossiliferous, argillaceous limestone with shale partings; and a black, non-calcareous shale, 60 feet (18.3 m) thick, in upper quarter of formation on Flyaway Creek. Traced from the east into southeastern part of report area. To the south, beds of Hume Formation pass into purer carbonates in the upper part of Cranswick Formation. To the west, beds of Hume Formation pass into shale in upper part of Mount Baird Formation.
		MOUNT BAIRD FORMATION	1950 (594.4) at type section	Dark greenish grey, calcareous shale weathering orange brown, with four thin sequences of rubbly, thin bedded argillaceous limestone, two occurring in lower fifth, and two in the upper quarter of the type section near Snake River. Where present as a tongue, near headwaters of Cranswick River, it consists of black calcareous shale weathering orange brown. A shelf slope deposit developed in southeastern part of report area.
	LOWER, MIDDLE AND UPPER DEVONIAN	*UNNAMED SHALE UNIT*	0 to 1241 (378.3)	A recessive, poorly exposed unit of black, non-calcareous shale in Blackstone-Hart rivers area of northeastern Ogilvie Mountains; bluish grey weathering siliceous shale interbedded with minor black shale in Nahoni Range; brownish grey and reddish shale in Ogilvie Mountains near Yukon-Alaska boundary and in Ogilvie-Hart rivers areas; silty and ferruginous shale and minor sandstone along northeastern flank of Ogilvie Mountains. Approximately the same distribution as underlying Ogilvie Formation in southwestern part of report area.
	LOWER AND MIDDLE DEVONIAN	*OGILVIE FORMATION*	285 (86.9) to 2640 (804.7)	Medium brown to grey, aphanitic to fine grained, thin bedded to massive, resistant, cliff-forming limestone, weathering light to medium grey; scattered beds of coarser grained encrenite, some of which are fetid; scattered intervals of dolomite in lower one-quarter to one-third of formation in the Blackstone-Hart rivers area, and in lower two-thirds of formation in southern Nahoni Range area. Developed on carbonate platform west of Richardson Trough.
	LOWER AND MIDDLE DEVONIAN	*CRANSWICK FORMATION*	443 (135) to 1822 (555.4)	Medium brownish grey to black, aphanitic to fine grained, thin bedded to massive limestone in lower half; and black, fine grained limestone and argillaceous limestone, interbedded with black calcareous shale in upper half of formation in type section immediately west of Snake River. Occurs on carbonate platform east of the Richardson Trough, and is approximately coeval to Ogilvie Formation west of the trough.
	LOWER DEVONIAN	*MICHELLE FORMATION*	184 (56) to 614 (187)	Moderately resistant, black, silty and argillaceous limestone and dolomite weathering orange brown; and dark, variably carbonaceous, calcareous and silty shale; some beds are richly fossiliferous. Formation extends from Hart River in east to Nahoni Range in the west in southwestern part of report area.
	LOWER AND MIDDLE DEVONIAN	*ROAD RIVER FORMATION AND TONGUE*	450 (137.2) to 3416 (1041.2)	A rough, four-fold, lithological subdivision is apparent in thicker sequences of Devonian part of formation. An upper unit of interbedded, dark siliceous shale and chert; underlain by a unit of interbedded encrinal limestone, argillaceous limestone and shale; a unit of dark grey to black shale with widely spaced interbeds of limestone and argillaceous limestone, in part showing graded bedding and brecciation; and a basal unit of graptolitic shale with widely spaced micritic limestone beds. Most completely developed in Richardson and Selwyn Troughs; and partly developed in Blackstone Trough.
	LOWER DEVONIAN AND UPPER SILURIAN	*UNNAMED CARBONATE UNIT*	407 (124.1) to 540 (164.6)	An upper recessive, dark grey weathering unit of medium bedded, dark brownish grey, aphanitic to fine grained dolomite, with silty and calcareous dolomite in lower half of unit. A lower orange-brown weathering unit of medium grey to light greenish grey, fine grained, granular, evenly bedded dolomite, with some beds of greenish grey shale, silty and argillaceous limestone, and some slightly calcareous dolomite. Formation occurs on carbonate platform east of the Richardson Trough, and corresponds to Kutchin Formation west of the trough.
	Disconformably overlies rocks of Silurian age			
	LOWER DEVONIAN	*KUTCHIN FORMATION*	352.2 (107.4) to 2684 (818.1)	Evenly thin to thick bedded, light grey to black, fine grained to aphanitic dolomite, dolomitic limestone and limestone, weathering a banded light to dark grey. Some of the beds are slightly argillaceous and silty, and an occasional bed is brecciated. An atypical development occurs in Mount Burgess area, consisting of an upper unit of recessive, thin bedded, dark grey, fine grained dolomite; a middle unit of hematitic red, silty and sandy shale; and a basal unit of chert pebble conglomerate in a matrix of reddish brown silty shale. Formation occurs on carbonate platforms west and north of the Richardson Trough. It is locally missing north of Mount Burgess.
	Disconformably overlies Middle Ordovician rocks in Mount Burgess area, and Silurian rocks in White Uplift. Base of formation is not exposed in other areas.			GSC

The dolomite, dolomitic limestone and limestone of the Kutchin Formation were deposited under environmentally restricted shallow shelf conditions. The presence within the carbonates of relatively even, rhythmic colour banding; finely laminated algal(?) structures; rare, thin, brecciated layers; and the apparent absence of most invertebrate fossils except for ostracodes, points to a very shallow water, intertidal or supratidal environment.

The conglomerate grading upwards into shale and dolomite and resting on Middle Ordovician dolomite at Mount Burgess (Sec. 24) is located on the southeast flank of the Dave Lord High. The hiatus at the base of the Kutchin Formation at this locality suggests that the Dave Lord High was a positive feature from Late Ordovician to early Emsian (late Early Devonian) time.

The principal fossil found in the approximate upper third of the Kutchin Formation in the northern Ogilvie Mountains is the giant ostracode, *Moelleritia canadensis* Copeland (1962). On the basis of stratigraphic position with adjacent, dated beds, this form is assumed to have a range approximately equivalent to the Zlichovian and Dalejan of the Early Devonian (see Fig. 3). A fauna not yet studied, and consisting of stromatoporoids, colonial and rugose corals, and brachiopods was recovered from near the base of the section at Locality 25 (base of formation is not exposed).

At the type section (Loc. 30) of the Kutchin Formation, A.E.H. Pedder (GSC Internal Report No. DKN-93-AEHP-79) has identified the following forms from the GSC sample locality 53211, collected about 60 feet (18.3 m) below the top of the formation:

stromatoporoids, not studied
Amphipora sp. indet.
Alveolites sp. undet. (digitate form)
Trypanopora sp. undet. (probably new)
Spongonaria sp. nov.
Planetophyllum sp nov.

Spongonaria sp. nov. and *Planetophyllum* sp. nov. in this sample are considered similar to those of GSC C-63102, which are from a horizon low in the type section (Loc. 4) of the Cranswick Formation (Pedder and Klapper, 1977, p. 227). Sample C-63102 is from 11.2 to 11.8 feet (3.4 to 3.6 m) below an occurrence of *Polygnathus inversus* indicative of the *inversus* Zone. The *Spongonaria* at the latter locality is considered identical to a form from the lower part of the Blue Fiord Formation at Sor Fiord, Ellesmere Island, which is aligned with the Lower Devonian *Polygnathus gronbergi* Zone (Pedder and Klapper, 1977, p. 231-233). The two measured sections of the Kutchin Formation in the White Uplift (secs. 30 and 47) are otherwise completely barren of megafossils. At both of these sections, the Kutchin Formation is underlain by an unnamed limestone rock unit containing a rich fauna of *Atrypella* and other fossils of Late Silurian age.

In conclusion, the Kutchin Formation is a restricted marine, shallow water, carbonate unit that is developed on the platform on the north and west sides of the Richardson Trough. It is somewhat similar in lithology and stratigraphic position to the Unnamed carbonate unit underlying the Cranswick Formation and disconformably overlying Silurian carbonate on the platform east of Richardson Trough. Because of the paucity of fossils in the restricted marine carbonates, the difficulty of correlating across the shale trough, and the inappropriate terminology applied by Pugh (1983) to subdivisions of his Bear Rock sequence, it is considered advisable at this time to use a distinctive name (Kutchin Formation) for the approximately equivalent carbonate unit on the west and north sides of the trough.

Unnamed carbonate unit

The Bear Mountain Formation of Kindle and Bosworth (1921) is now known to apply to strata underlying the limestone of the Hume Formation of Bassett (1961) and overlying beds of the Ronning Group of Hume and Link (1945) that outcrop on Bear Rock near Fort Norman. The name Bear Mountain Formation was changed by Hume and Link (1945, p. 16) to Bear Rock Formation following usage of the Canol geologists. The latter name was applied to "the brecciated and non-bedded dolomites and limestones lying below Middle Devonian strata and above a sharp disconformity with well-bedded Silurian limestones below it". Bassett (1961, p. 483) applied the name Bear Rock Formation to the strata underlying the Hume Formation (which he named) and overlying strata of Silurian or Ordovician age. Tassonyi (1969, p. 42) restricted the name Bear Rock Formation to strata covered by the original definition. The name as used by Tassonyi (1969) applied to brecciated dolomite with small amounts of associated evaporites, and any evaporitic sequence that underlies this dolomite in lithological continuity, occupying the position between the Hume and Ronning formations. He selected the Imperial Vermilion Ridge No. 1 well (65°07'51"N, 126°05'00"W) located near the type outcrop section as the subsurface reference section. In the Norman Wells area, Tassonyi (1969, p. 42) subdivided the Bear Rock Formation into two informal members. The lower, Evaporitic member, is characterized by anhydrite and, in places, gypsum, interbedded with dolomite. The upper, Brecciated member, consists chiefly of bedded or massive brown, crystalline, brecciated dolomite with some evaporite. The name Gossage Formation was introduced by Tassonyi (1969, p. 48) to apply to the limestone and dolomite overlying the Ronning Formation and underlying limestone of the Hume Formation. He subdivided the Gossage Formation into three informal members: a thin, Lower limestone member consisting predominantly of limestone; a thick, Middle dolomite member consisting predominantly of brown dolomite; and a thick, Upper limestone member consisting commonly of pelletoid limestone. He selected the interval between 1871 and 3460 feet (570.3 and 1054.6 m) in the Richfield Oil Corp. et al. Grandview Hills No. 1 well (67°06'12"N, 120°52'30"W) as the type section of the Gossage Formation, which he considered to be partly or entirely time-equivalent to the Bear Rock Formation.

Pugh (1983) completely revised the terminology applied to the various parts of the Bear Rock sequence. He subdivided the Bear Rock into five rock units designated as: Basal Tongue, Fort Norman, Tatsieta, Arnica and Landry formations. The thin sequence of limestone and green shale at the base of the Bear Rock was named the Tatsieta Formation by Pugh (1983) and is equivalent to Tassonyi's (1969, p. 49), Lower limestone member of the Gossage Formation. The type section for this unit selected by Pugh is between depths of 3262 and 3462 feet (944.3 and 1055.2 m) in the R.O.C. Grandview Hills No. 1 (A-37) well (67°06'12"N, 130°52'30"W). Pugh (1983) used the names Arnica and Landry formations to apply to Tassonyi's (1969) Middle dolomite and Upper pellet limestone members, respectively, of the Gossage Formation. Pugh's rationale for doing this is because of the use of the names Arnica and Landry formations as map units by Aitken et al. (1982) at the adjoining Mackenzie Mountain front.

The writer, as a participating member of Operation Mackenzie in 1957, is familiar with both of these rocks units. The name Arnica Formation was introduced by Douglas and D.K. Norris (1961, p. 14) for a thick sequence of banded dark grey dolomite that, in most places, overlies the Sombre

Formation. The type section, measured by the writer, is in the First Canyon of the South Nahanni River where it was designated as "map-unit 16" by Douglas and D.K. Norris (1960). The term Landry Formation was introduced by Douglas and D.K. Norris (1961, p. 18) to apply to the grey weathering, massive to thick bedded limestone that overlies the dolomite of the Arnica Formation in northwestern Root River map area, and overlies or grades laterally into the recessive limestone of the Funeral Formation in the more southerly parts of the area. Considering the pronounced variability recorded by Douglas and D.K. Norris (1961, p. 14-15, 18-19) for both the Arnica and Landry formations, and the great distances separating their type areas from the Norman Wells area, the application of these names to rock units within the Bear Rock is undesirable. Both the Arnica and Landry formations are useful terms for reconnaissance mapping but both will undoubtedly be modified and subdivided in the future to accommodate the facies changes that are known to occur within them. Both the Arnica and Landry formations are coeval only in the broadest sense to parts of the Bear Rock sequence. For the above reason, the formational nomenclature used by Pugh (1983) for the Bear Rock assemblage of units has not been adopted in this report. The name Fort Norman Formation is being introduced by Meijer Drees (in prep.) to apply to the lower anhydrite unit of the Bear Rock sequence as used by Pugh (1983).

In this report, the informal name Unnamed carbonate unit is applied to the restricted marine carbonate that underlies the Cranswick Formation and unconformably overlies carbonate of Silurian age. This definition, as indicated above, excludes the Landry Formation. The limestone of Pugh's (1983) Landry Formation is equivalent to the Cranswick Formation of A.W. Norris (1968a, b).

Carbonate rocks of the Unnamed carbonate unit can be traced westward along the front of the Mackenzie Mountains to the Snake River area beyond which they pass laterally into shale of the Road River Formation. They appear to be present in the subsurface throughout the Peel Plain where they form part of the carbonate platform.

The thickness of the Unnamed carbonate unit at Section 4, located near the headwaters of Cranswick River, is approximately 540 feet (164.6 m). To the west at Section 6, immediately west of Snake River, the thickness is about 407 feet (124.1 m), and to the east at Section 30, immediately west of Arctic Red River, it is about 646 feet (197 m) thick. An incomplete sequence of siliceous dolomite about 725 feet (221 m) thick, measured at Section 5 in the Canyon Ranges of the Mackenzie Mountains, is here excluded from the Unnamed carbonate unit.

The thickness of the Gossage Formation of Tassonyi (1969) (=Bear Rock Group of Pugh, 1983) in the type R.O.C. Grandview Hills No. 1 (A-37g) well (67°06'12"N, 130°52'30"W) is 1588 feet (484 m). According to Pugh (1983), thicknesses of the subdivisions of the Bear Rock Group in this well are as follows, in ascending order: Tatsieta Formation (=Lower limestone member of Tassonyi, 1969) - 200 feet (61 m); Arnica Formation (=Middle dolomite member of Tassonyi, 1969) - 586 feet (178.6 m); and Landry Formation (=Upper pellet limestone member of Tassonyi, 1969 = Cranswick Formation of Norris, 1968b) - 802 feet (244.5 m).

At Section 2a, immediately west of the Arctic Red River, the Unnamed carbonate unit comprises the following conspicuous rock units, in ascending order: 1. recessive, orange weathering, silty and argillaceous, platy dolomite, containing a few high-spired gastropods (22.5 m; 73 ft thick); 2. cliff-forming, grey weathering, thick bedded to massive, micritic limestone (45.5 m; 149.3 ft thick); and 3. colour banded light to dark grey and, in places, orange weathering, thin- to medium-bedded, moderately recessive, finely crystalline dolomite, with scattered beds of intraformational dolomite breccia in the lower quarter of the unit (129 m; 423 ft thick).

At sections 4 and 6, beds assigned to the Unnamed carbonate unit may be subdivided into a lower, thin- to medium-bedded orange-brown weathering dolomite unit; and an upper, dark grey weathering recessive dolomite unit. The lower unit at Section 4 is about 190 feet (57.9 m) thick and contains medium grey to light greenish grey, fine grained, granular, evenly bedded dolomite, with some beds of greenish grey shale; medium brownish grey and greenish grey, silty and argillaceous limestone; and some slightly calcareous dolomite toward the top. The upper unit at Section 4 is about 345 feet (105.2 m) thick and consists of medium bedded, dark brownish grey, aphanitic to fine grained dolomite, some beds with silty laminae; and some calcareous dolomite in the lower half of the unit. At Section 6 to the west, the lower, orange-brown weathering dolomite unit is 190 feet (57.9 m) thick; and the upper, dark grey weathering dolomite unit is about 217 feet (66.1 m) thick.

Tassonyi (1969, p. 50) indicated that the contact between his Lower limestone member of the Gossage Formation and the underlying Ronning Formation is marked in the subsurface by a sharp break on all mechanical logs. At sections 4 and 6, the orange-brown weathering dolomite unit of the Unnamed carbonate unit unconformably overlies light- to medium-grey weathering dolomite of presumed Silurian age. The unconformity separating the Devonian from underlying rocks is of wide regional extent and is apparent both in the subsurface and in outcrops.

In the subsurface of the Peel Plain area, rocks of the Gossage Formation are overlain by marly, silty, in part sparsely bioclastic limestone and shale of the Hume Formation. Commonly, the base of the Hume Formation is marked by a thin, dark, bituminous shale, which corresponds to a prominent increase in gamma values on the mechanical log (Tassonyi, 1969, p. 54). It is apparent, however, that where there is an alternation of limestone and dolomite, different workers have selected slightly different levels to mark the contact between the Gossage Formation of Tassonyi (1969) and overlying Hume Formation. An example of this is illustrated by Uyeno (1979, p. 237, Fig. 2). In the Powell Creek - Norman Wells area, the upper contact of the Gossage Formation appears to be transitional and diachronous. Faunal evidence suggests that it is older in the west and younger in the east.

In the report area at sections 4 and 6, the contact between the Unnamed carbonate unit and the overlying Cranswick Formation is drawn between dolomite and limestone. This contact appears to correspond to that of Tassonyi (1969) between his Middle dolomite member and his Upper pellet limestone member, or between Pugh's (1983) Arnica and Landry formations.

The carbonate and evaporitic rocks of the Unnamed carbonate unit were deposited on a broad, platform-like shelf. Within this platform three main factors influenced sedimentation, according to Tassonyi (1969, p. 59):

1. The onlap of the Unnamed carbonate unit on the erosion surface of the truncated Ronning Group.

2. Differential downwarp or tilting which took place along an axis roughly parallel to the present edge of the Canadian Shield.

3. The development of a trough-like depression or inner shelf where evaporite deposition took place between the broad, shallow, outer shelf and the Canadian Shield.

Within the outer, western part of the shelf, circulation was open or only slightly restricted. Rock types developed in this part of the shelf comprise (Tassonyi, 1969, p. 59): a thin, Lower limestone member; a thick Middle dolomite member; and a thick Upper pellet limestone member. The Lower limestone member shows aphanitic textures, fine silty beds, a clastic, sorted limestone bed, an erosion breccia, and a lack of typical detrital features, suggesting slow transgression and probably low relief on the bevelled erosion surface of the Ronning carbonates (Tassonyi, 1969, p. 59). The alternate light and dark banding seen in the Middle dolomite member is attributed to intermittent and rhythmic subsidence with resulting cyclic change in sedimentation. Tassonyi (1969, p. 60) noted an increase in limestone beds, crinoidal material, ostracodes and brachiopods in this member toward the west before it passes into the shaly, basinal facies of the Road River Formation in the Richardson Trough. The relatively uniform lithology of the Upper pellet limestone member, consisting of aphanitic lime muds, pellet and pellet-lump and algal-lump textures, suggests uniform conditions and continuous subsidence. In the report area, this upper member contains more clastic limestone fragments as well as more shelly benthonic fossils than it does to the east in the subsurface, which suggests a more open marine circulation and a higher energy environment. This latter unit is referred to as the Cranswick Formation.

Exceedingly few fossils have been recovered from the restricted marine carbonate and evaporitic rocks of the Unnamed carbonate unit.

Uyeno and Mason (1975) and Uyeno (1978) have described the conodont *Pandorinellina* n. sp. A from the Gossage Formation at Powell Creek (65°16'30"N, 128°46'00"W). At this section, the Bear Rock Formation is 476 feet (145.1 m) thick and the overlying Gossage Formation is 126 feet (38.4 m) thick with *Pandorinellina* n. sp. A occurring more or less throughout the latter formation (Uyeno and Mason, 1975, p. 716-717; Uyeno, 1978, p. 237, Fig. 2). Chatterton (1978, p. 168) has indicated that the range of *Pandorinellina* n. sp. A is from the conodont *serotinus* to *costatus costatus* Zones indicating a late Emsian (late Early Devonian) to early Eifelian (early Middle Devonian) age. The giant ostracode, *Moelleritia canadensis* Copeland, is the only megafossil found in beds of the Gossage Formation associated with *Pandorinellina* n. sp. A in the Powell Creek area.

From numerous samples of brecciated limestone of the Bear Rock Formation processed by Chatterton (1979, p. 175), conodonts were recovered from only two samples. From his Locality S-2 (64°52'N, 124°36'W), where the Bear Rock Formation is 540 feet (165 m) thick, he recovered *Pandorinellina* aff. *P.* n. sp. A Uyeno and Mason (1975) from 200 feet (61 m) below the top of the formation. From his Locality 8 (64°02'N, 123°29-32'W), where the Bear Rock Formation is 1421 feet (433 m) thick, he recovered *Polygnathus parawebbi* forma ∝ nov. and *Pelekysgnathus pedderi*? Uyeno and Mason from 263 feet (80 m) below the top of the formation. These latter forms are aligned by Klapper (in Klapper and Johnson, 1980, p. 422, Table 8) with the conodont *australis* Zone of Eifelian (early Middle Devonian) age. Chatterton's (1979) localities S-2 and S-8 are east of the Mackenzie River and the datings obtained suggest that the top of the Bear Rock Formation in this eastern area is younger than it is to the west.

At Section 4, near the headwaters of Cranswick River, *Moelleritia canadensis* and closely related ostracodes were recorded by Norris (1967, p. 35-36) from the upper 20 feet (6.1 m) of the Unnamed carbonate unit and from the lower 169 feet (51.5 m) of the overlying Cranswick Formation.

Fish remains mentioned by Norris (1968b, p. 22) and later described by Dineley (1965) are from a buff- to orange-weathering unit of the Unnamed carbonate unit at a section (65°22'N, 133°30'W; near Section 6) immediately west of Snake River. Dineley (1965, p. 93) identified the ostracoderm remains as *Corvaspis kingi* Woodward, and suggested a Late Silurian age for the host beds. The remains of three other ostracoderm groups associated with *Corvaspis* were examined by Denison (1964, p. 400, 451) who suggested that they may indicate a Gedinnian (Downtonian) age. The fish-bearing band at this locality occurs 70 feet (21.3 m) above the top of the "Ronning" Dolomite, and 40-50 feet (12.2-15.2 m) above limestone containing *Trimerella*, *Protathyris* cf. *didyma* (Dalman), *Conchidium*, and corals, dated by A.C. Lenz as Late Silurian.

Another collection of ostracoderms from the same orange weathering dolomite unit of the Unnamed carbonate unit was described by Broad and Lenz (1972) from a locality at 65°24'N, 133°25'W, which is 3.75 miles (6 km) north of the Dineley (1965) location. The ostracoderms are scattered throughout a grey, orange weathering, micritic dolomite or dolomitic limestone unit about 200 feet (61 m) thick. This unit is underlain gradationally and apparently conformably by a platy, grey, brown-grey weathering limestone about 50 feet (15.2 m) thick containing a shelly fauna. This unit is in turn disconformably underlain by dark, massive dolomite of the "Ronning" Formation (Broad and Lenz, 1972, p. 415). Fossils from the limestone unit include *Protathyris* cf. *didyma* (Dalman), and *Howellella* aff. *laeviplicatus* Kozlowski, which are dated as Late Silurian (Pridolian). The ostracoderms from the orange band are described as *Vernonaspis major* Denison and *V. epitegosa* Broad and Lenz, which are dated as Late Silurian or possibly Early Devonian in age.

In conclusion, in the western, outer edge of the platform, the Upper pellet limestone member of Tassonyi's (1969) Gossage Formation changes from a restricted to a more open marine carbonate to which the name Cranswick Formation has been applied by Norris (1968a, b). In the report area, the informal name Unnamed carbonate unit is restricted to the dolomites underlying the Cranswick Formation and unconformably overlying Silurian carbonate. Defined in this way, the top of the Unnamed carbonate unit is older in the report area than the top of the Bear Rock Formation in the type area to the east. Fossil evidence from the upper Bear Rock Formation and lower Hume Formation in the type areas of these rock units suggests that the contact separating them is a facies boundary that is older in the west and younger in the east.

The Unnamed carbonate unit of the report area is comparable faunally, lithologically and in stratigraphic position to the Kutchin Formation. The Kutchin Formation underlies the Ogilvie Formation and overlies Ordovician and Silurian carbonate rocks on the platforms flanking the west and north sides of the basinal facies of the Road River Formation in the Richardson Trough. The Unnamed carbonate unit is comparable also to the Tatsieta and Arnica formations of Pugh (1983) in the subsurface to the east.

Road River Formation and Tongue

The name Road River Formation was introduced and applied by Jackson and Lenz (1962, p. 32) to the dark-coloured graptolite-bearing shale, argillaceous limestone, and minor chert, dolomite, siltstone and sandstone of Ordovician-Silurian age that outcrop around the east and west flanks of the Richardson Uplift and in the Hart, Blackstone and Ogilvie River areas of the Ogilvie Mountains. The type section is on Tetlit Creek, a major tributary of Road River (Norford, 1964, p. 3). Within the shale basin of the Richardson Trough the Road River Formation is in excess of 10 000 feet (3048 m) thick and ranges in age from Cambrian to Middle Devonian. Norris (1968b, p. 23) introduced the name Prongs Creek Formation for that part of the Devonian shale sequence lying above the highest graptolites and below the Canol or Imperial formations. When applied in this sense, the Prongs Creek Formation is analogous, both lithologically and faunally, to the McCann Hill Chert of Churkin and Brabb (1965, p. 180), which outcrops in east-central Alaska near the Alaska-Yukon international boundary. There, the McCann Hill Chert is underlain by the Road River Formation and overlain by the Nation River Formation. Although the name Prongs Creek Formation is considered useful by the writer, the name Road River Formation is currently preferred by some workers. The main reasons for dropping the name Prongs Creek are the lack of a distinctive and consistent parastratigraphic marker for the base of the rock unit above the highest occurrence of graptolites, and the implication in the Stratigraphic Code that biological criteria should not be used in the definition of a rock unit.

The Devonian part of the Road River Formation occurs in a narrow linear belt flanking the eastern, northern, and western sides of the Richardson Anticlinorium. The thickest development of these beds in the report area occurs within the southern continuation of the Richardson Trough. Exposures occur in Knorr Range (Sec. 7), along Royal Creek (secs. 8 and 38), lower Prongs Creek (Sec. 10), upper Prongs Creek (Sec. 11), and west of Clear Creek (Sec. 12), all within the northern Wernecke Mountains. To the west, the Devonian part of the Road River Formation is exposed in the central part of the Ogilvie Mountains (secs. 40 and 43), which is within the northern part of the shale basin of the Cordilleran Trough of Lenz (1972, Fig. 2, p. 328). Rocks of the Road River Formation form the lower part of the Devonian succession in the Ogilvie - Hart rivers area of the Ogilvie Mountains, where they are overlain by the Michelle Formation.

Because of the difficulty in drawing a precise boundary between the Silurian and Devonian parts of the Road River Formation at most sections, thickness measurements are made from the base of the formation, so that rocks of Silurian age are included in the measurement. In the southern part of the report area this measurement is from the top of a prominent Ordovician and/or Silurian carbonate rock unit. The depocentre for the Devonian part of the Road River Formation is probably at or near Royal Creek (Sec. 8), where a maximum thickness of 3416 feet (1041.2 m) was measured. From there, eastward, it thins to 2715 feet (827.5 m) at Section 7 in Knorr Range and pinches out as a tongue between the Cranswick and Mount Baird formations at Section 6, immediately west of Snake River, where it is 386 feet (117.7 m) thick. Westward, the Road River Formation thins to 1381 feet (420.9 m) at Section 12 near Clear Creek. To the north, at Section 13 on the Porcupine River, the Road River is only about 450 feet (137.2 m) thick. South of the report area at Royal Creek, Lenz (1977a, p. 40, Fig. 2) recorded a thickness of approximately 1770 feet (839.5 m) for the Road River Formation. The lower 450 feet (137.2 m) were assigned to the Upper Silurian (Pridolian), and the upper 1320 feet (402.3 m) were assigned to Lower Devonian (Lochkovian, Pragian and Zlichovian). On the east flank of the Richardson Mountains, at Section 35 on Trail River, the Road River Formation is 1746 feet (532.2 m) thick (Norris, 1968b, p. 239).

Within the thicker sections of the Devonian part of the Road River Formation a rough four-fold lithological subdivision is apparent. A lower unit consists of graptolitic shale with widely spaced micritic limestone beds. This is succeeded by a unit of dark grey to black shale with widely spaced thin interbeds of limestone and argillaceous limestone, some of which show brecciation and graded bedding. The overlying third unit consists of interbedded fossiliferous encrinal limestone and argillaceous limestone, with minor shale and chert. The uppermost, fourth unit, consists of interbedded dark siliceous shale and chert that is commonly barren of fossils except for minor scattered plant tissue. The upper three units of this succession were formerly placed in the Prongs Creek Formation by Norris (1968a, b).

On the eastern flank of the Richardson Trough, the Road River Formation pinches out above the Cranswick Formation and below the Mount Baird Formation. There, the lithology of the tongue consists of black calcareous shale and black, 'sooty', carbonaceous shale.

About twenty distinctive carbonate masses, described by Macqueen (1974, p. 325-326) as banks or biostromes, occur along a strike length of about 3 miles (4.8 km) in the upper third of a 2000-foot (610 m) sequence of the Road River Formation on the east flank of Knorr Range (sections MQ-1-9 of Macqueen, 1974, Fig. 1) located 4.2 miles (6.8 km) north-northwest of Section 7 of this report. The larger masses are as much as 75 feet (23 m) thick and between 200 and 300 feet (60 and 90 m) in strike length. They appear to be concordant and confined to one stratigraphic level within the surrounding shale of the Road River Formation. In detail, these masses consist of very pure, pelletoid grain packstones or wackestones with some sparry calcite matrix. They are fine- to coarse-grained with rare oolites or compound grains. Fossils noted by Macqueen (1974, p. 325) comprise (?)calcareous algae, colonial corals, bryozoans, echinoderm ossicles and ostracodes. These same carbonate masses were referred to by Lenz (1972, p. 328) as small reef developments occurring on the east flank of the Bonnet Plume High during Early Devonian time. Their stratigraphic position would suggest that these masses occur within units 2 or 3 of the Devonian part of the Road River Formation.

To the west, in Section S-12 (65°58'N, 134°50'W) at the mouth of lower Peel River Canyon, Perry et al. (1974, p. 1058, Fig. 2) indicated that the upper part of the Road River Formation, consisting of calcareous shale, contains large exotic blocks of limestone 50 to 100 feet (15 to 30 m) in diameter. At the same section, the capping rock of the Road River Formation is a limestone breccia containing abraded stromatoporoids, corals, and cobbles of two-hole crinoid encrinite. Perry et al. (1974, p. 1058) indicated also that a similar two-hole crinoid-bearing breccia occurs at the top of the Road River Formation on Solo Creek (65°51'25"N, 134°15'30"W). Perry et al. (*ibid.*) interpreted the detrital limestone blocks in the breccias as derived from the Ogilvie Formation to the west and transported by slumping down the paleoslope into the adjacent Road River shale basin.

The lower boundary of the Devonian part of the Road River Formation in the report area is not marked lithologically, hence its placement within the sequence is based on fossils. Recently, the Silurian/Devonian boundary was fixed

by international agreement on a stratotype at Klonk near Suchomasty, Bohemia, Czechoslovakia. The horizon chosen is immediately below the first occurrence of *Monograptus uniformis*, within bed 20 at Klonk (Chlupác, 1972, p. 111, 113; McLaren, 1972), which is close to the base of the conodont *Icriodus woschmidti woschmidti* or the equivalent *I. w. hesperius* Zone. This horizon in Czechoslovakia marks the boundary between the Budnanian and Lochkovian stages. The lower Lochkovian in the Road River Formation of the Yukon Territory is commonly marked by the presence of the conodont *I. woschmidti*, and the presence of the brachiopods *Gypidula pelagica*, *Ancillotoechia infelix* and *Spirigerina marginaliformis* (Lenz, 1977a, p. 42).

The upper boundary of the Road River Formation in the Ogilvie - Hart rivers area is at the contact with the overlying Michelle Formation.

To the west, in the Nation River area of east-central Alaska, the Road River Formation is overlain by the Limestone and shale member of the McCann Hill Chert (Churkin and Brabb, 1968). In the Salmontrout River area of east-central Alaska, the Road River Formation is overlain by limestone of the Salmontrout Formation, the base of which contains conodonts as old as the *hesperius* Zone and as young as the *sulcatus* Zone (Lane and Ormiston, 1979).

On the lower Porcupine River (Sec. 13) in the northwestern part of the report area where the Road River Formation is represented by a condensed sequence, it is unconformably overlain by conglomeratic beds containing megafossils of Pennsylvanian-Permian age in the clastic material, but may be as young as Early Cretaceous according to D.K. Norris (pers. comm.).

On the eastern, northern and western flanks of the Richardson Uplift and in the Hungry River - Knorr Range area to the south, the Road River Formation is overlain by beds of the Canol Formation. A hiatus between the top of the Road River Formation and the base of the Canol Formation is suggested at Section S-12 (65°58'N, 134°50'W) on Solo Creek where the top of the Road River contains a conodont fauna indicative of the Lower Devonian, *inversus* Zone (Klapper in Perry and others, 1974, p. 1094). This is based on the assumption that the base of the Canol Formation at Solo Creek is the same age as it is at Powell Creek, where it is assigned by Uyeno (1979) to the upper Middle Devonian, Lowermost *asymmetricus* Zone. The Road River Formation at a section on Peel River (65°54'N, 135°56'W) containing the Pragian, Lower Devonian graptolite, *Monograptus yukonensis* near its top, is overlain by the Canol Formation containing Upper Devonian conodonts, including *Palmatolepis* sp. (Bassett and Stout, 1968, p. 744). The same relationship, showing the hiatus between the top of the Road River Formation and base of the Canol Formation, has been recorded also by Lenz (1972, p. 347) at sections on upper Rock River (66°45'N, 136°05'W), lower Canyon on Peel River (65°57-58'N, 134°50-55'W), and upper Canyon on Peel River (65°53'N, 135°40-45'W).

The predominantly argillaceous rocks of the Road River Formation within the report area were deposited in the Richardson, Blackstone and Selwyn troughs under relatively deep water basinal conditions. In the more complete successions across the southern part of the Richardson Trough, where a four-fold lithological subdivision is apparent, it is the lower graptolite shale and the upper siliceous shale and chert units that reflect deeper water conditions. A marked shallowing of the troughs is reflected in the rocks of the middle two units which contain, in places, considerable interbedded clastic and argillaceous limestone with shelly, benthonic fossils. These two units appear to have been deposited during the interval when carbonates of the Michelle and Ogilvie formations were being deposited on the adjacent platforms. The upper, dark, siliceous shale and chert unit of the Road River Formation is analogous to and approximately coeval with the Chert and shale member of the McCann Hill Chert of east-central Alaska.

The rich brachiopod fauna of the Devonian part of the Road River Formation in the vicinity of the headwaters of Royal Creek has been studied by Lenz (1966, 1967, 1968a, b, 1969, 1971, 1977a, b, c), and Lenz and Pedder (1972). The Lower Devonian graptolites of the Road River Formation from widely scattered localities in the Yukon Territory and District of Mackenzie have been studied by Jackson and Lenz (1963, 1969, 1972) and Lenz and Jackson (1964, 1971). Studies on the conodonts of the Road River Formation include those by Klapper (1969) and Klapper and others (1971) from sections in the Royal Creek area; by Fåhraeus (1971) on sections in the Solo Creek and in the Hart - Blackstone rivers area; by Uyeno and Mason (1975) from a section on Road River; and by Klapper (in Perry and others, 1974) from a section on Peel River.

The sections of the Road River Formation near the headwaters of Royal Creek contain a far more abundant and diverse shelly, benthonic fauna than any so far discovered in the report area. The presence of more limestone in the sections, and their location near the southern end and east side of a narrow trough connecting with the Richardson Trough to the north and the Selwyn Trough to the south (Lenz, 1977a, Fig. 1, p. 39), undoubtedly has a bearing on this abundance.

At the headwaters of Royal Creek, Late Silurian (Pridolian) fossils, designated the *Cryptatrypa triangularis* fauna by Lenz (in Jackson and others, 1978), occur in the lower part of the sections. Brachiopods in this fauna include (Lenz, 1977a, p. 41): *Dicaelosia*, *Aegiria*, *Conchidium*, *Ferganella*, *Gracianella* spp., *Atrypella*, *Cryptatrypa triangularis* Johnson, Boucot and Murphy, *Coelospira*, *Aesopomum* cf. *prongsi* Lenz, *Anatrophia*, *Ancillotoechia*, *Salopina*, *Stegerhynchus angaciensis* Chernyshev, *Metaplasia lenzi* Johnson, Boucot and Murphy, and *Rhynchotreta*. Conodonts associated with the brachiopods include *Ozarkodina excavata excavata* and *O. remscheidensis remscheidensis*. The former subspecies indicates a Late Silurian age. Poorly preserved graptolites identified as *Monograptus* ex gr. *transgediens* were collected within the brachiopod fauna. Lenz (1977c, p. 272) indicated that a 10 metre gap separates the highest Silurian from lowest Devonian strata in the Royal Creek sections.

Succeeding beds contain a *Gypidula pelagica* fauna, assigned to the Lower Lochkovian of the Lower Devonian. Brachiopods of this interval include (Lenz, 1977a, p. 42): *Gypidula pelagica lux* Johnson, Boucot and Murphy, *Cyrtina*, *Protocortezorthis*, *Spirigerina marginaliformis* Alekseeva and *Ancillotoechia infelix* (Barrande), and this fauna is marked by the first appearance of *Salopina submurifer* Johnson, Boucot and Murphy. Conodonts present in the unit include *Ozarkodina remscheidensis remscheidensis* and *Icriodus woschmidti*. The presence of the conodont *I. woschmidti* and the brachiopods *Gypicula pelagica*, *Ancillotoechia infelix* and *Spirigerina marginaliformis* indicates an early Lochkovian age, and correlation with the same fauna in Nevada (Johnson, Boucot and Murphy, 1973); in the 'Delorme' Formation at Cathedral Mountain, southwestern District of Mackenzie (Norris and Uyeno, 1981); and elsewhere. Although graptolites and trilobites are absent from the interval at Royal Creek, the lower Lochkovian index graptolite, *Monograptus uniformis*, and *Warburgella rugulosa* n. subsp. have been recovered together from a section at

65°37'36"N, 136°45'00"W on Hart River (Lenz, 1969). In Nevada, *M. uniformis* occurs with the *Gypidula pelagica* fauna, which confirms the early Lochkovian age, and correlation with conodont faunas 1 and 2 of Klapper et al. (1971) [=*hesperius* and *eurekaensis* Zones of Klapper (1977) and Klapper and Murphy (1975)].

Upper Lochkovian beds at the headwaters of Royal Creek are represented by the *Spirigerina supramarginalis* unit of Lenz (1977a, p. 42). This faunal unit is identical to the *Spirigerina* unit (Lenz, 1968) and is another name for the *Quadrithyris* Zone of Nevada (Lenz, 1973; Johnson, 1975). New brachiopods appearing in this faunal unit include (Lenz, 1977a, p. 42):

Phragmostrophia mucronata Lenz
Toquimaella kayi Johnson
Spirigerina supramarginalis (Khalfin)
"Dolerorthis"
Ogilviella rotunda Lenz (a few occur in underlying unit)
Cortezorthis
Muriferella
Katunia? postmodica (Scupin)
Thliborhynchia kerri Johnson
T. pedderi (Lenz)
Plicoplasia

Conodonts from the interval include (Lenz, 1977a, p. 42):

Pedavis pesavis pesavis
Ozarkodina johnsoni
Pandorinellina optima
P. steinhornensis
Pelekysgnathus serratus

These are correlated with conodont fauna 4 of Nevada (Klapper et al., 1971), which is now placed in the *pesavis* Zone of Fåhraeus (1971). This conodont fauna lies above beds with the Upper Lochkovian index graptolite *Monograptus hercynicus* at Royal Creek (Lenz, 1977a, p. 42), Prongs Creek (Lenz, 1979; Sec. 11 of this report), and in Nevada (Johnson, 1970). The widely recognized *Spirigerina supramarginalis - Quadrithyris* unit is present at Royal Creek (Lenz, 1977a, p. 42), at Prongs Creek (Lenz, 1966, 1968, 1970), in the Arctic Islands (Lenz, 1973; Johnson, 1975), and in Nevada (Johnson, Boucot and Murphy, 1968).

The succeeding *Davidsoniatrypa johnsoni* faunal unit of Lenz (1977a) occupies approximately the middle third of the composite sequence at the headwaters of Royal Creek. The unit is characterized by a number of holdovers from the underlying unit as well as the introduction of new elements. New brachiopods appearing in this unit (Lenz, 1977a, p. 42, 43) include:

Plicocyrtina sinuplicata Havlicek
Davidsoniatrypa johnsoni Lenz
Desquamatia
Atrypa
Spinatrypa
Totia cf. *intermediafera* (Khodalevich)
Latonotoechia
Gypidula boucoti Lenz
Grayina
Kayserella
Mesodouvillina stelcki Lenz
Aesopomum, 2 species

The trilobite *Lacunoporaspis*? is present in the unit. The Pragian index graptolite, *Monograptus yukonensis*, occurs in the upper part of the unit and ranges into younger beds. Conodonts from the *Davidsoniatrypa johnsoni* faunal unit are aligned with faunas 5 and 6 of Klapper et al. (1971, p. 289, Fig. 1) that are now equated with the *sulcatus* and *kindlei* Zones (Klapper, 1977, Fig. 2, p. 35; Lane and Ormiston, 1979, p. 45).

The *Davidsoniatrypa johnsoni* faunal unit shows strong affinity with the Bohemia - Uralian region. It is dated as middle to late Pragian of the Early Devonian (Lenz, in Jackson, Lenz and Pedder, 1978, p. 30, 31).

The *Sieberella* cf. *webbi - Nymphorhynchia pseudolivonica* Fauna occurs in the upper part of the Road River Formation at the headwaters of Royal Creek (Lenz, 1977a, p. 43). Most of the brachiopods found in this unit are common, long ranging genera and species that persist from underlying units. New forms appearing in the unit include (Lenz, 1977a, p. 43):

Spinulicosta
Carinagypa
Warrenella, early species
Megastrophia iddingsi
Mystrophora
Didymoparium
Parachonetes macrostriatus
Athyrhynchus spp.
"Sibirispira", bisulcata
Spinatrypa, coarse ribbed form
Desquamatia, distinctive species

Correlation and dating of this faunal unit is accomplished primarily by means of conodonts. Conodonts determined by Klapper (1969) and Klapper et al. (1971) were assigned to faunas 7 and 8 of Klapper et al. (1971), which are now placed in the *dehiscens* Zone (Klapper, 1977), and dated as latest Pragian to early Zlichovian of the Early Devonian.

Conodonts from the uppermost part of the Road River Formation at the headwaters of Royal Creek, above the highest occurrence of the *Sieberella* cf. *webbi - Nymphorhynchia pseudolivonica* Fauna, have been aligned with fauna 9 of Klapper et al. (1971) in Nevada. Fauna 9 has been aligned more recently with the *gronbergi* and *inversus* Zones (Klapper, 1977, Fig. 2, p. 35), although the *gronbergi* Zone has not yet been recognized in the northern Yukon Territory. This highest conodont fauna at Royal Creek is represented in the lower Ogilvie Formation (Perry et al., 1974) and in the lower Cranswick Formation (Pedder and Klapper, 1977) of the report area. It is aligned approximately with the brachiopod *Carinatina lowtherensis* Fauna, a late Zlichovian assemblage that has received little study. *Carinatina* cf. *lowtherensis* has been recorded from the lower part of the type section (Loc. 6) of the Cranswick Formation (Pedder and Klapper, 1977).

The Road River Formation of the northern Yukon Territory is an important source of Devonian and older graptolites. The latest Silurian (late Pridolian) *Monograptus transgrediens* Zone is typified by the subspecies *Monograptus transgrediens praecipuus* Pribyl, which has been recorded by Lenz and Jackson (1971, p. 4-6) from Hart River (=Sec. 15 of this report) and Prongs Creek (=Sec. 10 of this report). The earliest Devonian (early Lochkovian) *Monograptus uniformis* Zone is recorded by Lenz and Jackson (1971, p. 4, 6) from Hart River (=Sec. 15 of this report) and from the headwaters of Royal Creek (Lenz, 1968). In the Hart River section, the zonal designate is associated with the trilobite *Warburgella rugulosa canadensis* Ormiston, and in the Royal Creek section with the conodont *Icriodus woschmidti* Ziegler and the brachiopod *Gypidula pelagica* (Barrande). The Early Devonian (late Lochkovian) *Monograptus hercynicus* Zone is recorded by Lenz and Jackson (1971, p. 4-5, 7-9) from at or near

Section 10 (this report) on Prongs Creek. These authors indicate that, where graptolites are absent, the interval can be recognized by the presence of *Toquimaella kayi* Johnson, *Spirigerina supramarginalis* (Khalfin), and other representatives of the *Spirigerina supramarginalis* unit of Lenz (1968, 1977a).

Monograptus thomasi Jaeger of Early Devonian (early Pragian) age has been described by Lenz and Jackson (1971, p. 4, 13-14) from a 10-foot (3.28 m) thick interval immediately below *Monograptus yukonensis* in a section on Royal Creek (=Sec. 10, this report), and has been recorded also from a section at 65°55'30"N, 135°53'46"W in the Lower Canyon of Peel River, similarly below the lowest occurrence of *M. yukonensis*.

The *Monograptus yukonensis* Zone of late Pragian, Early Devonian age, is the youngest and most widely recognized graptolite zone in northwestern Canada. Within the report area of the northern Yukon Territory and adjacent District of Mackenzie, the zone has been recognized by Lenz and Jackson (1971, Textfig. 1, p. 2-4, 17-20) in the Road River Formation at numerous localities. *Monograptus yukonensis* may occur within an interval several hundred feet in thickness, and is commonly associated with *Monograptus telleri* Lenz and Jackson in the lower range of the zone. The tentaculitid, *Nowakia acuaria* (Richter), has been recorded from the zone at Royal Creek (Lenz and Jackson, 1971, p. 4).

Uyeno and Mason (1975, p. 716-717) have described conodonts from the Prongs Creek Formation (here placed in the Road River Formation) from their Locality 6 (66°35'N, 135°35'W), on the north bank of a gorge of Road River, east flank of the Richardson Mountains, Yukon Territory. From between 269 and 276 feet (82 and 84.1 m) above beds bearing *Monograptus yukonensis* they recorded (Uyeno and Mason, 1975, p. 716):

Polygnathus perbonus (Philip) (late form)
P. glenisteri Klapper
Pandorinellina sp. cf. *P. exigua* (Philip)
P. expansa Uyeno and Mason

This conodont fauna is associated with *Gasterocoma? bicaula* Johnson and Lane and is from near the base of the Middle member of the Prongs Creek Formation of A.W. Norris (1968b). It was aligned with Faunal unit 9 of Klapper et al. (1971) and more recently with the *inversus* Zone of Klapper (1977, Fig. 2, p. 35). This dating indicates correlation with the lower part of the Ogilvie Formation and with the lower part of the Cranswick Formation.

From the same section, Uyeno and Mason (1975, p. 716) recorded the following conodonts from 437 feet (133.2 m) above beds bearing *Monograptus yukonensis*:

Parapolygnathus angusticostatus (Wittekindt)
Polygnathus costatus costatus Klapper
P. linguiformis linguiformis Hind (P element of morphotype of Bultynck, 1970)
P. sp. aff. *P. eiflius* Bischoff and Ziegler
P. sp. cf. *P. pseudofoliatus* Wittekindt
Pandorinellina expansa Uyeno and Mason

This fauna is aligned with the *costatus costatus* Zone of early Middle Devonian (Co2c) age, and suggests correlation with the upper part of the Cranswick Formation and, in places, with the lower part of the Hume Formation.

Uyeno and Mason (1975, p. 715) indicated that the Upper member of the Prongs Creek Formation at their locality 6 was inaccessible for measurement. As mentioned previously, this member is generally unfossiliferous except for scattered plant tissue.

Michelle Formation

The name Michelle Formation was introduced by Norris (1968b, p. 16) for a predominantly argillaceous limestone and shale unit overlying graptolite shale of the Road River Formation and underlying with sharp contact the carbonate of the Ogilvie Formation. The type section is located near and west of Hart River (Sec. 14, Fig. 5) on the northern flank of the Ogilvie Mountains. On the 1:500 000 scale Geological Survey of Canada Map 1581A by D.K. Norris (in press), beds of the Michelle Formation are included in the upper part of map unit CDR . On the 1:250 000 scale Geological Survey of Canada maps 1526A, 1527A, 1528A by D.K. Norris (1982, 1983), the Michelle Formation is indicated as the DMI map unit.

The Michelle Formation crops out in the northeastern part of the Ogilvie Mountains which is within the southwestern part of the report area (see Norris, 1968b, Fig. 7, p. 53). To the north and northwest, the Michelle Formation passes into dolomite of the Kutchin Formation, and to the west and south it passes into shale of the Road River Formation. The outcrop belt of the Michelle Formation is within the Taiga-Nahoni Fold Belt, as defined by D.K. Norris (see above), and within the area designated as the Blackstone Trough by Lenz (1972).

Measured thicknesses in the outcrop belt range from a minimum of 184 feet (56 m) at Section 21 on the southeast flank of Nahoni Range, to a maximum of 614 feet (187 m) at Section 19 on the east side of Blackstone River. In the subsurface, the formation has been recognized in the S.O.B.C. Blackstone Y.T. D-77 well (65°46'N, 137°15'W) in the interval 7150-7623 feet (2179.3-2323.5 m) where it is 473 feet (144.2 m) thick.

The Michelle Formation consists mainly of interbedded, black, calcareous shale and abundantly fossiliferous, black, micrograined to fine grained, platy to thick bedded, moderately resistant, argillaceous limestone weathering a conspicuous orange-brown. Brownish grey weathering dolomite, and silty and argillaceous dolomite occur in the upper part of the formation at Section 17. Some beds of the black, argillaceous limestone are fetid, and Ludvigsen (1970, p. 412) reported a considerable amount of organic material in insoluble residues after acid treatment. The formation is generally more recessive-weathering than the overlying carbonates of the Ogilvie Formation, but is more resistant than the underlying soft shale of the Road River Formation.

The lower contact with the Road River Formation is gradational, and was selected by Norris (1968b, p. 16) at the level where argillaceous limestone becomes the dominant rock type. The upper, sharp contact with the more resistant carbonate of the Ogilvie Formation was considered possibly to be disconformable, but faunal evidence suggests, that if there were a hiatus, it was of very short duration.

Rocks of the Michelle Formation represent a transition from basinal shale of the underlying Road River Formation to relatively pure platform carbonate of the overlying Ogilvie Formation, which reflects a marked decrease in depth of sea covering the area. The fauna of the upper Road River Formation is largely pelagic and consists of graptolites,

dacryoconarid tentaculitids, orthoconic nautiloids, and small, thin-shelled pelecypods. The Michelle Formation marks the appearance of numerous shelly benthonic elements, of which brachiopods and trilobites are the most important components, and which indicate the transition to shelf carbonate deposition.

The Michelle Formation is by far the most fossiliferous, exceeding in numbers and diversity of fossils contained, of any other Devonian formation known in the northern Yukon Territory. The fauna includes, in order of decreasing abundance of specimens and diversity: brachiopods, trilobites, conodonts, tentaculitids, crinoidal debris, gastropods, ostracodes, nautiloids, corals, pelecypods, bryozoa, algae, and fish remains. Since the reports of Norris (1967, 1968), which were submitted for publication in 1964, some of the fossil groups represented in the Michelle Formation have been studied in detail. These include the nautiloids by Collins (1969), the stromatoporoids by Stern and Mehrota (1970), the brachiopods and tentaculitids by Ludvigsen (1970, 1972), the conodonts by Fåhraeus (1971), and the ostracodes by Berdan and Copeland (1973).

Nautiloids identified by Collins (1969) from the Michelle Formation comprise:

Leurocycloceras superplenum Collins (the most common form)
?Rayonnoceras sp.
Lobobactrites sp.

This same association occurs in the Road River Formation above the highest occurrence of *Monograptus yukonensis*.

Stromatoporoids from the Michelle Formation identified by Stearn and Mehrota (1970, p. 4) comprise the following:

Anostylostroma laxum (Nicholson)
Trupestroma cf. *T. ideale* Birkhead
Anostylostroma sp.
Stromatopora cf. *S. bucheliensis* (Bargatzky)

Brachiopods identified by Ludvigsen (1970, p. 412-413, 1972, p. 301) from the Michelle Formation of the Hart-Blackstone rivers area comprise the following:

Carinagypa loweryi (Merriam)
Carinatina sp.
Cortezorthis n. sp. aff. *C. cortezensis* Johnson and Talent
Desquamatia n. sp.
Gorgostrophia sp. cf. *G. neutra* (Barrande)
Parachonetes macrostriatus (Walcott)
"Leiorhynchus" sp.
?Leptostrophia spp.
Megastrophia sp. cf. *M. iddingsi* (Merriam)
Muriferella sp. cf. *M. masurskyi* Johnson and Talent
Phragmostrophia sp.
Radiomena sp.
Reticulariopsis sp. aff. *R. reticularioides* (Grabau)
Schizophoria sp. cf. *S. nevadaensis* (Merriam)
"Strophochonetes" filistriata (Walcott)
Warrenella n. sp. (=*Warrenella transversa* Ludvigsen and Perry, 1975)

Ludvigsen (1970) concluded that the brachiopods of the Michelle Formation displayed sufficient similarity to those of the *Eurekaspirifer pinyonensis* Zone of Nevada for the two faunas to be considered contemporaneous, and dated the enclosing beds as Emsian (late Early Devonian).

Dacryoconarid tentaculites identified by Ludvigsen (1972, figs. 3, 4, p. 300, 301) from the Michelle Formation comprise the following:

Guerichina lenini Ludvigsen
Metastyliolina conica Ludvigsen
Nowakia parabarrandei Churkin and Carter
Styliolina sp. B.
Styliolina sp. cf. *S. fissurella* (Hall)
Turkestanella acuaria (Richter)
Turkestanella minuta Ludvigsen

Ludvigsen (1970, Fig. 5, p. 420; 1972, p. 304) concluded that this fauna has its closest affinity with the *Guerichina strangulata* Zone of Bohemia, which indicates a late Pragian age.

The relatively abundant trilobite fauna of the Michelle Formation was studied by Ormiston (1971; in Ludvigsen, 1970, p. 424, 425) who listed the following forms:

Astycoryphe sp. aff. *A. cimelia* Ormiston
?Astycoryphe sp.
Ceratolichas n. sp. cf. *C. gryps* (Hall and Clarke)
Cornuproetus sp. cf. *C. haentzscheil* Alberti
?Dechenella sp.
Lacunoporaspis norrisi Ormiston
Lacunoporaspis sp.
Leonaspis sp. aff. *L. eremia* Ormiston
Leonaspis sp.
Otarion sp.
Proetus sp. cf. *P. nerudai* Pribyl
Proetus sp.
Reticuloharpes sp. cf. *R. reticulatus* (Hawle and Corda)
Reticuloharpes sp.
Schizoproetoides sp.
?Schizoproetoides sp.

The most abundant form in this trilobite assemblage is *Lacunoporaspis norrisi*, which was formerly designated as *Dechenellurus* sp. B by Ormiston (in Norris, 1968b, p. 19). Ormiston noted (in Ludvigsen, 1970, p. 425) that the affinities of the Michelle trilobites lie with the Emsian beds of the Arctic Islands and Alaska. Forms showing identity or close affinity to Emsian forms in the Canadian Arctic comprise: *Astycoryphe* sp. aff. *A. cimelia*, *Leonaspis* sp. aff. *L. eremia*, *Schizoproetoides* sp., and *Lacunoporaspis* sp. Forms occurring in the limestone and shale member of the McCann Hill Chert of east-central Alaska comprise: *Astycoryphe* sp. aff. *A. cimelia*, *Reticuloharpes* sp. cf. *R. reticulatus*, and *Lacunoporaspis* close to *norrisi*. Ormiston (in Ludvigsen, 1970, p. 425) pointed out also that *Proetus* sp. cf. *P. nerudai* and *Cornuproetus* sp. cf. *C. haentzscheli* are similar to European forms of Pragian age. Ormiston dated the Michelle trilobite fauna as undifferentiated Emsian in age, with the qualification that there are no forms in the fauna diagnostic of late Emsian.

Ostracodes from the Michelle Formation identified by Copeland (in Ludvigsen, 1970, p. 426) comprise the following:

Adelphobolbina sp.
?Adelphobolbina sp.
Bairdiocypris sp.
Beyrichia (Beyrichia) sp. A
Chironiptrum sp.
?Eukloedenella sp.
Hanaites sp.
?Hollinella sp.
Kloedenella sp.
?Tricornina sp.

Copeland (in Ludvigsen, 1970, p. 426) indicated that the Michelle ostracode fauna is similar to that illustrated by Berdan (in Churkin and Brabb, 1968, Table 1, p. 232, Pl. 4) from the Limestone and shale member of the McCann Hill Chert in east-central Alaska.

The echinoderm ossicles with double and cross-like axial canals, *Gasterocoma? bicaula* Johnson and Lane, first appear in the Michelle Formation but are exceedingly rare. Throughout the northern Yukon Territory this form first occurs in abundance in the lower part of the overlying Ogilvie Formation and equivalent beds.

The goniatite, *Teicherticeras lenzi* House (in House and Pedder, 1963, p. 508, Pl. 75, figs. 1-3, 10, 11; Text-fig. 3), was collected from a locality on Ogilvie River between sections 20 and 21 of this report. Its horizon and locality was recorded at 296 feet (90.2 m) below the base of the Hume equivalent (=Ogilvie Formation of this report) at 65°23'N, 138°31'W) (=Locality H-P-1 of this report). Enclosing beds are recorded as "black, styliolinid mudstone". Comparison with the nearest sections (20 and 21 of this report) suggest the enclosing beds belong in the lower part of the Michelle Formation or the upper part of the Road River Formation. House (*ibid.*) dated the goniatite as probable Emsian in age.

Fåhraeus (1971, p. 670) listed the following conodonts obtained from four sections of the Michelle Formation measured by Ludvigsen (1970) in the Hart - Blackstone rivers area of the Yukon Territory:

Belodella devonica (Stauffer)
Hindeodella priscilla Stauffer
Ozarkodina denckmanni Ziegler
Panderodus gracilis (Branson and Mehl)
Polygnathus dehiscens Philip and Jackson
Spathognathodus optimus Moskalenko
Pelekysgnathus furnishi Klapper (very sparsely represented)

Fåhraeus (1971, p. 670) concluded that this fauna belongs in the upper part of the *Polygnathus dehiscens* Zone (=*P. lenzi* fauna of Klapper, 1969) which he dated as late Pragian of the Early Devonian. More recently, Jackson, Lenz and Pedder (1978, p. 13) placed the *dehiscens* Zone in the lower Zlichovian, but pointed out that the zone overlaps a small uppermost part of the Pragian in Czechoslovakia. In 1971, Fåhraeus (p. 670) concluded also that the conodont fauna of the Michelle Formation is slightly younger than the highest conodont fauna found up to that date in the Road River Formation at the headwaters of Royal Creek.

Cranswick Formation

The name Cranswick Formation was proposed by A.W. Norris (1968b, p. 27) for a sequence of Devonian limestone and minor amounts of shale that overlies dolomite of the Unnamed carbonate unit and, at the type section, underlies a tongue of the Road River Formation. The type section selected by A.W. Norris (1968b, p. 27, Fig. 3, Pls. XIII and IV) is at Locality 6 immediately west of the Snake River at the Mackenzie Mountain front. The name Cranswick Formation is applied also to the sequence of limestone overlying dolomite of the Unnamed carbonate unit and underlying shale of a tongue of the Mount Baird Formation (new name) at Section 4, located near the headwaters of Cranswick River. In a previous report (Norris, 1968b), the limestone at this section was referred to the Ogilvie Formation. The limestone beds formerly classified as part of the Gossage Formation at sections 2 and 3 (see Norris, 1968b, Fig. 3) are here considered to be part of the Cranswick Formation. Because of the uncertainty in correlating westward across the shale basin of the Richardson Trough, it seems preferable to use a distinct name for the open marine carbonates that are approximately coeval with the Ogilvie Formation west of the trough. The name Cranswick Formation also replaces the name Ogilvie Formation in the Campbell Uplift (secs. 31 and 32).

On the composite 1:500 000 scale GSC Map 1581A of the Operation Porcupine area by D.K. Norris (in press) rocks of the Cranswick Formation are included in map unit SDu. On the 1:250 000 scale GSC Map 1517A of the Aklavik area by D.K. Norris (1981d), rocks of the Cranswick Formation are designated as map unit DG; and on GSC Map 1529A of the Snake River area by D.K. Norris (1982d) rocks of the Cranswick Formation are in map unit DL. To the east, on GSC Map 1452A of the Upper Ramparts River area by Aitken et al. (1982), rocks of the Cranswick Formation are designated as map unit D1.

The thickness of the Cranswick Formation at the type locality (Sec. 6) is 443 feet (135 m). To the southeast, at Section 4 near the headwaters of Cranswick River, it thickens to 1822 feet (555.4 m). Sections 31 and 32 in the Campbell Uplift show 686 and 280 feet (207.5 and 85.3 m) of Cranswick beds, respectively, but are incomplete.

The lithology of the Cranswick Formation at the type section consists of two members; a lower, 208 foot (63.4 m) thick member of medium brownish grey to black, aphanitic to fine grained, thin bedded to massive limestone; and an upper, 235 foot (71.6 m) thick member of black, fine grained limestone and argillaceous limestone, interbedded with black calcareous shale (Norris, 1968b, p. 27). Nodular chert occurs in scattered limestone beds in the lower quarter, near the middle and in the upper third of the formation at Section 4. Some dolomite and dolomitic limestone occur also in the lower 220 feet (67.1 m) of the formation at Section 4.

The lower contact of the Cranswick Formation in the type area is with dolomite of the Unnamed carbonate unit. The upper contact at the type section is with black bituminous and calcareous shale referred to as a tongue of the Road River Formation. At Section 4, near the headwaters of Cranswick River, the Cranswick Formation is

overlain by a unit of greenish-grey, calcareous shale referred to as a tongue of the Mount Baird Formation (new name).

In the Campbell Uplift, rocks there assigned to the Cranswick Formation unconformably overlie dolomitic rocks assigned to the Vunta Formation, the upper part of which is of probable Middle Silurian age (Norris, 1968b, Sec. 32, Fig. 5). On the southern flank of Campbell Uplift, limestone rocks of the Cranswick Formation are unconformably overlain by a thin wedge of clastic rocks of the Upper Devonian Imperial Formation, which is, in turn, unconformably overlapped by shale of Middle to Late Albian, late Early Cretaceous age (Norris, D.K. and Calverley, 1978, p. 59-65; GSC Map 1517A of Norris, D.K., 1981d).

The Cranswick Formation was deposited on a carbonate platform flanking the east side of the Richardson Trough. Deposition under open marine, relatively deep water, low energy conditions is suggested by the limestone of most of the formation. The interbedded limestone and dolomite in the lowermost part of the formation at Section 4 suggest an oscillation of open and environmentally restricted marine conditions.

A composite list of megafossils identified by Pedder (in Pedder and Klapper, 1977) from the Lower member of the Cranswick Formation at the type section comprises the following:

Amphipora sp. (C-63102)
bulbous stromatoporoids (C-63102)
Alveolites sp. (C-63102)
Bogimbalites sp. nov. (C-63108)
Cavanophyllum sp. nov. (C-63107)
Crassialveolites sp. (C-63107, C-63108)
Dohmophyllum (sensu lato) sp. (C-63107)
Echyropora sp. (C-63108)
Favosites sp. cf. *F. goldfussi* sensu Hill and Jell, 1969 (C-63107)
Planetophyllum sp. nov. (C-63102)
Spongonaria sp. cf. *S. richardsonensis* Crickmay (C-63102)
Spongonaria sp. nov. (C-63102)
Taimyrophyllum sp. nov. (C-63107)
Carinatina sp. cf. *C. lowtherensis* Johnson and Boucot (C-63107)
Gasterocoma(?) *bicaula* Johnson and Lane (C-63107)
trilobite fragments (C-63107)

A goniatite, cf. *Foordites* sp. (C-63119; identified by W.W. Nassichuk), was recorded by Pedder (in Pedder and Klapper, 1977, p. 231) from the upper, recessive, argillaceous member of the Cranswick Formation at Section 6. Collections by A.W. Norris from the Upper member at Section 6 contain numerous dacryoconarid tentaculitids, some inarticulate and articulate brachiopods, trilobite fragments, and a few *Gasterocoma*(?) *bicaula* Johnson and Lane.

Pedder (in Pedder and Klapper, 1977, p. 231, 233) indicated that *Spongonaria* sp. cf. *richardsonensis* (C-63102) is present also in the lower part of the Blue Fiord Formation at Sor Fiord, Ellesmere Island, where it occurs within beds that are probably equivalent to the conodont *Polygnathus gronbergi* Zone. *Planetophyllum* in C-63102 may be identical to *P. planetum* Crickmay, which was illustrated by Rice (1967, Pl. 2, figs. 7, 8) from the Fitzgerald Formation of northeastern Alberta. *Carinatina lowtherensis* Johnson and Boucot (1972, p. 37, Pl. 1, figs. 1-14) occurs typically in the Disappointment Bay Formation on Lowther Island, where it occurs with conodonts assigned to the conodont *Polygnathus inversus* Zone.

Klapper (in Pedder and Klapper, 1977, p. 233) concluded that the conodonts in the lower 20.3 m (66.6 ft) of the Cranswick Formation at the type section are assignable either to the *gronbergi* or *inversus* Zone; the upper 39.3 m (128.9 ft) of the Lower member and lower 10 m (32.8 ft) of the Upper member of the formation are referred to the *inversus* Zone; and higher beds of the Upper member are assigned to the *serotinus* Zone.

From Section 4 (=S-16), Perry (in Perry and others, 1974, p. 1094) recorded the following brachiopods from about 165 feet (50.3 m) above the base of the Cranswick Formation:

Carinapyga sp.
Parachonetes macrostriatus? (Walcott)
Phragmostrophia sp.
Strophochonetes sp.

Also from Section 4 (=S-16), Perry and others (1974, p. 1069) recorded *Carinapyga* sp. from an interval 515 to 615 feet (157 to 187.5 m) above the base of the Cranswick Formation from beds formerly assigned by Norris (1968b) to the Ogilvie Formation. None of these brachiopods is particularly diagnostic, but Perry (in Perry and others, 1974, p. 1069) indicated that *Carinapyga* sp. occurs in the Emsian and Emsian-Eifelian intervals in the lower and middle parts of the Ogilvie Formation at numerous localities.

From 25 feet (7.6 m) from the top of the Cranswick Formation at Section 4 (=S-16), Klapper (in Perry and others, 1974, p. 1094) recorded *Pandorinellina exigua* n. subsp. A (=*P. expansa* Uyeno and Mason, 1975, Pl. 1, figs. 6, 9, 11-19), a form that ranges from the upper part of the *inversus* to the *costatus costatus* Zone (Klapper, 1977; Uyeno and Klapper, 1980, Fig. 8.3, p. 85). It is probably the *serotinus* or *costatus costatus* Zone that is represented, based on the stratigraphic position of *P. expansa* at Section 4.

Norris (1968a, Fig. 3) recorded *Gasterocoma*? *bicaula* Johnson and Lane and *Moelleritia canadensis* Copeland from between 0 and 253 feet (0 and 77.1 m) above the base of the Cranswick Formation at Section 4. From the nearby Section 2a to the north-northeast, ostracodes, including *Moelleritia canadensis*, were the only fossils found in the lower micritic limestone beds of the Cranswick Formation.

The corals of the Cranswick Formation from Section 4 have been examined by A.E.H. Pedder (GSC Internal Report No. AWN-95-AEH-1979). From the lower, resistant part of the Cranswick Formation, between 0 and 705 feet (0 and 214.9 m) above the base of the formation, Pedder identified:

Amphipora sp. (54432, 54540)
bulbous stromatoporoid (54434)
encrusting stromatoporoids (54432)
Alveolites sp. indet. (54432, 54439, 54441)
Alveolitella sp. undet. (54432)
Aulacophyllum (s.l.) sp. nov. (54439)
cyathophyllid undet., but possibly *Exilifrons* sp. (54441)
Grabaulites(?) sp. undet. (54488)
Pachyfavosites sp. undet. (54440)

From between 975 and 1100 feet (297.2 and 335.3 m) above the base of the Cranswick Formation at Section 4, Pedder identified:

Alveolites sp. (54484)
Spongonaria sp. cf. *S. richardsonensis* Crickmay (54490, 54541, 54486, 54487 and 54447)

Pedder indicated that *Spongonaria* sp. cf. *S. richardsonensis* is identical with the form so named by Pedder and Klapper (1977) from the lower cliff-forming member of the Cranswick Formation at the type section (Loc. 6). This suggests that the base of the Cranswick Formation at Section 4 is older than it is at Section 6.

From the upper part of the Cranswick Formation at Section 4, between 1185 and 1590 feet (361.2 and 484.6 m) above the base of the formation, Pedder identified the following:

encrusting stromatoporoid (54463)
Alveolites sp. undet. (54459, 54460)
Lyrielasma? sp. nov. (54463)
Roemeripora spelaeana (Etheridge) (54451, 54456, 54460, 54462)
Roemeripora? sp. (54453)
Thamnopora sp. undet. (54459, 54460)
gastropod, undet. (54459)
ostracodes, undet. (54459)

The most diagnostic form in this assemblage is *Roemeripora spelaeana*, which has been identified also by Pedder (Internal GSC Report BSN-94-AEHP-1979) from the upper, pellet limestone member of the Gossage Formation of Tassonyi (1969) in the Crossley Lake S. K-60 (68°29'39"N, 129°29'14"W) and Kugaluk N-02 wells (61°31'55"N, 131°31'19"W).

Part of the Cranswick Formation, previously classified as Ogilvie Formation by Norris (1968a, b), occurs as scattered outcrops in the Campbell Uplift. From an isolated outcrop (GSC locs. C-71726 and C-57461) southwest of Campbell Lake at 68°03'30"N, 133°55'00"W, A.W. Norris (GSC Internal Report No. 6-AWN-1978) identified the following:

undet. planispiral gastropod
Orbiculoidea(?) sp.
Innuitella innuitana Crickmay
cf. *Leiorhynchus* sp.
Warrenella collina (Crickmay)
Gasterocoma? *bicaula* Johnson and Lane
echinoderm ossicle with single axial canal
Schizoproetoides sp.

This sample is from a position close to the type localities recorded by Crickmay (1968, p. 6, 7) for *Innuitella innuitana* at 68°03'02"N, 133°59'42"W, and for *Warrenella collina* at 68°02'38"N, 134°00'44"W.

From Quarry 4, described by D.K. Norris and Calverley (1978, p. 59, Fig. 31), near the Mackenzie Highway, north of Campbell Lake at 68°18'30"N, 133°20'00"W, A.W. Norris (GSC Internal Report 6-AWN-1978) identified the following fossils from beds of the Cranswick Formation:

stromatoporoid
favositid coral fragment
cup coral fragment
"Atrypa" sp. cf. *"A." nevadana* Merriam
Costispirifer? sp.
Ancillotoechia sp.
Gasterocoma? *bicaula* Johnson and Lane
echinoderm ossicle with single axial canal
bryozoan fragment
dechenellid tail fragment

Conodonts from a sample (GSC loc. C-41900) of the same beds and locality as above, and identified by T.T. Uyeno (GSC Internal Report No. 3-TTU-1979), have been assigned to the *Polygnathus inversus* Zone of late Zlichovian to early Dalejan, late Early Devonian age. This assignment would suggest a correlation with the lower but not lowermost part of the Ogilvie Formation west of the Richardson Trough.

Near the Mackenzie Highway on the east side of Campbell Lake, at 68°13'N, 133°24'W, an upper sequence of limestone beds, about 195 feet (59.4 m) thick, of the Cranswick Formation is exposed. The lower datum of the upper sequence is the top of a lower outcrop at this locality. Megafossils from 110 feet (33.5 m) above the base of the upper sequence comprise the following (GSC loc. C-71728, Internal Report No. 6-AWN-1978):

Dolerorthis? sp.
cf. *Spinulicosta* sp.
Spinatrypa sp.
Gasterocoma? *bicaula* Johnson and Lane
echinoderm ossicle with single axial canal
Dechenella? sp. - tail fragment

Megafossils from the top of the upper sequence, that is 195 feet (59.4 m) above base of section, are as follows (GSC loc. C-71729; Internal Report No. 6-AWN-1978):

alveolitid coral fragment
favositid coral fragment
undet. planispiral gastropod
bactritid fragment
Dolerorthis? sp.
Gasterocoma? *bicaula* Johnson and Lane
echinoderm ossicle with single axial canal

The fossils from these two samples suggest a late Early Devonian or early Middle Devonian age.

The two units of Section 31 located on the east side of Campbell Lake, previously described by Norris (1967, p. 243-252; 1968a, Fig. 5), are here placed in the Cranswick Formation. The lower unit, 350.6 feet (106.9 m) thick, is sparsely fossiliferous, and is presumed to be of Early Devonian age. The upper unit is 330 feet (100.6 m) thick, with its lower boundary arbitrarily placed at the base of a covered interval. Some of the more significant fossils recovered from this upper unit comprise: *Gasterocoma*? *bicaula* Johnson and Lane from 151.5 to 166.5 feet (46.2 to 50.7 m) above base; *Plectospirifer* sp., *Odontocephalus*? sp., and *Dechenella* (*D.*) sp. from 151.5 to 161.5 feet (46.2 to 49.2 m) above base; and *Pelekysgnathus pedderi* Uyeno and Mason (1975, p. 715) recorded from 280 feet (85.3 m) above the base of the upper unit. *P. pedderi* was recently placed by Uyeno and Klapper (1980, p. 89) in the genus *Steptotaxis*. The genus *Plectospirifer* occurs in the Hume Formation and the trilobites *Odontochephalus*? sp. and *Dechenella* (*D.*) sp. suggest an Eifelian age. The conodont *S. pedderi* is suggestive of the *australis* Zone, according to Klapper and Johnson (1980, p. 422, Table 8), and of a mid-Eifelian, early Middle Devonian age. This dating suggests that the upper part of the upper unit of the Cranswick Formation at Section 31 probably should be correlated with the lower part of the Hume Formation in the Powell Creek area. The dated beds of the Cranswick Formation in the Campbell Uplift suggest that the interval of time represented is approximately equivalent to that of the Cranswick Formation at Section 4 near the headwaters of the Cranswick River. Rocks equivalent to the Unnamed carbonate unit or the Kutchin Formation appear to be absent in the Campbell Uplift.

From a section located at 65°30'N, 131°15'W, near Section 2 of this report, Crickmay (1962, p. 2-3) reported the following fossils from beds that he considered to be equivalent to the Bear Rock Formation. Those strata are here considered to be part of the Cranswick Formation:

Chlamydophyllum sp. indet.
Favosites sp. indet.
Spongonaria filicata Crickmay
Gypidula cf. *pseudogaleata* (Hall)
Schuchertella sp. indet.
Stropheodonta sp.
Atrypa cf. *nevadana* Merriam
Spinatrypa sp. n.
Ambothyris sp. indet.
Fimbrispirifer sp. indet.
Dechenella sp. indet.

These fossils are reported from a level about 1200 feet (365.8 m) below the occurrence of *Billingsastrea verrilli* Crickmay, a form indicative of the Hume Formation, and about 900 feet (274.3 m) above the highest beds containing Silurian fossils, including *Halysites* (s.s.), that are indicative of the Peel Formation of Pugh (1983). One of the more diagnostic fossils in the above list is *Spongonaria filicata*. This species is reported by Pedder (in Jackson, Lenz and Pedder, 1978, p. 67, 158, Pl. 44, figs. 5, 6) from 840 feet (256.2 m) above the base of the Ogilvie Formation (1170 ft/ 356 m thick) from a section at 67°25'N, 137°02'W in the Ogilvie Mountains, Yukon Territory, where it is associated with conodonts probably assignable to the *Polygnathus serotinus* Zone of Dalejan, late Early Devonian age.

Ogilvie Formation

The name Ogilvie Formation was introduced by A.W. Norris (1968b, p. 28) for a Devonian carbonate unit overlying the Michelle and Kutchin formations and underlying shale of the McCann Hill Tongue (=Unnamed shale unit of Norris, 1968b) and clastic and carbonate rocks of Carboniferous age. The type section is on Mount Burgess and on the unnamed peak to the east (Section 24 of this report). On the 1:500 000 scale composite GSC Map 1581A of the Operation Porcupine area by D.K. Norris (in press), beds of the Ogilvie Formation are included in the upper part of map unit SDu. On the 1:250 000 scale GSC Maps 1516A, 1518A, 1519A, 1522A, 1523A, 1524A, 1526A, 1527A and 1528A by D.K. Norris published in 1981 and 1982, the Ogilvie Formation is designated as map unit Do.

In the present report, the name Ogilvie Formation is restricted to the carbonate shelf deposit west of the shale basin marked by the Richardson Anticlinorium. An approximately coeval carbonate unit outcropping on the east (Mackenzie Fold Belt and Campbell Uplift) side of the Richardson Anticlinorium is referred here to the Cranswick Formation. The outcrop belt of the Ogilvie Formation in the report area is within the northern Ogilvie Mountains, which are part of the Taiga - Nahoni Fold Belt of D.K. Norris (1983). The Ogilvie Formation is known also to underlie, in the subsurface, a large part of the Eagle Plain which coincides with the Eagle Fold Belt. To the east and south, the Ogilvie carbonate passes laterally into shale of the Road River Formation. To the west, it passes into the Limestone and shale member of the McCann Hill Chert in the Nation River area of east-central Alaska.

The thickness of the Ogilvie Formation is extremely variable, as is indicated by data presented by A.W. Norris (1968b, Table 4, p. 29, 30) and by an isopach map prepared by Perry (in Perry et al., 1974, Fig. 1, p. 1057). The depocentre of maximum carbonate deposition of the formation is near the junction of the Blackstone and Ogilvie rivers, where the thickness is in excess of 4000 feet (1220 m). A maximum thickness of 4428 feet (1349.7 m) for the Ogilvie Formation was measured at Section 19 on the northern flank of Ogilvie Mountains immediately east of Blackstone River. Originally, it was assumed, on the basis of megafossils, that the upper 1790 feet (545.6 m) of this section was repeated by faulting, although no physical evidence of faulting could be detected in outcrops. Another relatively thick sequence of the formation occurs at Section 39 in the Ogilvie Mountains about 12 miles (19.2 km) east of the Ogilvie River, where it is about 3430 feet (1054.5 m) thick. In the subsurface throughout most of the Eagle Plain area the formation is between 2000 and 3000 feet (610 and 915 m) thick. In the outcrop belt to the south and west of Eagle Plain the thickness is generally less that 2000 feet (610 m). The thickness at Mount Burgess (Type sec. 24) is 2190 feet (667.5 m). In general, the thickness of the Ogilvie Formation is approximately inversely proportional to the thickness of the overlying shale of the Unnamed shale unit.

The lithology of the Ogilvie Formation in most sections consists mainly of medium brown to grey, aphanitic to fine grained, thin bedded to massive, resistant, cliff-forming limestone, weathering light to medium grey. Beds of coarser grained encrinite, some of which are fetid, contain variable amounts of pyrobitumen at scattered intervals. Some of the darker beds contain variable amounts of argillaceous and silty material. Chert, in the form of small pods and thin lenses, occurs in sporadic intervals but is more common in the upper part of the formation. In the Blackstone - Hart rivers area the lower one quarter to one third of the Ogilvie Formation in a few sections contains variable and scattered intervals of dolomite. A few sections in the southern Nahoni Range area exhibit dolomitized beds in the lower two thirds of the formation. Where the beds have been dolomitized, minor intergranular and vuggy porosity has developed with pyrobitumen present in some of the vugs.

The lower contact of the Ogilvie Formation with the Michelle Formation is sharp and distinct in most sections when seen from a distance, and this was originally interpreted by Norris (1968b, p. 28) as possibly marking a disconformity. Perry (in Perry et al., 1974, p. 1058) recorded a slight angular discordance between the base of the Ogilvie and top of the Michelle at his Section S-1 (near Sec. 17 of this report), but this minor truncation of beds was interpreted by Perry as local channelling.

In the area underlain by the carbonate shelf succession, such as in the Nahoni Range where the Ogilvie Formation overlies the Kutchin Formation, the boundary is gradational and is drawn between light to medium grey limestone and the underlying brown and orange weathering platy dolomite and dolomitic limestone. In this area, the dolomite of the Kutchin Formation is the lateral equivalent of all of the Michelle Formation and the upper part of the Road River Formation.

At Mount Burgess (Sec. 24), on the eastern flank of the Dave Lord High (see Fig. 9), a very thin, atypical Kutchin Formation underlies the Ogilvie Formation, and the Kutchin Formation is in turn unconformably underlain by Middle Ordovician rocks. At a locality (66°18'N, 139°48'W) about 18.5 miles (29.6 km) north of Mount Burgess, the Kutchin Formation is missing entirely and the Ogilvie Formation unconformably overlies carbonate rocks dated by conodonts

(GSC loc. C-51512) as of Early Ordovician (Arenigian) age. At this locality, the base of the Ogilvie Formation is dated by conodonts (GSC loc. C-51513) as of Devonian (Emsian-Eifelian) age (see GSC Map 1522A of D.K. Norris, 1981i).

Fossil evidence indicates that the lower boundary of the Ogilvie Formation is more or less isochronous throughout the report area and, also, that if there is a hiatus between the Ogilvie and Michelle formations, it was of very short duration.

The upper boundary is drawn between resistant limestone of the Ogilvie Formation and an overlying, very poorly exposed succession of dark, variegated shale that is here referred to as the Unnamed shale unit (=Unnamed shale unit of Norris, 1968b, p. 39-41). Faunal and thickness data indicate that the upper boundary of the Ogilvie Formation is notably diachronous from place to place.

In the Ogilvie - Blackstone - Hart rivers area (approximately equivalent to the Blackstone Trough of Lenz, 1972, Fig. 3, p. 328), where the Ogilvie Formation overlies the Michelle Formation, the lower part of the Ogilvie Formation is, in places, variably dolomitic. Where the interval is completely dolomitized, fossils are exceedingly sparse or absent and consist of high-spired gastropods and vague skeletal structures suggestive of stromatoporoids. In the intervals consisting of alternating limestone and dolomite bands, a few dolomitic beds exhibit small-scale brecciation, and bird's-eye and laminar structures. It is in the more calcareous beds of the dolomitic sequence that the large ostracode, *Moelleritia* (Copeland, 1962), is found. The upper one third to one half of the formation in this area consists of well bedded to massive limestone and, in places, slightly argillaceous limestone containing a more diverse stromatoporoid, coral, brachiopod, trilobite, and crinoid debris fauna. This composite sequence suggests an initial, very shallow water, intertidal to supratidal, restricted environment for the formation, gradually deepening to open marine conditions. However, north of the Blackstone Trough, where the Ogilvie Formation consists entirely of limestone, open marine conditions were initiated earlier, and persisted throughout Ogilvie time.

Klapper (in Perry et al., 1974, p. 1062-1065) proposed a sequence of informal conodont faunal units based on collections from the Ogilvie Formation. These, in ascending order, are as follows: *Polygnathus perbonus perbonus*, *P. perbonus* n. subsp. D., *P. costatus costatus*, *P. pseudofoliatus*, an interval of no diagnostic conodonts, and the *Polygnathus varcus* Zone.

The *P. perbonus perbonus* faunal unit has been recorded (Klapper, in Perry et al., 1974, p. 1063) from the following sections measured by Perry: S-3 at 955 feet (291 m) above the base of the Ogilvie; S-11; S-13; S-14; and S-15 at 245-260 feet (75-79 m). Associated forms commonly include *Pelekysgnathus glenisteri* and/or *Pandorinellina exigua exigua*. Faunas with *Pelekysgnathus glenisteri* but without *Polygnathus perbonus perbonus* occur at the following sections: S-1, 0 feet; S-4, 130 feet (40 m); and S-6, 520 feet (158 m). At Section S-1, the lower part of the *Polygnathus perbonus perbonus* faunal unit is found in the basal beds of the Ogilvie Formation, where it is immediately underlain by beds of the Michelle Formation containing conodonts of the *dehiscens* Zone. The apparent absence of elements of the *gronbergi* Zone at this section suggests a disconformity between the Ogilvie and Michelle formations.

The *P. perbonus perbonus* ("late form") faunal unit is aligned by Klapper (1977, Fig. 2, p. 35) with the *inversus* Zone and possibly also with the older *gronbergi* Zone, although elements of the *gronbergi* are conspicuously absent throughout the northern Yukon Territory.

Klapper (in Perry et al., 1974, p. 1063) recorded the late form of *P. perbonus perbonus* occurring near the top of his conodont Fauna 9 (Klapper et al., 1971, p. 289) in central Nevada, which was aligned with the brachiopod *Eureka-spirifer pinyonensis* Zone. The age of the *P. perbonus perbonus* faunal unit was regarded as Emsian undifferentiated.

The *Polygnathus perbonus* n. subsp. D faunal unit was recorded from the following sections and horizons (Klapper, in Perry et al., 1974, p. 1064, 1065): S-1, 960 feet (293 m) above base; and S-15, 515 feet (157 m) above base. Besides the name bearer, this unit contains the α morphotype (Bultynck, 1970) of *P. linguiformis linguiformis*, the late form of *P. perbonus perbonus*, which ranges up from the underlying faunal unit, and *Pandorinellina exigua* n. subsp. A. This faunal unit now is aligned by Klapper (1977, Fig. 2, p. 35) with the *serotinus* Zone, which is in turn aligned with brachiopod interval 14 (*Elythyna* Fauna) of Nevada (Johnson, 1977).

Evidence for the *Polygnathus costatus patulus* Zone between the *serotinus* and *costatus costatus* Zones is lacking in the Yukon Territory, although it has been recorded by Lane and Ormiston (1979) from the top of the Salmontrout Formation in east-central Alaska.

The *Polygnathus costatus costatus* faunal unit of Klapper (in Perry et al., 1974, p. 1065) is recognized in the Ogilvie Formation at the following localities: S-3, 1145 feet (349 m) above base; S-8, 1515 feet (462 m) above base; and S-10. It is aligned with the *P. costatus costatus* Zone (Klapper, 1977, p. 35), which in the Belgian sequence ranges from Co2bIII to Co2cIII. A possible equivalent of the *costatus costatus* Zone in the District of Mackenzie is a fauna in the lower part of the Hume Formation recorded by Uyeno and Mason (1975, p. 717) that includes *Pelekysgnathus pedderi* Uyeno and Mason (1975) and species of *Icriodus* not found in the Ogilvie Formation (Klapper, 1977, p. 45). However, more recently, the *pedderi* fauna has been placed by Klapper (in Klapper and Johnson, 1980, p. 422, Table 8) in the succeeding *australis* Zone.

The *Polygnathus pseudofoliatus* faunal unit of Klapper (in Perry et al., 1974, p. 1065) occurs in the Ogilvie Formation between 1715 and 1785 feet (523 and 544 m) above the base of the formation at Locality S-5. This faunal unit includes *Polygnathus pseudofoliatus* and *P. angustipennatus*, but lacks the subspecies of *Polygnathus kockelianus*. According to Klapper (1977, p. 47), it may be correlated with either the *australis* Zone or the *kockelianus* Zone. Similar faunas are reported from the upper Hume Formation of the Powell Creek area (Uyeno, in Lenz and Pedder, 1972) and in the lower Elm Point Formation of Manitoba (Uyeno, in Norris and Uyeno, 1972).

Conodonts indicative of the *ensensis* Zone, which succeeds the *kockelianus* Zone and precedes the *varcus* Zone, have not yet been found in the Yukon Territory. However, elements of this zone have been recorded by Chatterton (1979, Table 4, secs. 1, 5, 6) and by Klapper (in Klapper and Johnson, 1980, p. 410, 413, 424, Table 9) in transitional beds between the Nahanni and Hare Indian formations, and between the Hume and Hare Indian formations, in the western District of Mackenzie. It is this stratigraphic interval that commonly contains *Leiorhynchus castanea* (Meek) and associated megafossils.

An undifferentiated *Polygnathus varcus* Zone was recorded by Klapper (in Perry et al., 1974, p. 1065) from Locality S-4 (Mount Burgess) at 2045 feet (623 m) above the base of the Ogilvie Formation. The diagnostic conodont elements in the sample comprise: *Polygnathus rhenanus* Klapper, Philip and Jackson and *Ozarkodina brevis* (Bischoff and Ziegler).

Brachiopods of the Ogilvie Formation have been studied by Perry (1971; and in Perry et al., 1974, p. 1060-1062). Forms listed by Perry (*ibid.*, p. 1060) from the lower Emsian part of the Ogilvie Formation show affinities to elements characteristic of the Cordilleran Subprovince of the Old World Province (Boucot et al., 1969) and comprise the following:

Athyrhynchus sp.
Bifida ogilviensis Perry
Cortezorthis sp. 1
Carinagypa sp.
Muriferella aff. *masurskyi* Johnson and Talent
Phagmostrophia aff. *merriami* Harper, Johnson and Talent
Warrenella sp. A.

Cosmopolitan forms from the lower Emsian part of the Ogilvie Formation comprise:

Atrypa sp.
Cyrtina sp.
Howellella sp.
Megastrophia sp.
Nucleospira sp.
Schizophoria sp.
Spinatrypa sp.
Spinulicosta sp.

Most of the brachiopods listed above are represented in Emsian beds of the Arctic Islands and in the *Eurekaspirifer pinyonensis* Zone of Nevada.

From the top of the Ogilvie Formation at Locality S-19, Perry (in Perry et al., 1974, p. 1061, 1094) recorded the following megafossils:

Pentamerella sp.
Pholidostrophia sp.
Najadospirifer sp.
Schizophoria sp.
Spinulicosta sp.
?*Gasterocoma bicaula* Johnson and Lane

This fauna is associated with conodonts suggesting an Emsian to Eifelian age, and may be assignable to the *Leptathyris circula* Zone of Nevada.

An Eifelian brachiopod fauna from the upper 70 feet (21 m) of the Ogilvie Formation at Section S-5 consisted of the following (Perry, in Perry et al., 1974, p. 1060, 1061):

"Productella" sp.
Spinulicosta sp.
?*Vallomyonia devonica* (Walcott)

Perry indicated that the affinities of the fauna are with both the upper *Leptathyris circula* and lower *Warrenella kirki* Zones of Nevada, dated as late Eifelian in age on the basis of associated conodonts.

Warrenella kirki (Merriam), the name bearer of the *kirki* Zone in Nevada, was recorded by Perry (in Perry et al., 1974, p. 1061, 1093) from the top of the Ogilvie Formation at Locality S-9 from a bed lacking diagnostic and datable conodonts. East of the report area, this form occurs abundantly in the upper Hume Formation.

Leiorhynchus castanea (Meek) occurs at the top of the Ogilvie Formation at Locality S-21 in beds lacking a datable conodont fauna (Perry, in Perry et al., 1974, p. 1061, 1094). This fossil occurs abundantly in the basal argillaceous beds of the Hare Indian Formation at Section 3 of this report (Norris, 1968a, p. 37), and in basal beds of the Hare Indian Formation at sections to the east along the Mackenzie front (Caldwell, 1971, p. 14).

Stringocephalids occur in scattered beds within the upper 1020 feet (310.9 m) of the Ogilvie Formation at Mount Burgess (Sec. 24; Norris, 1968b, p. 32). Conodonts associated with *Stringocephalus* sp. cf. *S. obesus* Grabau, from the top of the section at Mount Burgess, are assigned to the undifferentiated *varcus* Zone of Givetian age (Perry, in Perry et al., 1974).

A summary of the tetracoral fauna in the Ogilvie Formation has been presented by Perry and others (1974, p. 1065-1066) based on determinations and comments by A.E.H. Pedder.

The occurrence of *Martinophyllum* sp. in the lower 150 feet (46 m) of the Ogilvie Formation at Section S-26 suggests an Emsian age (Perry and others, 1974, p. 1066). This genus is known also in the *Sieberella* cf. *webbi* unit of Lenz (1968) in the Road River Formation at Royal Creek, in the Michelle Formation of the Blackstone - Hart rivers area, and in the Salmontrout limestone of eastern Alaska.

Spongonaria filicata Crickmay, *Spongonaria excavata* (Crickmay), *Spongonaria philotetes* Crickmay, *Spongonaria ogilviensis* Crickmay, and the tabulate/worm consortium of *Squameofavosites/Chaetosalpinx* are forms that occur in the late Emsian part of the Ogilvie Formation (Perry et al., 1974, p. 1066).

"Hexagonaria" sp. ex gr. *smithi* Pedder from 1010 feet (307.9 m) and *Embolophyllum* cf. *aequiseptatum* (Hill) from 1025 feet (312.4 m) above the base of the Ogilvie Formation at Section S-26 are similar to forms in the Taemas Limestone of New South Wales of late Emsian age (Perry et al., 1974, p. 1066).

Taimyrophyllum sp. from (the top) 625 to 635 feet (190.5 to 193.6 m) above the base of the Ogilvie Formation at Section S-18 is associated with conodonts that suggest an Emsian to early Eifelian age (Perry et al., 1974, p. 1066, 1094).

The presence of *Radiastraea* cf. *verrilli* (Meek) at 1410 feet (429.8 m) above the base of the Ogilvie Formation at Section S-6, where the formation is 1965 feet (598.9 m) thick, suggests an Eifelian age.

More recently, corals from the type section of the Ogilvie Formation at Mount Burgess (Sec. 24; 2190 ft; 667.5 m thick) have been identified by A.E.H. Pedder (GSC Internal report AWN-97-AEHP-79), based on collections by A.W. Norris made in 1962. Pedder identified the following forms from the interval 117.9 to 309.2 feet (35.9 to 94.2 m) above the base of the formation:

Alacophyllum (s.l.) sp. indet.
Aulocystites sp. undet.
Aulopora sp. indet.
Alveolites sp. indet.
Grabaulites? sp. undet.
Lekanophyllum sp. indet.
Roemeripora sp. cf. *R. spelaena* (Etheridge)
Stachyodes sp. undet. (a stromatoporoid)
Thecostegites sp. nov.
undet. solitary rugose coral fragment

These corals were dated as Zlichovian and/or Dalejan of late Early Devonian age, and were considered to occur in a moderately deep water platform facies. The genus *Thecostegites* was recognized for the first time in Canada. Previously this genus had been recorded by Oliver, Merriam and Churkin (1975, Pl. 20, figs. 13, 14) from the Seward Peninsula, Alaska.

Pedder identified indeterminable coral debris associated with *Gasterocoma*? *bicaula* Johnson and Lane among other fossils from 377.5 feet (115.1 m) above the base of the Ogilvie Formation. These he dated as Zlichovian to early Eifelian. The fossils occur in a debris bed and show a mixture of moderately deep and shallow water platform forms.

From the interval 549.4 to 823.8 feet (167.5 to 251.1 m) above the base of the formation Pedder identified:

Alveolites sp. undet.
Aulopora sp. indet.
Coenites sp. indet.
Cyclochaetetes sp. undet.
Dendrostella sp. nov.
Disphyllum (s.l.) sp. indet.
Favosites sp. undet.
Lekanophyllum sp. indet.
Mariusilites sp. undet.
Pachyfavosites sp. undet.
Thamnopora sp. indet.
Roemeripora? sp.
Zonophyllum sp. nov., - flattened eccentric form

This assemblage of corals was dated as early or late Eifelian of the early Middle Devonian. An oscillating, moderately shallow to moderately deep water platform environment is interpreted for this interval.

Pedder identified the following corals from the interval 835.9 to 1132.5 feet (254.8 to 345.2 m) above the base of the Ogilvie Formation:

Alveolites sp. (a form typical of the Hume Formation)
Aulocystis? sp. indet.
auloporid
Crassialveolites sp. indet.
Cladopora sp. indet.
Coenites? sp. indet.
Dendrostella trigemme (Quenstedt)
Favosites sp. undet.
Mariusilites sp. undet.
Microplasma caespitosum (Schlüter)
Psydracophyllum lonsdaleiaforme Pedder
Radiastraea tapetiformis (Crickmay)
Radiastraea verrilli (Meek) s.l.
Sociophyllum glomerulatum (Crickmay)
Syringopora sp. indet.
Thamnopora sp. indet.
Utaratuia? sp. nov. ex gr. *U.*? *praeclara* (Crickmay)
"Xstriphyllum" hyperbolicum Crickmay

This assemblage was dated by Pedder as late Eifelian and the interval correlated with the Hume Formation of the Norman Wells area.

Corals identified by Pedder from the interval 1145.9 to 1157.9 feet (349.3 to 352.9 m) above the base of the Ogilvie Formation comprise the following:

Aulopora sp. indet.
Australophyllum? sp. indet.
Crassialveolites sp. undet.
Cyclochaetetes sp.
Dendrostella trigemme (Quenstedt)
Favosites sp. undet.
Grypophyllum? sp. indet.
Sociophyllum sp. nov.
Syringopora sp. undet.

This assemblage was dated by Pedder as late Eifelian or early Givetian, and the limestone rock of the interval was considered to be of shallow to very shallow water platform origin.

Corals identified by Pedder from the interval 1163.4 to 1539.9 feet (354.6 to 469.4 m) above the base of the Ogilvie Formation comprise the following:

Dendrostella trigemme (Quenstedt)
Microalveolites sp. nov.

The sparse corals in this interval that overlap the lower range of stringocephalids in this section are dated by Pedder as early Givetian.

The only coral occurring in the interval 1761.9 to 2177.1 feet (537 to 663.6 m) above the base of the Ogilvie Formation and identified by Pedder is the following:

Dendrostella sp. nov.

This form occurs at several levels within the interval and is commonly associated with digitate and bulbous stromatoporoids and stringocephalids. The limestone within the interval is considered to be of shallow to very shallow water platform facies. The interval is dated as Givetian on the basis of stringocephalids ranging throughout the interval, and *varcus* Zone conodonts recovered from the upper 50 feet (15.2 m) of the formation at this section.

The trilobites from the Ogilvie Formation discussed by Norris (1968a, b) and by Perry, (in Perry et al., 1974) were identified by A.R. Ormiston.

From 870 feet (265.2 m) above the base of the Ogilvie Formation at Section S-1 where the formation is 1170 feet (356.6 m) thick, Perry et al. (1974, p. 1066) recorded *Astycoryphe* cf. *cimelia* Ormiston and *Schizoproetoides* sp.; and from 885 feet (269.8 m) in the same section, Perry recorded *Schizoproetoides* sp. A Ormiston. These were dated as Emsian.

From 960 feet (293 m) above the base of the Ogilvie Formation at Section S-1, Perry et al. (1974) recorded *Acanthopyge* (*Nitidulopyge*) *nitidula* Barrande, *Koneprusia* cf. *pennata* Lütke, *Leonaspis* sp., and *Otarion* cf. *druida* Erben. This assemblage of trilobites was dated as either late Emsian or Eifelian in age.

Perry et al. (1974, p. 1066) recorded *Lacunoporaspis* n. sp. from 330 feet (100.6 m) above the base of the Ogilvie Formation at Section S-15, where the formation is 550 feet

(167.6 m) thick. This form is of Emsian age and is considered to be conspecific with *Lacunoporaspis* cf. *norrisi* (Ormiston, 1971, Pl. 3, fig. 8) from 135 feet (41 m) above the base of the McCann Hill Chert, Alaska.

Ormiston, in Perry et al. (1974, p. 1066, 1067) pointed out that the Emsian trilobite fauna of the Ogilvie Formation is markedly similar to that of the coeval part of the McCann Hill Chert. Ormiston indicated also that *Koneprusia pennata*, *Acanthopyge* (*Nitidulopyga*) *nitidula*, and *Otarion druida* are present in Emsian age beds of the Lower Harz region of Germany. *Koneprusia* in North America, was known previously only from the Emsian part of the McCann Hill Chert (Ormiston, 1969; 1972, Pl. 1, Fig. 12), and from Siegenian age beds of the Cortez Range, Nevada (Haas, 1969).

At Section S-5, *Dechenella* (*D.*) *maclareni* Ormiston was recorded by Perry et al. (1974, p. 1067) from the upper 20 feet (6.1 m) of the Ogilvie Formation, where the formation is 1785 feet (549.1 m) thick. It is dated as late Eifelian on the basis of brachiopods and conodonts recovered from the upper 70 feet (21.3 m) of the formation.

At Section S-8, where the Ogilvie Formation is 2310 feet (704.1 m) thick, Perry et al. (1974, p. 1067) recorded *Ganinella* cf. *schebalienoensis* Yolkin and *Leonaspis* cf. *eremia* Ormiston from 1605 feet (489.2 m) above base; *Ancyropyge arctica* Ormiston and *Dechenella* aff. *valentini* Stumm from 1700 feet (518.2 m) above base; and *Dechenella* (*D.*) *maclareni* Ormiston and *Leonaspis* aff. *elliptica* (Burmeister) from 1815 feet (553.2 m) above the base of the formation. These species are considered to be of Eifelian age.

The goniatite *Cabrieroceras* cf. *karpinskyi* Holzapfel is recorded by Perry et al. (1974, p. 1067, 1093) from between 1765 and 1775 feet (538 and 541 m) above the base of the Ogilvie Formation at Section S-5, where the formation is 1785 feet (544.1 m) thick. A late Eifelian age is favored for this form on the basis of comparison with *Cabrieroceras* from Nevada, where it is firmly dated as Eifelian on conodont evidence (Perry et al., 1974, p. 1067).

The distinctive and widely distributed echinoderm ossicles with dumbbell-shaped and cross-like axial canals, here referred to as *Gasterocoma*? *bicaula* Johnson and Lane (1969), occur at irregular intervals within the lower part of the Ogilvie Formation. In east-central Alaska, Lane and Ormiston (1979, p. 46) record this form in the upper Salmontrout Formation and in the lower part of the Old Camp Formation. Associated conodonts at this locality indicate a range from the *serotinus* through the *patulus* into the *costatus costatus* Zones. In the Arctic Archipelago, Uyeno and Klapper (1980, p. 81) record the range of this form to be from the conodont *dehiscens* to *serotinus* Zones of the Blue Fiord Formation into the lower part of the overlying Bird Fiord Formation, which is not precisely dated but may be of Eifelian age. The "two-hole" ossicle occurring in members B and C of the Dawson Bay Formation in the outcrop belt of Manitoba (Norris, Uyeno and McCabe, in press), associated with Middle *varcus* Subzone conodonts of Givetian age, is a much smaller and more distinctive form.

Unnamed shale unit

The informally designated Unnamed shale unit is here used in the same sense as the "Unnamed shale unit" of A.W. Norris (1967, 1968a, b). It appears to be approximately equivalent to the Upper member of the McCann Hill Chert of adjacent Alaska, but may also include other, younger Devonian and Mississippian shale units. The McCann Hill Chert was introduced by Churkin and Brabb (1965, p. 180-182) for a 200 to 800 feet (61 to 243.8 m) thick sequence, consisting of limestone and shale in its lower part, and siliceous shale, chert, siltstone, and chert grit in its upper part. The type section is in the Nation-Tatonduk rivers area, of east-central Alaska, where it overlies dark shale of the Road River Formation, and underlies greywacke, chert conglomerate and silty shale of the Nation River Formation. Recently, R.B. Blodgett (pers. comm., January 16, 1982) has shown that the Lower member of the McCann Hill Chert, in the Jones Ridge-Squaw Mountain area of east-central Alaska, changes from a limestone and shale to a limestone. He has used the name Ogilvie Formation to apply to this limestone because of its lithological and faunal similarities to the Ogilvie Formation that previously had been traced by A.W. Norris (1968b, Fig. 5, sec. 23a) to the area immediately east of the Yukon-Alaska boundary. In the Jones Ridge-Squaw Mountain area of Alaska, the Ogilvie Formation is overlain by the (upper) Chert and shale member of the McCann Hill Chert.

The name Unnamed shale unit used in this report applies to a recessive unit comprising a variety of shales that overlie the markedly diachronous top of the carbonate Ogilvie Formation, and which are overlain by relatively resistant clastic carbonate rocks of Mississippian and younger age. The unit is poorly known because of its relative softness and lack of outcrops showing a continuous sequence. Commonly, the unit is marked by heavily vegetated valleys within which the outcrops are generally small, discontinuous and widely separated.

On the 1:500 000 scale composite GSC Map 1581A of the Operation Porcupine area by D.K. Norris (in press), rocks of the Unnamed shale unit have been included in a map unit designated as DCA. On the 1:250 000 scale GSC Map 1516A by D.K. Norris (1981), rocks of the Unnamed shale unit are included in map unit Dsh; on GSC Maps 1518A, 1519A, 1522A and 1527A by D.K. Norris (1981, 1982), they have been included in map unit DCA and on GSC Map 1526A by D.K. Norris (1982), they have been included in map units DCA and DMH.

The Unnamed shale unit appears to have approximately the same distribution as the underlying Ogilvie Formation, which occurs mainly within the southwestern part of the report area west of the Richardson Anticlinorium and southeast of the Dave Lord Uplift. Within this area, scattered outcrops of the unit have been noted in the northern Ogilvie Mountains of the Hart-Blackstone rivers area, along the eastern and southern flanks of the Nahoni Range, and in the Oglivie Mountains near the Yukon-Alaska boundary. To the north, it appears to be very thin or missing in the Mount Burgess area (Sec. 24).

A variety of shales were noted within the Unnamed shale unit at the scattered incomplete exposures. A black, fissile, noncalcareous shale occurs within the unit at the Ogilvie Mountains front between the Hart and Blackstone rivers (Sec. 18). Parts of the shale are oxidized to brick red and pink colours as seen from the air in the vicinity of, and immediately east of Hart River. The unit consists of black, hard, very fissile, siliceous shale weathering bluish grey or silvery grey, interbedded with minor amounts of soft, black shale at sections 21 and 22 along the eastern flank of Nahoni Range. Exposed beds consist of medium brownish grey shale, in part oxidized to a brick red colour at Section 23a in the Ogilvie Mountains between Ettrain and Jungle creeks near the Yukon-Alaska boundary. One of the more completely

exposed sequences of the Unnamed shale unit was measured at Section 46 in the southwestern part of the Ogilvie Mountains. There, the lower 470 feet (143.3 m) of the succession consists of black, hard, extremely fissile, noncalcareous, siliceous shale weathering silvery grey. A unit, about 37 feet (11.3 m) thick, of thinly and evenly bedded black chert occurs at 270 feet (74.2 m) above the base of the Unnamed shale unit. The upper 260 feet (79.2 m) of the section are more resistant and consist of thinly bedded, black, micritic, in part argillaceous limestone; some black, fissile, calcareous shale; and a few black, thinly bedded, cherty limestone beds near the middle of the sequence.

Clastic beds overlying the Ogilvie Formation on the eastern flank of the northern Ogilvie Mountains (Sec. 26) are suggestive of the Imperial Formation. The beds consist of fairly hard, black, noncalcareous, in part silty and ferruginous shale, with minor interbeds of sandstone.

Maximum thickness of the upper, Chert and shale member of the Unnamed shale unit in the type area in Alaska is about 730 feet (222.5 m) (Churkin and Brabb, 1965, Fig. 4). The thickness of the Unnamed shale unit in the report area appears to be roughly inversely proportional to the thickness of the underlying Ogilvie Formation. It is only about 560 feet (170.7 m) thick at the Ogilvie Mountain front between Hart and Blackstone rivers (Sec. 18), where the underlying Ogilvie Formation is 2305 feet (702.6 m) thick. Along the eastern flank of Nahoni Range, it varies in thickness from 1060 feet (323.1 m) at Section 22 in the north to 80 feet (249.9 m) at Section 21 in the south. In the southwestern part of the report area near the Yukon-Alaska boundary, the thickness of the Unnamed shale unit ranges from about 770 feet (234.7 m) at Section 46 to 580 feet (176.8 m) at Section 44. In the subsurface of the western Eagle Plain area in the Socony Mobil Western Minerals N. Cath. Y.T. B-62 well, at 66°11'13"N, 138°41'53"W, beds here assigned to the Unnamed shale unit are 1241 feet (378.3 m) thick and lie between depths of 1258 and 2499 feet (383.4 and 761.7 m). In this well, the underlying Ogilvie Formation is 1969 feet (600.2 m) thick.

Throughout the report area, the Unnamed shale unit conformably overlies resistant limestone beds of the Ogilvie Formation, the top of which is markedly diachronous from place to place. In the Nation River area of east-central Alaska, the upper Chert and shale member conformably overlies the lower Limestone and shale member of McCann Hill Chert, or limestone beds of the Ogilvie Formation. The latter relationship, as mentioned above, was recently established by R.B. Blodgett (pers. comm., January 16, 1982).

The contact between the uppermost shale and chert beds of McCann Hill Chert and the lowermost sandstone beds of the Nation River Formation, in the type area of east-central Alaska, is abrupt but definitely concordant and probably conformable according to Churkin and Brabb (1965, p. 181). The upper contact of the Unnamed shale unit along the Ogilvie Mountain front between Hart and Blackstone rivers (Sec. 18) is drawn at the base of hard beds consisting of silty shale, chert and cherty limestone, which contain fossils dated as late Mississippian (Chesterian) by E.W. Bamber (Norris, 1968b, p. 39). The upper contact on the east flank of Nahoni Range (Sec. 22) is drawn between bluish grey or silvery grey weathering, siliceous shale of the Unnamed shale unit and cherty carbonate beds that are of Carboniferous (Viséan) age according to E.W. Bamber (Norris, 1968b, p. 40).

In the southwestern and western parts of the report area, starting at about the *Polygnathus inversus* Zone (late Zlichovian-early Dalejan, late Early Devonian), shale deposition gradually encroached on the peripheral areas of the carbonate platform of the Ogilvie Formation. This encroachment continued over the carbonate platform so that by *Polygnathus varcus* Zone (Givetian, late Middle Devonian) time only the Mount Burgess area remained an active site of carbonate sedimentation. Eventually, it also was inundated. Shale deposition continued in the area until about Lower *Polygnathus asymmetricus* Zone (early Frasnian, early Late Devonian) time, after which the area was uplifted and an entirely different sedimentary regime, characterized by coarser clastic rocks, was initiated.

Fossils and age

The upper Chert and shale member of the McCann Hill Chert in the type area contains plant fragments and spores (Churkin and Brabb, 1965, p. 181). The plants are too poorly preserved for identification, but the spores from the upper part of the member are assigned to the Upper Devonian on the basis of similarity to assemblages in the overlying Upper Devonian Nation River Formation. Conodonts indicative of the Middle Devonian *australis* or *kockelianus* Zones are reported by Lane and Ormiston (1979, p. 50) from a level presumably high in the lower member of the McCann Hill Chert. Thus, evidence from the conodonts and spores suggests that the upper member of McCann Hill Chert ranges in age from Middle (late Eifelian) to early Late Devonian (early Frasnian).

Very few fossils have been recovered from the Unnamed shale unit of the report area. From the basal 140 feet (42.7 m) the dacryoconarid tentaculitids, *Nowakia* sp. aff. *N. holynensis* Boucek and *Styliolina* sp., have been reported by Perry et al. (1974, p. 1058, 1093-1094) from three sections as follows: S-13 at 65°22'N, 136°31'W; S-3 at 65°38'N, 136°47'W; and S-25 at 65°30'30"N, 140°10'00"W, all within the southwestern part of the report area. *Nowakia* sp. aff. *N. holynensis* suggests assignment to the dacryoconarid *holynensis* Zone, the base of which aligns with the upper part of the conodont *serotinus* Zone in Bohemia, of late Dalejan (late Early Devonian) age (Lütke, 1979, p. 285). The goniatite, *Agoniatites* sp. cf. *A. fulguralis* (Whidborne), has been reported by House and Pedder (1963, p. 501, p. 509-510) from beds of the Unnamed shale unit outcropping on Ogilvie River at 65°20'N, 138°44'W. This fossil indicates a late Middle Devonian (Givetian) age. The locality is near sections 20, 21 and 23 of this report. Plant fragments have been noted at different levels within the unit at several sections.

At Section 21, plant fossils were noted about 300 feet (91.4 m) above the base; and at Section 26, plant stem impressions were collected loose at 338-388 and 453-457 feet (103-118.3 and 138.1-139.3 m) above the base. Also from Section 24, extremely corroded spores comprising *Hystricosporites* sp. and *Pilasporites plurigenus* Balme and Hennelly were identified by D.C. McGregor in a sample from 304-309 feet (92.7-94.2 m) above base. McGregor indicated that *Hystricosporites* is the more diagnostic form with a range from Emsian to Famennian of the Devonian and extending rarely into the Carboniferous.

From the subsurface of Socony Mobil Western Minerals North Cath. Y.T. B-62 well (66°11'13.5"N, 138°41'53"W), located 24 kilometres east of Section 26, anaptychi (or spathiocarids) have been identified by A.W. Norris from a black siliceous shale at a depth of 1298 feet (395.6 m). The black siliceous shale in this well is 113 feet (34.4 m) thick and occurs between depths of 1258 and 1371 feet (383.4 and 417.9 m), the lower depth being 1390 feet (423.7 m) above the top of the Ogilvie Formation. Goniatite anaptychi (or

spathiocarids) have been recorded previously by Norris (1968b, p. 43) from the Canol Formation at Section 1, immediately east of Arctic Red River; by House and Pedder (1963, p. 534-535, Text-fig. 15) from their "upper dark shale unit" (=lower Canol Formation of Tassonyi, 1969, p. 94) on Carajou Ridge, associated with *Ponticeras* sp. cf. *P. tschernyschewi* (Holzapfel); and from the Canol Formation at Thunder River. The faunal evidence and lithological similarity in the B-62 well suggest that a thin succession, equivalent to the Canol Formation, is present in the upper part of the Unnamed shale unit west of the Richardson Anticlinorium. The beds designated as Canol Formation by Pugh (1983, Fig. 27a) in the B-62 well are considered here as the basal beds of the Unnamed shale unit, [which are 1128 feet (343.8 m) below the base of the true Canol equivalent].

Mount Baird Formation

The name Mount Baird Formation is introduced here to apply to a rock succession consisting mainly of calcareous shale overlying a tongue of the Road River Formation and underlying the Canol Formation in the area west of Snake River. The succession is named after Mount Baird, which is one of the more prominent, named peaks in the Mackenzie Mountains, located a short distance to the south. The type section, Section 6, is that described by A.W. Norris (1968b, p. 35-36, 111-123) where the beds here named the Mount Baird Formation were referred to as the Hare Indian Formation, although it was known at that time that the lower part of the sequence was older than the Hare Indian and Hume formations, which are typically developed to the east. In some of the early industry reports, the Mount Baird beds were referred to informally as the "Battleship Grey Unit". On the 1:250 000 scale GSC Map 1529A of the Snake River area by D.K. Norris (1982), rocks of the Mount Baird Formation are included in a map unit designated as DHCI .

Beds of the Mount Baird Formation outcrop in the area immediately west of Snake River near the western end of the Mackenzie Fold Belt, where it abuts the southeast flank of the Richardson Anticlinorium. Based on data from the nearest outcrop and subsurface sections, the Mount Baird Formation occurs in a narrow belt between a carbonate platform succession to the east and a shale basin succession to the west. As one would expect, tongues typical of both carbonate and shale facies interfinger at Section 6. At Section 4, near the headwaters of Cranswick River, a tongue of the Mount Baird Formation occurs at the top of the section.

The thickness of the Mount Baird Formation in the type area is about 1950 feet (594.4 m). Near the headwaters of Cranswick River at Section 4, where the beds are present as a tongue and truncated by a fault, about 260 feet (79.2 m) of strata were measured.

The lithology of the Mount Baird Formation at the type section consists predominantly of dark greenish grey, calcareous shale, weathering orange-brown. Four relatively thin units of more resistant, thin bedded, rubbly, argillaceous, micritic limestone, weathering yellowish brown, occur in the succession; two in the lower one-fifth, and two in the upper quarter of the section. At Section 4, where the Mount Baird Formation appears to pinch out as a tongue overlying the Cranswick Formation, it consists of black calcareous shale weathering orange-brown.

The Mount Baird Formation at Section 6 overlies a tongue of black bituminous shale of the Road River Formation. The contact is sharp, but appears to be conformable. At Section 4, near the headwaters of Cranswick River, a tongue of the Mount Baird Formation overlies resistant, cherty limestone beds of the Cranswick Formation (A.W. Norris, 1968b, Pl. II).

The Mount Baird Formation is overlain by dark shale of the Canol Formation at Section 6. The actual contact is covered there, but the relationship is assumed to be unconformable because fossils from the uppermost exposed Mount Baird beds suggest correlation with the Hume Formation. Near the headwaters of Cranswick River, at Section 4, the upper beds of the Mount Baird Formation have been truncated by faulting.

The calcareous shale and argillaceous limestone beds of the Mount Baird Formation are interpreted as shelf slope deposits that are transitional between a shallow water carbonate shelf succession to the east, and a deep water, noncalcareous shale basin succession to the west. This transitional facies appears to be confined to a relatively narrow belt on the southeast flank of the Richardson Anticlinorium. Lithologically, the Mount Baird Formation is somewhat analogous to the Hare Indian Formation of the Norman Wells area, and to the Funeral Formation of the South Nahanni River area.

Fossils are relatively abundant in the Mount Baird Formation, particularly in the argillaceous limestone beds which contain a profusion of brachiopods, rugose and colonial corals, trilobites, pelecypods, gastropods, cephalopods, tentaculitids and echinoderm fragments. Dacryoconarid tentaculitids and inarticulate brachiopods are confined mainly to the more argillaceous parts of the sequence. Although a list of tentative identifications of this rich fauna was provided by Norris (1968b, p. 37-38), most of it, with the exception of some *Warrenella* and trilobites, has not been systematically studied.

The brachiopods, *Warrenella crickmayi* Ludvigsen and Perry (1975, p. 78-79, Pl. 15, figs. 10-32, Text-fig. 20) and *Warrenella weigelti meeki* Ludvigsen and Perry (1975, p. 82-84; Pl. 16, figs. 16-20; Pl. 17, fig. 25; Pl. 18, figs. 1-12; Text-fig. 22) are from the upper part of the Mount Baird Formation from two localities in the Snake River area near the type section. *W. crickmayi* is known also from the Headless Formation from a section 32 kilometres northwest of Caribou Pass and the Backbone Ranges of the Mackenzie Mountains at 63°44'N, 129°38'W (Ludvigsen and Perry, 1975, p. 90). *Warrenelli weigelti meeki* associated with *Warrenella kirki* (Merriam), has been recorded also from the Headless Formation, 355 feet (108.2 m) below the base of a thin Nahanni Formation, 32 kilometres north of the South Nahanni River and Arnica Range at 64°48'N, 125°15'W (Ludvigsen and Perry, 1975, p. 90). These forms, on the basis of their relationships to older and younger *Warrenella*, are dated as late Eifelian or early Givetian. The association of *W. kirki*, which has been well dated elsewhere, suggests an Eifelian, probably early Eifelian age.

Trilobites identified by A.R. Ormiston from the type section of the Mount Baird Formation comprise the following: *Dechenella* (*D.*) sp. cf. *D.* (*D.*) *paragranulata* Ormiston, from 347 feet (105.8 m) above base; *D.* (*D.*) sp. cf. *D.* (*D.*) *maclareni* Ormiston, from 360.5, 1112 and 1179 feet (109.9, 338.7 and 359.4 m) above base; and *D.* (*D.*) *maclareni* Ormiston from 1347 feet (410.6 m) above base of formation. The most diagnostic form is *D.* (*D.*) *maclareni* which indicates an Eifelian, early Middle Devonian age, according to Ormiston.

Nucleospira sp. was recovered from near the top of the formation between 1592 and 1632 feet (485.2 and 503.5 m) above the base, and this form, according to Hogg (1965), suggests correlation with the upper part of the Hume Formation to the east.

Hume Formation

The name Hume Formation was proposed by Bassett (1961, p. 486) for the sequence consisting of fossiliferous Middle Devonian limestone and, in places, interbedded shale that overlies the Bear Rock Formation and underlies the Hare Indian Formation. The type section of the Hume Formation designated by Bassett is on the east branch of Hume River at the front of the Mackenzie Mountains (65°20'30"N, 129°58'00"W). The Hume Formation is equivalent to the unit designated as the "Lower Ramparts Limestone Member" by Hume and Link (1945, p. 19) on Mackenzie River. Crickmay (1960, p. 877) proposed the name Norman Wells Formation for strata equivalent to Bassett's Hume Formation in the Norman Wells area. Although the name Norman Wells Formation predates that by Bassett, it has not gained acceptance.

The Hume Formation was recognized by Tassonyi (1969) in the subsurface throughout the lower Mackenzie River region and can be traced from the type area along the front of the Mackenzie Mountains to Arctic Red River (secs. 1 and 2) and near Cranswick River (Sec. 3). These sections are located immediately east of, and just within, the southeastern part of the report area.

The thickness of the Hume Formation ranges from 400 feet (121.9 m) at the type locality to 550 feet (167.6 m) in the central Mackenzie region (Bassett, 1961, p. 487). The average thickness in the subsurface of the Norman Wells area is 375 feet (114.3 m). Northwestward, the Hume Formation decreases in thickness from 293 feet (89.3 m) in the R.O.C. et al., Grandview Hills No. 1 well (67°06'12"N, 130°52'30"W), to 195 feet (59.4 m) in the Richfield et al. Point Separation No. 1 well (67°34'06"N, 134°00'10"W) (Tassonyi, 1969, p. 63). Immediately east of, and just within, the southeast corner of the report area, the thickness ranges from 398 feet (121.3 m) at Section 2 to 757 feet (230.7 m) at Section 3.

Bassett's (1961, p. 487) lithological description and five-fold subdivision of the Hume Formation is as follows in ascending order: (1) limestone, finely crystalline, with interbeds of brown to dark grey, platy, calcareous shale 25 feet (7.6 m) thick; (2) limestone, argillaceous, upper half very fossiliferous, and grey, calcareous shale 240 feet (73.2 m) thick; (3) limestone, very fossiliferous, 90 feet (27.4 m) thick; (4) shaly limestone and calcareous shale 15 feet (4.6 m) thick; and (5) limestone, fossiliferous, 30 feet (9.1 m) thick.

Tassonyi (1969, p. 64-67) subdivided the Hume Formation into three informal members, and designated the Imperial Loon Creek No. 2 well (65°07'20"N, 126°28'51"W) as the subsurface reference section. Tassonyi's (1969) Lower member consists of brown, bioclastic limestone, calcareous shale and thin bedded, brown and grey, dense, argillaceous limestone, having a thickness of 125 feet (38.1 m) in the reference well. The Middle member consists predominantly of grey-green, greenish grey or grey, calcareous shale with interbedded, dense, argillaceous or silty, fossiliferous limestone, having a thickness of 60 feet (18.3 m). The Upper member, with an average thickness of 197 feet (60 m) in the Norman Wells area, consists of brown limestone, including argillaceous to pure calcilutite and fine, bioclastic limestone.

The lithology of the Hume Formation in the Arctic Red River area (A.W. Norris, 1968b, p. 33, secs. 1 and 2, Pl. VIII) comprises richly fossiliferous, black, nodular, irregularly and evenly bedded limestone and argillaceous limestone weathering brown and grey, separated by dark shale laminae. On Flyaway Creek (Norris, 1968b, p. 33, Sec. 8, Pl. VII), the formation consists of black, fine grained, rubbly, thick- to thin-bedded limestone weathering dark to light grey, some beds of which contain numerous corals; and black, fissile, ferruginous noncalcareous shale, 60 feet (18.3 m) thick, in the upper quarter of the formation.

To the south, in Section 4, near the headwaters of Cranswick River, beds of the Hume Formation change to purer carbonates that are assigned to the upper part of the Cranswick Formation. To the west, as in Section 6 in the Snake River area, beds of the Hume Formation pass into shale in the upper part of the Mount Baird Formation.

Bassett (1961, p. 487) indicated that the contact between the Hume Formation and underlying Bear Rock Formation is sharp and probably disconformable at many localities in the central Mackenzie River region. However, at some localities, a thin transition zone seems to connect the Hume and Bear Rock formations. Where the transition zone is relatively thick, selection of the lower contact is rather arbitrary, and was placed by Bassett (1961) at the top of the uppermost dolomite bed.

Tassonyi (1969, p. 65-66) indicated that the contact or contact zone of the Hume Formation with the underlying pellet limestone of the Gossage is marked in the subsurface by dark shale partings, or greyish green pyritic shale, or pyritic dense limestone. In the Norman Wells area, interbedded dolomitic limestone, poorly pelleted limestone, and limestone and dolomite intervene between argillaceous limestone and shale of the Hume Formation and the brecciated dolomite and anhydrite of the Bear Rock Formation. This mixed lithology was assigned to the Gossage Formation and the base of the Hume Formation was selected at its top.

At Section 2, immediately west of Arctic Red River, the lower contact is drawn between recessive, richly fossiliferous argillaceous limestone and shale of the Hume Formation, and the underlying resistant, dark, micritic limestone of the Cranswick Formation (Norris, 1967, p. 9-10).

To the west, at Section 3 on Flyaway Creek, where the Hume Formation is less easily recognized because it has become a different facies with less shale and purer limestone, the contact is drawn between limestone and argillaceous limestone (weathering orange-brown), of the Hume Formation, and micritic limestone (weathering medium to dark grey), of the Cranswick Formation.

In the Norman Wells area, the upper contact of the Hume Formation with the Hare Indian Formation is sharp but shows no erosion, according to Bassett (1961, p. 487). For the same area, Tassonyi (1969, p. 66) indicated that, in the subsurface, the contact between the limestone of the Hume Formation and bituminous shale of the overlying spore-bearing member of the Hare Indian Formation is well expressed on all mechanical logs, and reflects an abrupt change in environmental conditions.

At Section 1, immediately east of Arctic Red River, the Hume Formation is overlain by a 2-foot (0.6-m) thick

argillaceous limestone coquina bed of *Leiorhynchus castanea* (Meek) of the Hare Indian Formation, which, in turn, is sharply and disconformably overlain by the Canol Formation (Norris, 1968b, p. 33). Immediately west of Arctic Red River (Norris, 1968b, p. 33, Sec. 2, Pl. VIII) and on Flyaway Creek (Norris, 1968b, p. 33, Sec. 3, Pl. VII), the coquina bed is missing and the Hume is sharply and disconformably overlain by shale of the Canol Formation.

The area of deposition of the Hume Formation was a shallow shelf of low relief. The bedded, in part bioclastic and lagoonal, dense limestone and shale, indicate a normal marine environment. Influx of argillaceous material, particularly toward the north, suggests instability and uplift of a source area in that direction.

Fossils are exceedingly abundant in the Hume Formation, particularly in the more argillaceous limestone beds. Numerous workers have listed, described and illustrated, or commented on part of this rich fauna; these include Warren and Stelck (1950, 1956), Crickmay (1960, 1966), Bassett (1961), Lenz (1961), McLaren (1962), McLaren, Norris and McGregor (1962), Braun (1966), Tassonyi (1969), Norris (1968a, b; 1979) Caldwell (1971), Lenz and Pedder (1972), Pedder (1975), Uyeno (1979), Chatterton (1979), and others.

Two broad megafaunal associations have been recognized for many years in the Hume Formation of the lower and central Mackenzie River region. The lower, *"Schuchertella" adoceta* Zone, in the Hume Formation, was introduced and used by Crickmay (1960, p. 1), and a similar usage has been followed by Caldwell (1971), Lenz and Pedder (1972), Pedder (1975), and others. Pedder (1975, p. 572) has pointed out that where the Hume Formation is relatively thin, as in the Anderson River area, the zone occurs in the basal beds of the formation. In thicker sections, as in the Franklin and Mackenzie mountains, the zone spans a sequence about 195 feet (59.4 m) thick, the base of which is about 25 feet (7.6 m) above the lower contact of the formation. Most of the associated brachiopods in the *adoceta* Zone extend into higher zones. Pedder (1975, p. 572) has indicated that the corals *"Microcyclas" multiradiatus* (Meek), *Radiastraea trochomisca* (Crickmay) and *Taimyrophyllum triadorum* Pedder probably are diagnostic of the zone. *"S." adoceta* has been found in the Dunedin Formation of northeastern British Columbia (Taylor and Mackenzie, 1970), in the Headless Formation and lower part of the Nahanni Formation of southwestern District of Mackenzie (Ferguson and Noble, 1971), and in other formations in the southwestern District of Mackenzie.

The succeeding *Carinatrypa dysmorphostrota* Zone of Pedder (1975, p. 572) is equivalent approximately to the *Radiastraea verrilli* Zone of Crickmay (1950, 1966) and to the *"Spinulicosta" stainbrooki* fauna of Caldwell (1971). *C. dysmorphostrota* is preferred by Pedder (1975) as the zonal index because both *R. verrilli* and *"S." stainbrooki* occur with *"Schuchertella" adoceta* in the basal beds of the Hume Formation on Anderson River. The zone occurs in roughly the upper quarter of the Hume Formation, where it is best represented in the more argillaceous beds. Diagnostic brachiopods in the zone include *Spinatrypa borealis* (Warren), *Spinatrypa andersonensis* (Warren), and *Spinatrypa coriacea* Crickmay (Pedder, 1975, p. 572). Other important brachiopods in the zone listed by Caldwell (1971, p. 6) include *Desquamatia arctica* (Warren) and *"Plectospirifer" compactus* (Meek). Corals considered diagnostic of the zone comprise (Pedder, 1975, p. 572): *Radiastraea tapetiformis* (Crickmay), *Taimyrophyllum stirps* (Crickmay) (strict sense), *Aphroidophyllum howelli* Lenz, *A. meeki* Pedder and *Mackenziephyllum insolitum* Pedder.

Conodonts identified by Uyeno (1978, p. 236-237) from an interval 45.4 to 58.2 m (148.9 to 190.9 feet) above the base of the Hume Formation at Powell Creek are indicative of the *australis* Zone (Klapper and Johnson, 1980, p. 444-445) and dated as early to mid-Couvinian age (Co1a to Co2b). These conodonts are within the brachiopod *"Schuchertella" adoceta* Zone. More recently, Uyeno (pers. comm., February 15, 1982) has identified conodonts indicative of the *australis* Zone from as low as 13.7 m (45 feet) above the base of the Hume Formation at Powell Creek.

Conodonts identified by Uyeno (1978, p. 236-238) from between 110.6 and 131.1 m (362.9 to 430.1 ft) above the base of the Hume Formation at Powell Creek are aligned by Klapper (in Klapper and Johnson, 1980, p. 445) with the *kockelianus* Zone of late Couvinian (Co2c to Co2d), early Middle Devonian age.

From the type section of the Hume Formation on Hume River, Braun (1966, p. 249-250) obtained three distinct ostracode assemblages, which he referred to informally as faunas a, b, and c in ascending sequence. Fauna a characterizes the basal 5 feet (1.5 m) of the formation; fauna b the succeeding 200 feet (61 m); and fauna c the remaining 197 feet (60 m) of the Hume Formation. Ostracode faunas a, b and c of Braun (1966) were later referred to by Braun (1978) as upper DM4, lower DM5 and upper DM5 sub-assemblages, which he assigned to the Eifelian of the lower Middle Devonian.

The fossils listed by Norris (1968b, p. 34-35) from the upper 35.6 feet (10.9 m) of exposed Hume beds at Section 1 immediately east of Arctic Red River, and from the complete Hume Formation (398 ft/121.3 m thick) at Section 2 immediately west of Arctic Red River, are indicative of the *Carinatrypa dysmorphostrota* Zone. As mentioned above, this zone in the Powell Creek area, is represented in roughly the upper quarter of the formation. The underlying *"Schuchertella" adoceta* Zone of the Hume Formation is not recognizable in the Arctic Red River area. One might expect to find representatives of this zone in the upper part of the Cranswick Formation of this area. To the west, at Section 3 on Flyaway Creek, the limestone and shale beds considered to be laterally equivalent to the Hume Formation are conspicuously less fossiliferous. The beds in question are more like those of the Cranswick Formation recognized to the south and west.

Hare Indian Formation

The name "Hare Indian River shale" was introduced by Kindle and Bosworth (1921, p. 45B) to designate the shale underlying the "Ramparts Limestone", partly exposed at the lower end of the Ramparts gorge on Mackenzie River. Only the upper 95 feet (29 m) of the formation are exposed at this type locality. These authors mentioned exposures also at the mouth of the Hare Indian River, after which the rock unit was named, and also in the cliffs below Fort Good Hope. Hume and Link (1945, p. 20) substituted the name "Middle Ramparts shale member" for this unit and selected a type section in the Imperial Range on Mountain River, where the unit is completely exposed. Bassett (1961, p. 490-492) retained the name used by Kindle and Bosworth (1921) but abbreviated it to Hare Indian Formation. This name, as used by Bassett, applies to the predominantly shale sequence overlying carbonate of the Hume Formation and underlying either carbonate of the Ramparts Formation or dark shale of the Canol Formation where the Ramparts is not developed.

Bassett (1961) and Tassonyi (1969) recognized the Hare Indian Formation throughout the Norman Wells area, and it is known to extend as far north as Anderson River. Westward, along the Mackenzie Mountain front, it is last seen as an erosional remnant in Section 1 immediately east of the Arctic Red River. Northwest of the Norman Wells area, Tassonyi (1969, p. 71, Fig. 11) recognized the formation in all wells except the Richfield et al. Point Separation No. 1 well (67°34'06"N, 134°00'10"W), where the Canol is shown resting disconformably on a thin, shaly facies of the Hume Formation.

The thickness of the Hare Indian Formation where it is fully developed in the Norman Wells-Fort Good Hope area ranges from 500 to 600 feet (152.4 to 182.9 m) (Bassett, 1961, p. 491). At Section 1, immediately east of Arctic Red River, 2 feet (0.6 m) of the formation are present as an erosional remnant.

Two lithologically distinctive shale units were recognized by Bassett (1961) and Tassonyi (1969) in the Hare Indian Formation. The lower, thinner part of the formation is referred to informally by Tassonyi (1969, p. 71) as the Spore-bearing member. It also is referred to as the Bluefish Member by some workers (e.g. Pugh, 1983). The lower, Spore-bearing member consists of very dark brownish grey or black bituminous, in part noncalcareous and calcareous shale. In the Imperial Hoosier Ridge No. 1 well (65°24'16"N, 127°32'14"W), selected by Tassonyi (1969, p. 71) as the type section, this member is 85 feet (25.9 m) thick, but more commonly it is between 30 and 50 feet (9.1 and 15.2 m) thick. The upper unit of the formation consists predominantly of dark grey, calcareous shale with generally less than 10 per cent of interbedded calcareous siltstone and argillaceous or silty limestone.

The erosional remnant of Hare Indian beds at Section 1, immediately east of Arctic Red River, consists of 2 feet (0.6 m) of dark grey, evenly and irregularly thin-bedded, slightly argillaceous, abundantly fossiliferous limestone, weathering pale brown and in places stained a rusty brown (Norris, 1968b, p. 90).

The lower contact of the Hare Indian Formation with the Hume Formation is described by Bassett (1961, p. 490) as being sharp but conformable. It is apparent that, where this contact is gradational, different workers have selected slightly different levels. The upper contact of the formation with the Ramparts Formation is generally sharp in the Norman Wells area, but appears to be transitional in the Circle River area, according to Tassonyi (1969, p. 73). Where the limestone of the Ramparts Formation is not present, the shale of the Hare Indian Formation is overlain by shale of the Canol Formation. Bassett (1961, p. 491) listed the following criteria for distinguishing these two shales where they superficially resemble one another. The Hare Indian Formation is commonly slightly calcareous, rarely sulphurous, rarely siliceous, commonly of light greenish grey, grey or medium grey colour, contains some macrofossils, and abundant microfossils. In contrast, the Canol Formation is rarely calcareous, commonly sulphurous, commonly siliceous, dark grey to black in colour, and is rarely fossiliferous.

West and northwest of Gayna River and vicinity, at approximately 65°18'N, 129°21-27'W, the hiatus progressively increases between the base of the Canol and underlying formations (see Braun, 1977, Text-fig. 2, p. 89). As mentioned above, an erosional remnant of the Hare Indian Formation is last seen at Section 1 immediately east of Arctic Red River, where it is disconformably overlain by the Canol Formation. In Section 2, to the west, where the Hare Indian Formation is missing, the Canol disconformably overlies beds of the Hume Formation.

The environment of deposition of the basal Spore-bearing member of the Hare Indian Formation is considered by Tassonyi (1969, p. 76) to be of shallow water and euxinic origin. Tassonyi (1969) postulated that open circulation may have been cut off by a regional uplift to the north, coinciding approximately with the Campbell Uplift, which extends eastward across the Anderson Plain. He suggested that this tectonic uplift may have influenced sedimentation across the whole shelf area during deposition of the Spore-bearing member. An alternative interpretation is that the Spore-bearing member represents a stillstand on the shelf, with depressions in the Hume Formation filling up with black organic mud. The upper member of the Hare Indian Formation was deposited in a shallow water, more open marine environment, as is indicated by the calcareous shale and occasional thin interbeds of limestone.

Numerous workers have described or illustrated, listed, discussed or commented upon the fossils occurring in the Hare Indian Formation of the lower and central Mackenzie River region. These include: Meek (1867), Warren (1944), Warren and Stelck (1950, 1956), Crickmay (1960, 1963, 1966), McLaren (1962), Braun (1966, 1977), Caldwell (1967, 1971), Norris (1968a, b), Tassonyi (1969), Lenz and Pedder (1972), Pedder (1975), Chatterton (1979), Uyeno (1979), and others.

The succession of megafossils recognized by Caldwell (1971, p. 6-7) in the Hare Indian Formation comprises the following in ascending sequence: *Leiorhynchus castanea*, *"Emanuella" meristoides*, and *Rhyssochonetes aurora*. The *castanea* fauna, recognized as a zone by Warren and Stelck (1950, p. 73) and Pedder (1975, p. 572-573), occurs in the basal Spore-bearing member of Tassonyi (1969). The *castanea* fauna throughout the area commonly occupies a relatively thin succession less than 20 feet (6.1 m) thick which, by definition (Bassett, 1961; Tassonyi, 1969), comprises the basal beds of the Hare Indian Formation. Common associates of the *castanea* fauna include *Cassidirostrum pedderi* McLaren in the Anderson River area (Caldwell, 1971, p. 6); *Pentamerella? borealis* (Meek) and *Warrenella kirki* (Merriam) listed by Pedder (1975, p. 572); and numerous tentaculitids and *Styliolina fissurella* (Hall) noted by Bassett (1961) and Tassonyi (1969, p. 72).

Common associates of the succeeding *"Emanuella" meristoides* fauna of Caldwell (1971, Text-fig. 2, p. 6) comprise: *Emanuella "richardsoni"* (Meek), *Warrenella kirki* (Merriam), and *Warrenella franklini* (Meek). This fauna occurs approximately in the lower half of the Hare Indian Formation above the *castanea* fauna.

Fossils commonly associated with the succeeding *Rhyssochonetes aurora* fauna of Caldwell (1971, Text-fig. 2, p. 6) comprise: *Echinocoelia* sp. *"Emanuella" meristoides* (Meek), *Warrenella kirki* (Merriam), and *Productella"* sp. This fauna occurs in roughly the upper half of the Hare Indian Formation.

A rich *castanea* fauna occurs in the 2 feet (0.6 m) of basal beds of Hare Indian Formation recorded by A.W. Norris (1968b, p. 37) from Section 1, immediately east of Arctic Red River. This fauna includes: productellid n. genus and sp., *Spinulicosta* sp., *Schizophoria* sp. cf. *S. macfarlanei* (Meek), *Desquamatia* sp. cf. *D. arctica* (Warren), and other atrypid species, *Hadrorhynchia intermissa* Crickmay, *Leiorhynchus awokanak* McLaren, *Leiorhynchus castanea* (Meek), *Emanuella meristoides* (Meek), *Warrenella kirki* (Merriam), and cf. *Straparolus* sp.

Conodonts, identified by Uyeno (1978, p. 238) from the *castanea*-bearing beds at Powell Creek and here considered the basal beds of the Hare Indian Formation, are assigned to the conodont *ensensis* Zone (Uyeno, pers. comm., November 6, 1981; Klapper in Klapper and Johnson, 1980, p. 413). The conodont *ensensis* Zone is shown by Klapper and Johnson (1980, Text-fig. 1, p. 403) to be aligned with the uppermost Eifelian and lowermost Givetian Stages of the Middle Devonian.

The ammonoid *Cabrieroceras karpinskyi* (Holzapfel) is recorded by Uyeno (1979) in concretions from the basal part of the Hare Indian Formation, from his Locality 5, located 13 miles (20.9 km) southeast of Norman Wells. This ammonoid, according to House (in House and Pedder, 1963, p. 515), characterizes the middle to upper Givetian.

Conodonts identified by Uyeno (1979, p. 238) from the upper part of the formation at Powell Creek, that is from 130.5 m (428.1 ft) and 141 m (462.6 ft) above the base, indicate assignment to an undifferentiated *varcus* Zone. At other localities, this interval contains the *Ectorensselandia laevis* Zone of Pedder (1975, p. 573) or the *Rhyssochonetes aurora* fauna of Caldwell (1971, Text-fig. 2, p. 6). Conodonts associated elsewhere with the latter form suggest that the upper Hare Indian beds probably are assignable to the Middle *varcus* Subzone.

The ostracodes from the Hare Indian Formation have been studied by Braun (1966, 1977, 1978). In the first paper, Braun (1966) established a microfaunal unit "d" for correlating the lower and middle, shaly parts of the Hare Indian Formation; and sub-assemblages e_1 to e_3 for correlating the upper, transitional beds of calcareous shale and argillaceous limestone below the *Stringocephalus*-bearing beds. In later papers, Braun (1977, 1978) used the term DM6 assemblage to apply to the succession of ostracode faunas in the Hare Indian Formation and equivalent rocks. A lower DM6 sub-assemblage is equivalent to the former "d" fauna, and an upper DM6 sub-assemblage contains the former e_1 to e_3 faunas.

In conclusion, a large number of taxa indicate that most of the Hare Indian Formation is Givetian in age, and where it occurs beneath the Ramparts Formation it probably ranges from early to middle Givetian. Where the upper beds of the formation are a facies equivalent of the Ramparts Formation, these upper beds may be late Givetian or possibly younger.

Canol Formation

The name Canol Formation was introduced by Bassett (1961, p. 494) for the black shale unit that overlies the Kee Scarp Formation (=Ramparts Formation of Tassonyi, 1969), and the Hare Indian Formation where the Kee Scarp is missing. Previously, this stratigraphic unit was referred to as the bituminous "Fort Creek shales" by Kindle and Bosworth (1921), and as the "Bituminous zone" of the "Fort Creek Formation" by Hume and Link (1945) and Hume (1954). The type section of the Canol Formation is on the northwest side of Powell Creek at the Mackenzie Mountain front (65°16'30"N, 128°46'30"W). There, it consists of 75 feet (22.9 m) of dark grey to black, predominantly noncalcareous, soft to very hard, greenish and yellowish weathering shale. It overlies cherty and shaly limestone beds of the Ramparts Formation and underlies 54 feet (16.5 m) of soft black shale of the Imperial Formation (Tassonyi, 1969, p. 90).

In the report area, the Canol Formation can be traced along the Mackenzie Mountain front westward to the Snake River area (secs. 1, 2, 3, 6), and along the east and west flanks of the Richardson Anticlinorium (secs. 11, 35). West of the Richardson Anticlinorium, the Canol Formation becomes indistinguishable in the upper part of the McCann Hill Tongue, and in the upper part of the upper Chert and shale member of the Unnamed shale unit of east-central Alaska. It is apparent also that, where the Canol Formation becomes silty and sandy, the unit has been placed in the lower part of the Imperial Formation.

On the 1:250 000 scale geological maps of the Operation Porcupine area prepared by D.K. Norris, beds of the true Canol Formation have been included in map unit DHCI on GSC map 1529A; and in map unit DCA on GSC maps 1523A, 1524A, 1528A, and the northeast part of 1527A. On GSC maps 1522A, 1526A and the southwest part of 1527A, the rocks designated as map unit DCA by D.K. Norris are referred to as the Unnamed shale unit in this report.

Thickness of the Canol Formation in the southeastern part of the area ranges from about 360 feet (109.7 m) at Section 3 to about 470 feet (143.3 m) at Section 1 (A.W. Norris, 1968b, p. 42). Along the eastern flank of the Richardson Mountains, the thickness is about 740 feet (225.5 m) at Section 35 on Trail River. On the southwest side of the Richardson Mountains, the thickness is about 500 feet (152.4 m) at Section 11 on upper Prongs Creek. A short distance to the west, at Section 12 on Clear Creek, beds of the Canol Formation become less distinguishable from the lower part of the Imperial Formation.

In the subsurface of the type area, the Canol Formation has been subdivided into three informal members by Tassonyi (1969, p. 92). The Lower member is characterized by high resistivity, and consists of black or dark-chocolate coloured, very hard, siliceous, noncalcareous shale. The Middle member is characterized by low resistivity, and consists of a thinner sequence of grey and dark grey, slightly calcareous and noncalcareous, and partly bituminous shale. The Upper member is characterized by a somewhat lower resistivity than the Lower member and consists of grey or black, slightly or moderately bituminous shale.

The lithology of the Canol Formation along the Mackenzie Mountain front between Arctic Red and Snake rivers (secs. 1-3, 6) consists of very dark grey to jet black, hard to soft, noncalcareous, in part siliceous shale and mudstone (Norris, 1968b, p. 41). On weathered surfaces the beds are commonly coated with a bright yellow, orange and apple green patina. Clay ironstone nodules weathering orange-brown, as well as a few small iron sulphide nodules, are present at several levels. West of Little Wind River at Section 11, the Canol beds are lighter grey in colour and contain considerable siltstone. Still farther west at Section 12, beds equivalent to the Canol Formation could be included arbitrarily in the lower part of the Imperial Formation.

The Canol Formation on Trail River (Sec. 35) abruptly overlies black shale and chert of the Road River Formation. At this locality, the Canol consists mainly of hard and soft, dark grey, noncalcareous shale, weathering brownish grey and rusty brown, with scattered layers of pale orange weathering, clay ironstone nodules (about 740 ft/225.6 m thick). A few of the shale beds in the lower part of the unit are somewhat silty.

Tassonyi (1969, p. 91-92) has shown that the relationship of the Canol Formation to underlying strata in the Norman Wells area may follow one of four main patterns as follows:

1. The Canol Formation may be missing by non-deposition, so that the Imperial Formation overlies the reef member of the Ramparts Formation.

2. The Canol Formation may overlie various beds of the Ramparts Formation.

3. Where the Ramparts Formation is not developed, the Canol Formation may overlie a relatively thin Hare Indian Formation.

4. In the northwestern part of the area studied by Tassonyi (1969), the Canol Formation unconformably overlies beds of the Hume Formation.

Along the Mackenzie Mountain front, immediately east of the report area, the Canol Formation unconformably overlies an eroded remnant of the Hare Indian Formation at Section 1, and an eroded surface of the Hume Formation at Section 2 (Norris, 1968b, Fig. 3). In the subsurface north of the Mackenzie Mountain front and north of sections 1 and 2, Pugh (1983, Fig. 27b) shows the Canol Formation resting on a variety of beds that obviously have been uplifted and truncated. Toward the western end of this cross-section he drops the name Canol and, in its place, uses the name Horn River Formation for the black shale overlying the Hume Formation.

The use of the name Horn River Formation in this area is inappropriate for several reasons. It is not coeval with the Horn River Formation in its type area on the northwest side of Great Slave Lake. Its use by Pugh (*ibid.*) implies that there is no unconformity between the Hume and overlying dark shale beds, and that the dark shale beds are mid-Middle rather than late Middle Devonian in age. The regional and paleontological evidences do not support Pugh's (1983, Fig. 27b) interpretation. In the Norman Wells area, the unconformity at the base of the Allochthonous beds of Mackenzie (1970b), or at the base of the Canol Formation where the Allochthonous beds are missing, has been well demonstrated by Braun (1977, 1978), Tassonyi (1969), Pedder (1975), and others.

Immediately west of Snake River at Section 6, the Canol Formation unconformably overlies argillaceous limestone beds of the Mount Baird Formation (new name). Section 6 is located within a transition between a carbonate platform succession to the east and a shale basin succession to the west. In the shale basin succession, the Canol Formation overlies beds consisting of dark grey, interbedded shale and chert forming the upper part of the Road River Formation, a unit formerly designated by Norris (1968b) as the Upper member of the Prongs Creek Formation. This relationship can be seen at sections 11 and 35.

At Section S-12 (65°58'N, 134°50'W) on Peel River, Perry and others (1974, Fig. 2) showed the Canol Formation resting unconformably on beds of the Road River Formation, and consisting of clastic limestone, argillaceous limestone and shale (formerly Middle member of Prongs Creek Formation of Norris, 1968b). Conodonts from the upper beds of the Road River Formation at this section are indicative of the *inversus* Zone (Klapper, in Perry et al., 1974, p. 1074; Klapper, 1977, p. 35, Fig. 2), suggesting a hiatus of considerable magnitude between the Canol and Road River formations.

The upper contact of the Canol Formation with the Imperial Formation in the report area is fairly sharp, and is marked by an abrupt change from black, fissile shale of the Canol Formation to greenish grey siltstone and sandstone interbedded with brownish grey, nonbituminous, and nonsiliceous shale of the Imperial Formation. This contact, although sharp, appears to be conformable.

The conspicuous dark shale of the Canol Formation marks the end of Devonian carbonate sedimentation throughout the area. It reflects an abrupt change from shallow water to much deeper water marine sedimentation. Immediately preceding the deposition of the Canol Formation, the eastern, southeastern and southern parts of the report area were uplifted and eroded. These events are indicated by the hiatus of variable magnitude separating the Canol from different underlying formations. Both the lithology of much of the Canol Formation and the paucity of fossils suggest deposition in a reducing, euxinic, stagnant, low energy, deep water basin.

Conodonts obtained by Uyeno (1979, p. 237, 239-240) from limestone concretions in the Canol Formation at Powell Creek (65°16'30'N, 128°46'00"W) are placed in the Lowermost *asymmetricus* Zone (Uyeno, pers. comm., November 6, 1981). Ostracodes from the Canol Formation of the same general area were assigned to fauna h by Braun (1966, Fig. 2, p. 255). Other fossils recorded by Braun (1966, Fig. 1) from the Canol Formation include siliceous sponge spicules, and siliceous spheres of radiolarian origin. MacKenzie (1974, p. 319) reported that radiolaria are widely distributed in the more siliceous parts of the Canol Formation. Tassonyi (1969, p. 93) recorded *Manticoceras* collected by D.J. McLaren from the Canol Formation on Carcajou ridge. A goniatite fauna consisting of *Ponticeras* cf. *tschernyschewi* (Holzapfel), *P.* sp., *Probeloceras* sp. and several specimens of *anaptychi* was reported by House and Pedder (1963, p. 498) from between 10 and 40 feet (3 and 12.2 m) above the base of their "upper dark shale unit". This dark shale unit was correlated with the basal part of the Canol Formation by Tassonyi (1969, p. 94), and referred to as the "Unnamed beds" by Braun (1966, Fig. 2). Later, MacKenzie (1970, p. 476) referred to this same unit as the "Allochthonous Beds", which he considered to be derived from the erosion of a thick, reefal facies of the Ramparts Formation, developed in the vicinity. Conodonts from the Allochthonous Beds at Powell Creek, recorded by Uyeno (1979, p. 237), are equated with the Lowermost *asymmetricus* Zone of Germany (Klapper and Johnson, 1980, p. 403, Fig. 1). Anaptychi are recorded also by House and Pedder (1963, p. 534-535, Figs. 15a, c) from the "Fort Creek Shale" at Thunder River, which Tassonyi (1969) has placed in the Canol Formation.

Norris (1968b, p. 43) recorded the shield-shaped organisms (anaptychi) from beds of the Canol Formation at Section 1, located immediately east of Arctic Red River. They also have been recorded by H.G. Bassett (pers. comm., 1963) from the Canol Formation, in a section measured by geologists of Shell Oil Company of Canada Limited and located at 65°17'N, 135°45'W, between sections 10 and 11 of this report. Copeland (1960, p. 7-9) referred these shield-shaped markings to the genus *Spathiocaris* and discussed their possible affinities to phyllopod carapaces or apertural coverings (anaptychi) of goniatites. Whatever their affinities, they have been noted also in Canol-like shale assigned in this report to the upper part of the Unnamed shale unit in the Socony Mobil Western Minerals North Cath. Y.T. B-62 well (66°11'13.5"N, 138°41'53"W), in an area west of the Richardson Anticlinorium.

Other fossil evidence from the report area is that collected by Bassett and Stout (1968, p. 744), who recorded a

conodont assemblage that contained *Palmatolepis* from the Canol Formation at its outcrop on Peel River (65°54'N, 135°56'W). At this locality, the assemblage is from 300 feet (91 m) above shale beds of the Road River Formation containing the Lower Devonian graptolite *Monograptus yukonensis*. This suggests that a hiatus of considerable magnitude separates the Canol and Road River formations. The missing strata include those of lowermost Upper Devonian (depending on which level the Middle/Upper Devonian boundary is drawn), the complete Middle Devonian, and the upper part of the Lower Devonian.

Palynomorphs from beds formerly considered to be part of the Imperial Formation on Trail River (Sec. 35), but here placed in the Canol Formation, were identified by D.C. McGregor and recorded by Norris (1968b, p. 46, 239-273). Recently, the palynomorphs from this section were reexamined and the identifications were revised by D.C. McGregor [March 26, 1982 (Internal GSC Report F1-2-1982 DCM)].

From a sample (GSC loc. 7310) from about 215 feet (65.5 m) above the base of the formation, the following were identified:

Aneurospora greggsii (McGregor) Streel
Convolutispora sp.
?*Cymbosporites magnificus* (McGregor) McGregor and Camfield
Geminospora sp.
Retusotriletes rugululatus Riegel
?*Rhabdosporites* sp.

McGregor indicated that the age of this assemblage is late Givetian or early Frasnian.

From a sample (GSC loc. 7052) from about 408.5 feet (124.5 m) above the base of the formation, the following were identified:

?*Aneurospora greggsii* (McGregor) Streel
Chelinospora concinna? Allen
?*Contagisporites optivus* (Chibrikova) Owens var. *optivus*
Convolutispora sp.
Cymbosporites magnificus (McGregor) McGregor and Camfield
?*Rhabdosporites langii* (Eisenack) Richardson
?*R. parvulus* Richardson

McGregor dated this assemblage as late Givetian or early Frasnian.

Both of the above samples are from approximately the lower half of the Canol Formation on Trail River.

All of the spores in the above two samples are extremely carbonized, and many of the sculptural details necessary for precise identifications have been altered or obliterated. It is probable that these spores represent a reworked assemblage, in which the younger age would be the more reliable dating.

In conclusion, the fossil evidence and stratigraphic position of the Canol Formation suggest that it is assignable to the conodont Lowermost *asymmetricus* Zone of the upper Givetian, upper Middle Devonian. It disconformably overlies various formations both in the report area and in the type area to the east. The magnitude of the hiatus separating the base of the Canol from underlying formations seems to be greatest in the area at the southern end of the Richardson Anticlinorium.

Imperial Formation

The stratigraphic unit to which the name Imperial Formation is now applied has undergone several nomenclatural modifications. Summaries of these changes have been presented by House and Pedder (1963, p. 495-496), Bassett (1961), and Tassonyi (1969). The interested reader is referred to these reports. The name Imperial Formation was introduced by Hume and Link (1945, p. 34-35) who selected a type section on Imperial River where the lower part of the formation is covered. The precise locality of this type section, according to Bassett (1961, p. 495), is on Imperial River at the Mackenzie Mountain front at 65°07'N, 127°51'W. Bassett (1961, p. 494-496) modified the definition of the Imperial Formation to include, at the bottom, a 361 foot (109.7 m) thick sequence of grey shale, which is separated from the underlying Canol Shale by an abrupt lithological break, and which grades upward into the overlying siltstone and shale of the Imperial Formation, as defined by Hume and Link (1945). The lower grey shale part of the sequence was referred to generally in the earlier literature as "the upper non-bituminous shale of the Fort Creek Formation". The complete Imperial sequence, according to Bassett (1961), is well exposed on the northeast flank of the Imperial anticline on Imperial River. The name Imperial Formation, as modified by Bassett (1961), applies to the sequence of Upper Devonian clastic rocks and minor interbedded limestone, which overlies the Canol Formation and is unconformably overlain by Cretaceous rocks throughout a large part of the central and lower Mackenzie River region. Tassonyi (1969, p. 96) continued the use of the name Imperial Formation in the same sense as Bassett (1961), but subdivided it informally into lower and upper members. More recently, Pugh (1983) has applied the name Tuttle Formation to a conglomerate, conglomeratic sandstone and shale unit outcropping on the flanks of the Richardson Mountains and formerly included in the upper part of the Imperial Formation by Norris (1968a, b).

Within the report area, clastic rocks of the Imperial Formation are widely distributed. They outcrop along the front of the Mackenzie Mountains, along the eastern, northern and western flanks of the Richardson Anticlinorium, and along part of the northern flank of the Wernecke Mountains. Rocks of the Imperial Formation form the bedrock surface of a large area immediately south of the Mackenzie River delta and the Campbell Uplift. Small areas of scattered exposures of Imperial beds have been mapped by D.K. Norris on the southeast flank of the Keele Range (see accompanying map, Fig. 1).

The thickness of the Imperial Formation at the type section is 2349 feet (716 m) according to Tassonyi (1969, p. 96). In the subsurface of the Norman Wells area, its maximum thickness is recorded as 1760 feet (536.5 m). Northwestward, in the Richfield et al. Point Separation No. 1 well (67°34'06"N, 134°00'10"W), 5075 feet (1546.9 m) of beds were assigned to the formation, but Tassonyi (1969, p. 96) indicated that this thickness may include some younger beds.

The thickness of the Imperial Formation along the front of the Mackenzie Mountains near Arctic Red River (Sec. 1) is 1763 feet (537.4 m), but the uppermost beds are not exposed. Along Trail River (Sec. 35), about 5960 feet (1816.6 m) of strata were measured by A.W. Norris (1968a, p. 45) of which the upper 440 feet (134.1 m) have been placed in the Dus map unit by D.K. Norris (in press), and are equivalent to beds placed in the Tuttle Formation by Pugh (1983). Upper parts of the Imperial Formation were measured at the north end of the Richardson Anticlinorium at "Snafu Mountain" (Sec. 33)

and near Rat River (Sec. 34), where 3200 feet (975.4 m) and 2345 feet (714.8 m) are represented, respec-tively. Both sections are incomplete. Here also, parts of these sequences may more properly belong in the Tuttle Formation. In the northern Wernecke Mountains on upper Prongs Creek (Sec. 11) and near Clear Creek (Sec. 12), about 3730 feet (1137 m) and 3240 feet (987.6 m) of beds assigned to the Imperial Formation were measured.

The lithology of the Imperial Formation has been described by Bassett (1961, p. 496) as a succession of fine grained clastic strata, predominantly shale and siltstone, but including some fine sandstone and minor limestone beds. Using gross lithology and electric log characteristics, Tassonyi (1969, p. 97) subdivided the Imperial Formation informally into lower and upper members. The Lower member, according to Tassonyi (1969), consists predominantly of marine shale; and the Upper member consists of inter-bedded marine siltstone, sandstone, shale and a few intercalated limestone beds. This subdivision corresponds approximately to Hume's (1954) upper, non-bituminous shale of the "Fort Creek Formation", and the Upper member, in the Norman Wells area, to Hume's (1954) Imperial Formation, which, in the subsurface, was designated the "Bosworth sandstone and shale" by Boggs (1944). Two conspicuous units, referred to by Tassonyi (1969, p. 97) as the "Jungle Ridge limestone lentil" and the "Canyon Creek sandstone lentil", occur within his Lower member and have limited extent in the Norman Wells area.

The lithology of the Imperial Formation at the type section on Imperial River at the Mackenzie Mountain front (65°07'N, 127°51'W) has been described by Chi and Hills (1973, p. 243). This section is about 1970 feet (600 m) thick and consists of grey-green shale and siltstone with grey-green, thinly bedded, cliff-forming, fine grained sandstone. Within the lower 1385 feet (422 m) of the section are five coarsening-upward cyclic sequences, each of which is commonly capped by a fossiliferous sandstone and argil-laceous limestone bed. The upper 585 feet (178 m) are described as soft, dark grey-green shale with a few thin beds of very fine grained sandstone and siltstone. The petrography of the type section of the Imperial Formation has been described by Robbins (1960).

The lithology and weathering characteristics of the Imperial Formation at Powell Creek (65°16'30"N, 128°46'00"W) have been illustrated schematically by Lenz and Pedder (1972, Fig. 8). They show about 1490 feet (454.2 m) of Imperial beds overlying the Canol Formation. The succession there, both lithologically and faunally, is comparable to that at Section 1 (located immediately east of the Arctic Red River) of this report.

The lithology of the Imperial Formation at Section 1 has been described by Norris (1968b, p. 43-44, Fig. 3, Pl. XII). At this locality, it consists of the following in ascending sequence: dark greenish grey, fine grained, quartzose sandstone, 75 feet (22.9 m) thick; dark grey shale and mudstone weathering rusty brown, 560 feet (170.7 m) thick; sandstone, silty sandstone and siltstone, 218 feet (66.4 m) thick; dark greenish grey recessive shale, 170 feet (51.8 m) thick; interbedded shale, silty shale and silty sandstone, 412 feet (125.6 m) thick; and a capping of resistant sandstone, 326 feet (99.4 m) thick. This section has been described also by Braman (1982, p. 18-20) who measured 2608.2 feet (795 m) of the sequence up to the contact with the overlying Lower Cretaceous Sans Sault Formation. Hills and Braman (1978) and Braman (1981) have indicated that the lower 354 feet (108 m) of the Arctic Red River section exhibit many of the distinctive lithological features that characterize turbidites. A medial sequence, 892.4 feet (272 m) thick, of dark, silty shale, includes an occasional thin zone of turbidites; and an upper sequence, 1246.7 feet (380 m) thick, of alternating sandstone and shale, is indistinguishable sedimentologically from the succession in the type Imperial Formation to the east.

The Imperial Formation on Trail River has been described by Norris (1968b, p. 239-267, Fig. 6), Hills and Braman (1978), and Braman (1981, p. 20-22, Fig. 3). A.W. Norris (1968b, p. 239) subdivided the Imperial Formation on Trail River into two units informally designated as lower and upper members. The name Imperial Formation is restricted here to the Lower member, and the name Tuttle Formation of Pugh (1983) is applied to the Upper member.

The Imperial Formation (as here restricted), on Trail River, may be subdivided into four rock units designated from 1 to 4 in ascending sequence. Unit 1, approximately 1390 feet (423.7 m) thick, sharply overlies black shale of the Canol Formation and consists of an alternating succession of dark grey shale, dark grey, silty shale, and dark greenish grey, silty, argillaceous and sericitic, fine grained sandstone. Some of the sandstone beds are crosslaminated and exhibit flow cast structures. The lower 400 feet (122 m) of Unit 2 is markedly ferruginous. Unit 2, approximately 1166 feet (355.4 m) thick, consists of dark grey, soft, fissile shale, with widely spaced, thin beds of siltstone, irregular layers of clay ironstone nodules, and thin beds of argillaceous and silty sandstone that become more numerous and closely spaced in the upper third of the unit. Unit 3, approximately 850 feet (259.1 m) thick, consists of: greenish grey, silty and argillaceous, quartzose fine grained sandstone, some beds of which are lenticular, crosslaminated, and contain macerated plant fragments; and dark grey to black, fissile shale that in places contains thin interbeds of argillaceous sandstone. Unit 4, approximately 660 feet (201.2 m) thick, consists of dark grey to black, ferruginous shale, and widely spaced, resistant, evenly and thick bedded sandstone, weathering medium brown and orange.

North of Trail River, at the north end of the Richardson Anticlinorium, two sections (33 and 34) of the upper part of the Imperial Formation have been described by A.W. Norris (1967, p. 267-298). In these sections, the sandstone units are generally coarser grained, with fragments up to granule size, and some of the sandstone beds are conglomeratic with pebbles (up to one third of an inch in diameter) of dark grey to black chert, light grey quartz, silty shale, and a few fragments of white feldspar(?). All or parts of both of these sequences may more properly belong in the Tuttle Formation of Pugh (1983).

To the west, in the northern part of Wernecke Mountains, two sections (11 and 12) have been described by Norris (1967, p. 68-101). These sections are somewhat comparable to that on Trail River.

Along the west flank of the Richardson Anticlinorium, D.K. Norris (1981j), on GSC Map 1523A, has subdivided the Imperial Formation into two parts: a lower, shaly, generally recessive unit; and an upper, sandy, resistant unit. He (D.K. Norris, pers. comm. September, 1982) pointed out that a thick overlying shale unit (Dus) may or may not belong in the Imperial Formation, and is possibly equivalent in part to the Ford Lake Shale of the Nation River area of east-central Alaska.

The lower contact of the Imperial Formation with the underlying dark coloured Canol Formation is sharp and relatively easy to recognize throughout the eastern and southeastern parts of the area. To the west, where the Canol Formation becomes silty and lighter in colour, as in

Section 12 (Norris, 1968b, Fig. 3), these beds are arbitrarily included in the Imperial Formation. In this latter area, the lower contact is with black siliceous shale and chert beds questionably assigned to the Canol Formation.

The upper contact of the Imperial Formation east of the report area, according to Bassett (1961, p. 497), is commonly marked by a basal Cretaceous sandstone or conglomerate. Along the northern flank of the Mackenzie Mountains in the southeastern part of the report area, and around the eastern, northern and western flanks of the Richardson Anticlinorium, the Imperial Formation is overlain by conglomeratic sandstone and silty shale designated the Tuttle Formation by Pugh (1983), or as the Dus map unit by D.K. Norris (in press). On Trail River (Sec. 35), datings by Braman (1981) based on spores, indicate that a hiatus separates the top of the Imperial Formation from the base of the Tuttle Formation. North of the north end of the Richardson Anticlinorium, at sections 33 and 34, a pronounced angular unconformity separates the top of the Imperial Formation from overlying coarsely clastic beds of Permian and younger ages. West of the Richardson Anticlinorium, the Imperial Formation is overlain by beds of the Carboniferous Hart River Formation.

The depositional sequence of the Imperial Formation in the type area, according to Chi and Hills (1973) and Hills and Braman (1978), is one of alternating nearshore and offshore marine sediments. The basal 1335 feet (407 m) of the section are dominantly nearshore marine with three, thin, offshore marine intervals. Above 1337 feet (407.5 m), the sequence is essentially an offshore marine interval with few spores and common marine, benthonic, shelly fossils. The clastic material is postulated by Hills and Braman (1978, p. 36) to have been derived from an eastern source area.

The clastic rocks of the Imperial Formation in the vicinity of Arctic Red River (Sec. 1) have been subdivided by Hills and Braman (1978, p. 35) into:

1. A lower 360.9 feet (110 m) thick turbidite sequence
2. A medial 918.6 feet (280 m) thick sequence of dark silty shale with a few thin zones of turbidites
3. An upper 1640.4 feet (500 m) thick sequence of alternating sandstones and shales, indistinguishable from those of the type Imperial. A western source area for the turbidites is postulated by Hills and Braman (1978, p. 36).

On Trail River (Sec. 35), the Imperial Formation consists mainly of shale, but includes a few turbidite sequences that become progressively more common upward in the formation (Hills and Braman, 1978, p. 36). A, B, C, D, (rarely) and E beds of the Bouma sequence (see Rupke, in Reading, 1978, p. 382, Fig. 12.16) are recognized by Hills and Braman (1978).

The basal A beds of the Bouma turbidite sequences are commonly medium- to fine-grained sandstone. Load casts, flutes, and tool marks indicate that the turbidites were derived from a source area to the north. A generalized isopach map of Upper Devonian clastic rocks of the report area, prepared by Norris (1968b, p. 776, Fig. 11), indicates that the depocentre of these clastics was a short distance northeast of Trail River.

Megafossils in the Imperial Formation have been listed, described or discussed by Warren and Stelck (1956), Bassett (1961), House and Pedder (1963), Norris (1968a, b), Tassonyi (1969), Lenz and Pedder (1972), and others. More recently, Chi and Hills (1973), Hills and Braman (1978), and Braman (1981) have studied the miospore biostratigraphy of the Imperial Formation.

In the Norman Wells area, megafossils reported by Hume (1954, p. 41) from 623 feet (189.9 m) above the base of the formation, as defined by Tassonyi (1969), are *Atrypa*, *Spirifer* and *Camarotoechia*. From presumably higher beds in the same area, Hume (1954, p. 41) reported *Atrypa*, *Cyrtospirifer*, *Cyrtina*, *Camarotoechia*, *Hypothyridina*, *Bellerophon*, *Pleurotomaria*, *Actinopteria*, and *Megistocrinus*.

Several ammonoid specimens were reported by early workers, including Miller (1938), Warren and Stelck (1956) and Hume (1954, p. 46), from beds placed by Tassonyi (1969) in the Upper member of the Imperial Formation. These have been identified by House (in House and Pedder, 1963, p. 496) as *Manticoceras cordiforme* Miller (1938) and indicate either the upper *cordatum* Zone or *holzapfeli* Zone of late Frasnian (early Late Devonian) age.

In the Powell Creek area, megafossils reported by Lenz and Pedder (1972, p. 37-38) from between 1077 and 1197 feet (328.3 and 364.8 m) above the base of the Imperial Formation comprise:

Frechastraea n. sp.
"Chonetes" sp.
Devonoproductus sp.
Productella sp.
Cyrtospirifer sp.
Theodossia n. sp.
Bellerophon sp.
Orecopia sp. cf. *O. mccoyi* (Walcott)
Tentaculites sp.

These fossils were placed in the *Theodossia* Zone of Frasnian, early Late Devonian age.

From the upper 555 feet (167.6 m) of Section 1, that is 1155 to 1710 feet (352 to 521.2 m) above the base of the Imperial Formation, a rich marine megafauna was reported by Norris (1968b, p. 46) from a succession of sandstone and shale. Fossils listed comprise:

Chonetes sp.
Acanthatia sp.
rhynchonelloid fragments
coarsely costate rhynchonelloid
Cyrtospirifer sp.
Bellerophon sp.
Leptodesma sp.
pelecypod fragments
Bactrites sp.
echinoderm ossicle with single axial canal

An early Famennian age was suggested by Norris (1968b) for this fauna on the basis of its similarity to a fauna described by McLaren (in Kerr et al., 1965), from the Arctic Archipelago, and a similarity to Famennian rhynchonelloids studied by Sartenaer (1969), from the southern District of Mackenzie. The marine megafossils from Arctic Red River are similar to those recorded by Lenz and Pedder (1972) from the Powell Creek section. Arctic Red River is the farthest west that marine megafossils have been recorded in the Imperial Formation.

From a section at or near Section 1 of this report, Braman (1981, p. 66) recovered miospores from between 687.7? and 843 m (2256.2? and 2765.7 ft) above the base of the Imperial Formation. These miospores were assigned by

Braman (1981) to the *Vallatisporites anthoideus - Grandispora gracilis* (AG) Biozone. According to Braman (1981, p. 65), this biozone encompasses the Middle - Upper *Palmatolepis triangularis* (F3b) through Middle *Palmatolepis crepida* (Fa1b) conodont zones. A sample immediately overlying this zone at Arctic Red River, from 844.3 m (2770 ft) above the base of the formation, yielded conodonts assigned to the Upper *Palmatolepis crepida* Zone (Fa1b).

Palynomorphs from the Imperial Formation on Trail River (Sec. 35) were identified by D.C. McGregor and recorded by Norris (1968b, p. 46, 239-273). Recently (March 26, 1982), the palynomorphs from this section were reexamined by D.C. McGregor and the identifications were revised (Internal GSC Report F1-2-1982-DCM).

From a sample (GSC loc. 7051) from about 762 feet (232.3 m) above the base of the Imperial Formation in Unit 1, McGregor identified the following:

Densosporites devonicus? Richardson
other unidentifiable spores

McGregor indicated that the specimens are extremely carbonized. The one identifiable specimen suggests an age in the range of Givetian to early Frasnian.

From a sample (GSC loc. 7311) from about 785 feet (239.3 m) above the base of the Imperial Formation in Unit 1, McGregor identified the following:

Aneurospora greggsii (McGregor) Streel
Convolutispora sp.
Hystricosporites sp.
Retusotriletes rugulatus Riegel
cf. *Rhabdosporites parvulus* Richardson

This assemblage is dated by McGregor as late Givetian or early Frasnian.

From a sample (GSC loc. 7312) from 878.5 feet (267.8 m) above the base of the Imperial Formation in Unit 1, McGregor identified the following:

Aneurospora greggsii (McGregor) Streel
Convolutispora sp.
Cristatisporites triangulatus (Allen) McGregor and Camfield
Cymbosporites magnificus (McGregor) McGregor and Camfield
Hystricosporites sp.

McGregor dated this assemblage as late Givetian or early Frasnian. He indicated that all the specimens are black in colour as a result of severe thermal alteration.

From a sample (GSC loc. 7050) from 1377.6 feet (419.9 m) above the base of the Imperial Formation in Unit 1, McGregor identified the following:

Aneurospora goensis Streel
A. greggsii (McGregor) Streel
Archaeoperiscacus oblongus Owens
?*Contagisporites optivus* (Chibrikova) Owens var. *optivus*
Retusotrilites rugulatus Riegel

McGregor dated this assemblage as late Givetian or early Frasnian, approximately in the range from Upper *varcus* to Lower *asymmetricus* Zones.

From a sample (GSC loc. 7317) from 4731 feet (1332.3 m) above the base and near the top of Unit 4 of the Imperial Formation, the following were identified by McGregor:

Ancyrospora simplex Grennel
Aneurospora greggsii (McGregor) Streel
cf. *Archaeozonotriletes famenensis* Naumova
Cymbosporites magnificus (McGregor) McGregor and Camfield
Cyrtospora cristifera (Luber) Van der Zwan
?*Hymenozonotriletes deliquescens* Naumova
Hystricosporites sp.
cf. *Retusotriletes domanicus* Naumova

McGregor concluded that the age of this assemblage is close to the Frasnian/Famennian boundary, but from the evidence at hand it was impossible to indicate a late Frasnian or early Famennian age.

All of the unoxidized spores from the Imperial Formation on Trail River are dark brown to black in colour, indicating severe thermal alteration. Judging from the comments by D.C. McGregor, the degree of alteration appears to increase downward in the section. Spores in the lower part of the section have undergone very intense carbonization with sculptural details greatly altered or obliterated.

From the above datings based on spores, it appears that the Imperial Formation on Trail River, as restricted in this report, ranges in age from late Givetian or early Frasnian at the base to late Frasnian or early Famennian at the top. However, marine faunal evidence suggesting a Lowermost *asymmetricus*, late Middle Devonian age for the Canol Formation at several localities to the east and south, would favour the early Frasnian over the late Givetian age for the base of the Imperial Formation on Trail River.

The Imperial Formation on Trail River has been studied also by Hills and Braman (1978) and Braman (1981). In the study by Braman (1981), he indicated that no palynomorphs were recovered from the lower 1300 m (4265 ft) of the Imperial Formation, on Trail River. However, between 1300 and 1505 m (4265 and 4937.6 ft) above the base of the Imperial Formation, he recorded miospores of the *Vallatisporites anthoideus - Grandispora gracilis* (AG) Biozone. This is the same biozone that occurs in the upper part of the Imperial sections on Arctic Red River (65°21'24"N, 130°45'00"W), Mountain River (65°27'N, 129°09'W), Powell Creek (65°16'N, 128°46'W), and Imperial River (65°07'N, 127°51'W). As indicated above, this biozone encompasses the middle Upper *Palmatolepis triangularis* (F3b) through Middle *Palmatolepis crepida* (Fa1b) conodont zones. This biozone, according to Braman (1981), is equivalent to spore zone F of McGregor and Uyeno (1972) from the upper part of the Griper Bay Formation on Melville Island, and the *magnifica* Zone of Chi and Hills (1976) from Devonian beds of Arctic Canada.

From between 843 and 848 m (2765.7 and 2782.1 ft) above the base in the Arctic Red River Section (Loc. 1), and between 1505 and 1675 m (4937.6 and 5495.4 ft) above the base of the Imperial Formation in the Trail River section (Loc. 35), Braman (1981, p. 68-70) recorded palynomorphs characteristic of his *Cornispora varicomata - Cornispora monocornata* (VM) Biozone. Braman (1981, p. 69) has aligned this biozone tentatively with the conodont Upper *Palmatolepis crepida* Zone (Fa1b), on the basis of a single conodont assemblage obtained within the biozone at 844.3 m (2770 ft) above the base of the Imperial Formation in the Arctic Red River section. A pronounced hiatus separates this biozone from a succeeding Upper Devonian biozone on Trail River.

Palynomorphs from clastic beds assigned to the Imperial Formation at sections 11 and 12 in the Hungry River - Knorr Range area, and at sections 33 and 34 located north of the north end of the Richardson Anticlinorium, are so badly corroded and carbonized that they are undeterminable. For this reason these beds remain undated.

Poorly preserved spores from the upper part of the Imperial Formation, as designated by Pugh (1983, Fig. 32b) in the Shell Peel River YT I-21 well (66°10'36.50"N, 134°18'52.18"W), have been dated by McGregor (in Norford and others, 1979, p. 8) as late Late Devonian, probably "Strunian" or very late Famennian.

Conodonts recovered from between depths of 810 and 1000 feet (246.9 and 304.8 m) in the Gulf-Mobil Caribou YT N-25 well (66°14'46"N, 134°50'04"W) were identified by T.T. Uyeno (GSC Internal Report 16-TTU-1974). The top of the Imperial Formation in this well was picked by Pugh (1983, Fig. 32b) at a depth of 677 feet (206.4 m) so that the samples are from between 133 and 323 feet (40.5 and 98.5 m) below the top of the formation. Uyeno (*ibid.*) indicated that most of the conodonts from this 190 foot (57.9 m) interval are fragmentary but suggested a range from the *Palmatolepis rhomboidea* Zone to the *P. styriaca* Zone of the Famennian, late Late Devonian. These are the youngest dated beds of the Imperial Formation containing a marine microfauna.

In conclusion, the oldest beds of the Imperial Formation at Powell Creek have been collated with the conodont Lower *Polygnathus asymmetricus* Zone (F2a) of early Frasnian, early Late Devonian age (Braman, 1981, p. 58). A marine macrofauna ranging in age from Frasnian to early Famennian occurs in the Imperial Formation in the Norman Wells area, and can be traced westward in the upper part of the formation to the Arctic Red River area. The youngest beds of the Imperial Formation to be studied east of the Richardson Anticlinorium occur on Trail River (Sec. 35) and contain palynomorphs of the *Cornispora varicomata* - *Cornispora monocornata* (VM) Biozone of Braman (1981). This biozone is collated with the Upper *Palmatolepis crepida* Zone (Fa1b) of early Famennian, late Late Devonian age (Braman, 1981).

The nearest formation analogous to the Imperial Formation is the Nation River Formation of east-central Alaska. It is lithologically similar and occupies an approximately coeval stratigraphic position (see Scott and Doher, 1967).

Tuttle Formation

The name Tuttle Formation was introduced by Pugh (1983) to apply to an alternating succession of coarse- to fine-grained clastic rocks overlying the Imperial Formation and equivalent rocks, and unconformably underlying Mesozoic rocks, in an area flanking the eastern, northern and western sides of the Richardson Anticlinorium. On the western flank of the Richardson Anticlinorium these rocks intertongue with and, in places, are laterally equivalent to, the basinal Ford Lake Shale of east-central Alaska. West of Deception Fault in the Eagle River area (see GSC Map 1523A of D.K. Norris, 1981j), Paleozoic rocks as young as Early Permian occur below the Mesozoic unconformity. The type section of the Tuttle Formation selected by Pugh (1983) comprises the sequence overlying the Imperial Formation and underlying Mesozoic rocks in the Pacific Peel YT F-37 well (66°56'26"N, 134°51'54"W) between depths of 350 and 3216 feet (106.7 and 980.2 m). The Tuttle Formation, as defined by Pugh (1983), embraces the Dus and C map units of D.K. Norris (in press) on the 1:500 000 scale geological map. On the one to one quarter million scale maps (see for example Map 1523A of D.K. Norris, 1981j), the Tuttle Formation is included in map unit CT, and possibly also map units Dus and Dss.

The thickness of the Tuttle Formation in the subsurface of the type well is 2866 feet (873.6 m). This well is located in Peel Plain on the east side of the Richardson Anticlinorium, near Tober Lakes and south of Fort McPherson. Both the eastern and western flanks of the Richardson Anticlinorium are fault bounded, and maximum thicknesses of the Tuttle Formation are preserved immediately adjacent to these faults on the downthrown sides. Pugh (1983, Fig. 18) shows maximum thicknesses of about 1100 m (3608.9 ft) and 1420 m (4658.8 ft) for the Tuttle Formation on the east and west sides, respectively, of the Richardson Anticlinorium. The isopach map prepared by Pugh (1983, Fig. 18) suggests that the depocentre of the Tuttle Formation was within what is now the Richardson Anticlinorium, before it was uplifted and Tuttle rocks removed by erosion. In the subsurface of Eagle Plain, on the west side of the anticlinorium, coarse grained clastic rocks of the Tuttle pass southward into finer clastics of the Ford Lake Shale.

The lithology of the Tuttle Formation in the type well, according to Pugh (1983), consists of an alternating succession of chert-pebble conglomerate, very poorly sorted quartz and chert sandstone, siltstone, and dark greyish brown shale. The conglomeratic material consists predominantly of white, buff, grey, yellow, orange and pale green chert. Kaolinitic material is present in much of the sandstone, and micaceous material is present in the sandstone, siltstone and shale. Seven cycles of conglomeratic sandstone and sandstone, designated as M-1 to M-7, are recorded by Lutchman (1977) within the formation in the type well.

Beds formerly classified by A.W. Norris (1968b, p. 239-244) as the Upper member of the Imperial Formation, outcropping on Trail River, are assigned here to the Tuttle Formation. This succession is 1161 feet (353.9 m) thick and consists of the following units in ascending order: Unit 1 (81 ft/24.7 m thick) consists predominantly of a conglomeratic sandstone interbedded with conglomerate beds as much as 1 foot (0.3 m) thick. The angular to partly rounded pebbles are up to 0.25 inch (0.6 cm) in diameter and consist of white, green and black chert, white feldspar(?), and fragments of sandstone from the underlying Imperial Formation. The sandstone matrix is medium- to coarse-grained, medium greenish grey in colour, and commonly stained a bright orange. Some of the sandstone beds are argillaceous and silty, dark grey in colour, and contain abundant sericite along the foliate planes. The succeeding Unit 2 (about 410 ft/125 m thick) consists of soft, orange weathering, dark grey shale with closely spaced beds of argillaceous sandstone in the lower part of the unit. Unit 3 (176.3 ft/53.7 m thick) is resistant and similar to Unit 1, and consists mainly of conglomeratic sandstone, some sandstone, and minor shale. Unit 4 (494 ft/150.6 m thick) consists of an alternating succession of "salt and pepper", grey, in part crossbedded, fine- to coarse-grained sandstone weathering orange; and dark grey, fissile shale commonly containing laminae of sandstone.

In the outcrop succession on Trail River, Unit 4 is in fault contact with rocks of Cretaceous age. Units 1 and 3 of this Tuttle succession are resistant, ridge-forming, and easily mapped along the east side of the Richardson Anticlinorium. These resistant units presumably correspond to the M-1 and M-2 sandstone units of Lutchman (1977, p. M-5 to M-6).

The lower contact of the Tuttle Formation with the underlying Imperial Formation was established by Pugh (1983) on the basis of the following criteria: the appearance in the Tuttle of coarser clastic rocks, including medium- to coarse-grained sandstone and conglomeratic sandstone; the presence of kaolinite and quartz cement filling pore spaces; the presence of varicoloured chert conglomerate in the north that becomes finer grained, better sorted, and more quartzose to the south; the presence of carbonaceous fragments and, locally, coal; and the complete absence of carbonates. A pronounced hiatus separates the base of the Tuttle from the top of the Imperial Formation in Section 35 on Trail River (Braman, 1981). However, at the present time, there is insufficient paleontological data to determine if this paraconformity on Trail River is of local or regional extent. Evidence from palynomorphs does suggest, however, that the contact between the Tuttle and underlying Imperial Formation in the subsurface of Peel Plain is diachronous, and is older in the north and younger in the south (Pugh, 1983).

The upper contact of the Tuttle Formation reflects pre-Mesozoic erosion or present-day truncation along both flanks of the Richardson Uplift. Throughout much of its subsurface distribution, the Tuttle Formation is unconformably overlain by beds of Mesozoic age.

The rocks designated by Pugh (1983) as the Tuttle Formation were interpreted by Lutchman (1977) as a southward advancing, Mississippian, clastic wedge of fluvio-deltaic origin. The M-1 and M-7 sandstone units of Lutchman (1977) were considered to represent 7 pulses of sandstone deposition. His overall model is that of successive delta systems that initially were confined to the northern part of the wedge area and then moved southward to progressively fill a basin.

A different mode of origin is suggested by Hills and Braman (1978, p. 36) for the coarse, clastic rocks on Trail River, which are part of the Tuttle Formation as defined by Pugh (1983), but which formerly were designated by Norris (1968b, p. 239-244) as an upper member of the Imperial Formation. Hills and Braman (1978) point out that the Tuttle rocks on Trail River represent a turbidite sequence. The coarse grained conglomeratic sandstones, which are rich in chert pebbles, are typical of the A unit of a Bouma sequence (Rupke, 1978, p. 382). Associated features of the succession, such as load casts, flutes, and tool marks, indicate that the turbidites were derived from the north. Supporting evidence for a northern source area are pebbles of white, black and green chert in the conglomeratic sandstones on Trail River. Cherts of these colours, particularly a conspicuously banded green variety, are common in the rocks forming the core of the Barn Uplift in northern Yukon Territory.

It is probable that the M-1 to M-7 sandstone units of Lutchman (1977) within the Tuttle Formation represent the A units of a repetitive Bouma sequence.

The list of palynomorphs recorded by Norris (1967, p. 242) from the interval between 570 and 573 feet (173.7 and 174.7 m) above the base of the Tuttle Formation within Unit 3 at Section 35 on Trail River has been revised by D.C. McGregor (Internal GSC Report No. F1-2-1982-DCM; March 26, 1982). Within the sample (GSC loc. 7049) there are at least two ages of spores represented. The younger spores are as follows:

Cornispora varicornata Staplin and Jansonius
Cyrtospora cristifer (Luber) Van de Zwan

McGregor indicated that the age range of the above spores is from late early to early late Famennian of the Late Devonian.

Reworked spores in the sample comprise the following:

Archaeosperisaccus timanicaus Rashkevich
?*Cristatisporites triangulatus* (Allen) McGregor and Camfield
Cymbosporites magnificus (McGregor) McGregor and Camfield
Hystricosporites reflexus Owens
Lagenicula sp.
Ocksisporites sp.

McGregor reported that if the older reworked spores represent a single assemblage, then their collective age would be about mid-Frasnian of the early Late Devonian.

From near the top of Unit 4 at Section 35 on Trail River, which is about 1077 feet (328.3 m) above the base of the Tuttle Formation (GSC loc. 7048), the following were identified by D.C. McGregor (Internal GSC Report F1-2-1982-DCM, March 26, 1982; a revision of identifications presented in Norris, 1967, p. 240):

Cyrtospora cristifer (Luber) Van der Zwan
cf. *Dictyotriletes submarginatus* Playford
Hystricosporites sp.
Retispora lepidophyta (Kedo) Playford
Tumulispora malevkensis (Kedo) Turnau
T. ratituberculata (Luber) Turnau

This assemblage was dated by McGregor as post-Famennian Devonian, that is "Strunian" (=early Tournaisian, Tn1a or early Tn1b) in age.

It should be mentioned that the "Working Group on the Devonian-Carboniferous Boundary", of the IUGS, recommended in 1980 that the boundary between the Devonian and Carboniferous be drawn at the first appearance of the conodont *Siphonodella sulcata* within the evolutionary lineage from *S. praesulcata* to *S. sulcata*, which immediately precedes the entry of the ammonoid *Gattendorfia*. The base of the *Gattendorfia* Zone was the level recommended by the 1935 Heerlen Congress to mark the Devonian-Carboniferous Boundary. According to Clayton et al. (1977, Fig. 1), the base of the *sulcata* Zone is aligned with the upper part of Tn1b of Tournaisian age.

Palynomorphs from the lower 145 m (475.7 ft) of the Tuttle Formation on Trail River were assigned by Braman (1981, p. 71-73) to the *Retispora lepidophyta - Lophozonotriletes triangulatus* (LT) Biozone. An important element in this biozone is *Retispora lepidophyta* which, in Belgium, is restricted to the interval Fa2d to Tn1a or lower Tn1b. Braman (1981, p. 72-73) has pointed out that this biozone could not be older than uppermost Famennian or middle *Spathognathodus costatus* Zone, but may be somewhat younger because of the unconformable nature of the base of the biozone. The upper part of the biozone, according to Braman, is probably not younger than the middle of Tn1a or near the top of the conodont *Spathognathodus costatus* Zone.

Palynomorphs from the succeeding 120 m (393.7 ft) of Tuttle beds on Trail River were assigned by Braman (1981, p. 74-75) to the *Retispora lepidophyta - Vallatisporites pusillites* (LP) Biozone. Braman (1981) pointed out that the upper range of *Retispora lepidophyta* extends into this biozone, which would indicate that it is equivalent to the interval Tn1a to lower Tn1b of the Belgian stratigraphic sequence. Braman has theorized that this biozone is within the conodont *Protognathodus* Fauna and extends to the lower Tn1b, which is the level that marks the boundary between the Devonian and Carboniferous systems.

Palynomorphs from the highest beds of the Tuttle Formation exposed on Trail River were assigned by Braman (1981, p. 76-77) to the *Vallatisporites banffensis - Vallatisporites vallatus* (BV) Biozone. Braman considered this biozone to be probably equivalent to Tn1b or lower Tn2 of the Belgian stratigraphic sequence or to part of the conodont *Protognathodus* Fauna. This assignment was based solely on the position of the biozone above the highest occurrence of *Retispora lepidophyta*.

Clastic beds between depths of 70 and 2918 feet (21.3 and 889.4 m) in the Shell Peel River Y.T. I-21 well (66°10'37"N, 134°18'51"W) were assigned by Pugh (1983, Fig. 32b) to the Tuttle Formation. This well is located on the west side of Turner Lake in the Peel Plain east of the Richardson Mountains. Palynomorphs identified by D.C. McGregor (in Norford and others, 1970, p. 7-9) from this well indicate that the lower 430 feet (131.1 m) of Tuttle beds are in part equivalent to the Strunian, that is latest Late Devonian (post-Famennian and pre-Tournaisian). This lower interval is equated by Pugh (1983, Fig. 32b) with the M-4 sandstone unit of Lutchman (1977). Spores from succeeding beds of the Tuttle Formation in this well have been dated by McGregor (in Norford and others, 1970) as ranging in age from probable Tournaisian, at about 500 feet (152.4 m) above the base of the Tuttle Formation, to probable early or middle Tournaisian, at about 2200 feet (670.6 m) above the base.

PALEOPHYSIOGRAPHIC SUBDIVISIONS

Some attempt has been made to reconcile the paleophysiographic elements used by Lenz (1972, Fig. 3, p. 328), with the tectonic elements used by D.K. Norris (1983), and the control data from surface and subsurface sections. Paleophysiographic elements change position with the passage of time and the elements used here (see Fig. 9) are those considered pertinent to a discussion of the Devonian geology of the area.

The main carbonate platform areas comprise the Mackenzie Platform in the east and the Yukon Stable Block in the west. In addition, two relatively small carbonate platforms, both more or less surrounded by basinal shale, are referred to here as the White Mountains Platform and the Royal Mountain Platform. The basin and trough areas comprise the Richardson Trough in the central part of the area, connected to the Blackstone and Selwyn troughs in the southwestern parts of the area, to the Rapid Trough in the northwest, and to the Hazen Trough in the northeast. Land masses comprise the Dave Lord High in the west-central part of the area, and the Bonnet Plume High at the southeastern end of the Richardson Trough.

Mackenzie Platform

The main carbonate platform in the report area was referred to as the Mackenzie Platform by Lenz (1972, p. 328) and encompasses the large area lying west of the Canadian Shield and east of the Richardson Mountains, including the northern part of the Mackenzie Mountains. This paleophysiographic subdivision coincides with the following tectonic subdivisions of D.K. Norris (in press): Eskimo Lakes Block, Campbell Uplift, Northern Interior Platform, and the Mackenzie Fold Belt (see Fig. 2). Devonian exposures occur in the front ranges of the Mackenzie Mountains and in the Campbell Uplift. The Devonian sequence in the Mackenzie Mountains bears the closest similarity to that in the Mackenzie River Valley to the east. Throughout the Mackenzie Platform, Ordovician to Lower Devonian sediments consist of evenly bedded dolomite and limestone. Sediments of the Middle Devonian consist largely of argillaceous limestone and calcareous shale, and local carbonate reef development in the Norman Wells-Fort Good Hope area. The upper Middle Devonian was marked by the deposition of a relatively thin but widespread, black, bituminous and siliceous shale. During most of the remainder of the Upper Devonian a large part of the area was covered by a thick sequence of fine- to coarse-grained clastic sediments.

Widespread epeirogenic movements on the platform account for the absence of the Middle Ordovician, locally the lower Llandoverian, most of the Wenlockian, and parts of the Upper Silurian (Lenz, 1972, p. 329). Within the southeastern portion of the platform, parts of the Middle Devonian are missing due to uplift in the adjacent Bonnet Plume High and southern end of the Richardson Trough.

Yukon Stable Block

A triangular area west of the Richardson Mountains, south of the Old Crow-Babbage Depression of D.K. Norris (1983), and north of and including the northernmost Ogilvie Mountains, corresponds approximately to the eastern part of Jeletzky's (1962) Yukon Stable Block (see Fig. 9). Superimposed on this platform are two paleophysiographic elements, the Dave Lord High in the north, and the Blackstone Trough in the south, which subdivide the platform into three segments. The area covered by the northwest segment corresponds to the Keele Block of the Aklavik Arch Complex, the middle segment to a part of the Eagle Fold Belt, and the southern segment to a southern part of the Taiga-Nahoni Fold Belt of D.K. Norris (1983).

Ordovician to Middle Devonian sediments throughout most of this platform area consist mainly of dolomite and limestone, but Upper Ordovician to Lower Devonian sediments are locally absent and the hiatus is most pronounced on and adjacent to the Dave Lord High. The areas of the three segments have varied in size considerably through time, attaining maximum size during Early and Middle Ordovician time, and minimum size during Late Silurian time (Lenz, 1972, p. 329).

Most of the lower Devonian sediments consist of dolomite, and the upper Lower Devonian and Middle Devonian sediments consist mainly of limestone with some dolomite. Diachronously overlying the limestone is a unit of several types of shale, ranging in age from late Early Devonian at the base to early Late Devonian at the top. During the remainder of Late Devonian time, part of the platform area flanking the west side of the Richardson Trough was covered with clastic rocks derived from a northern provenance.

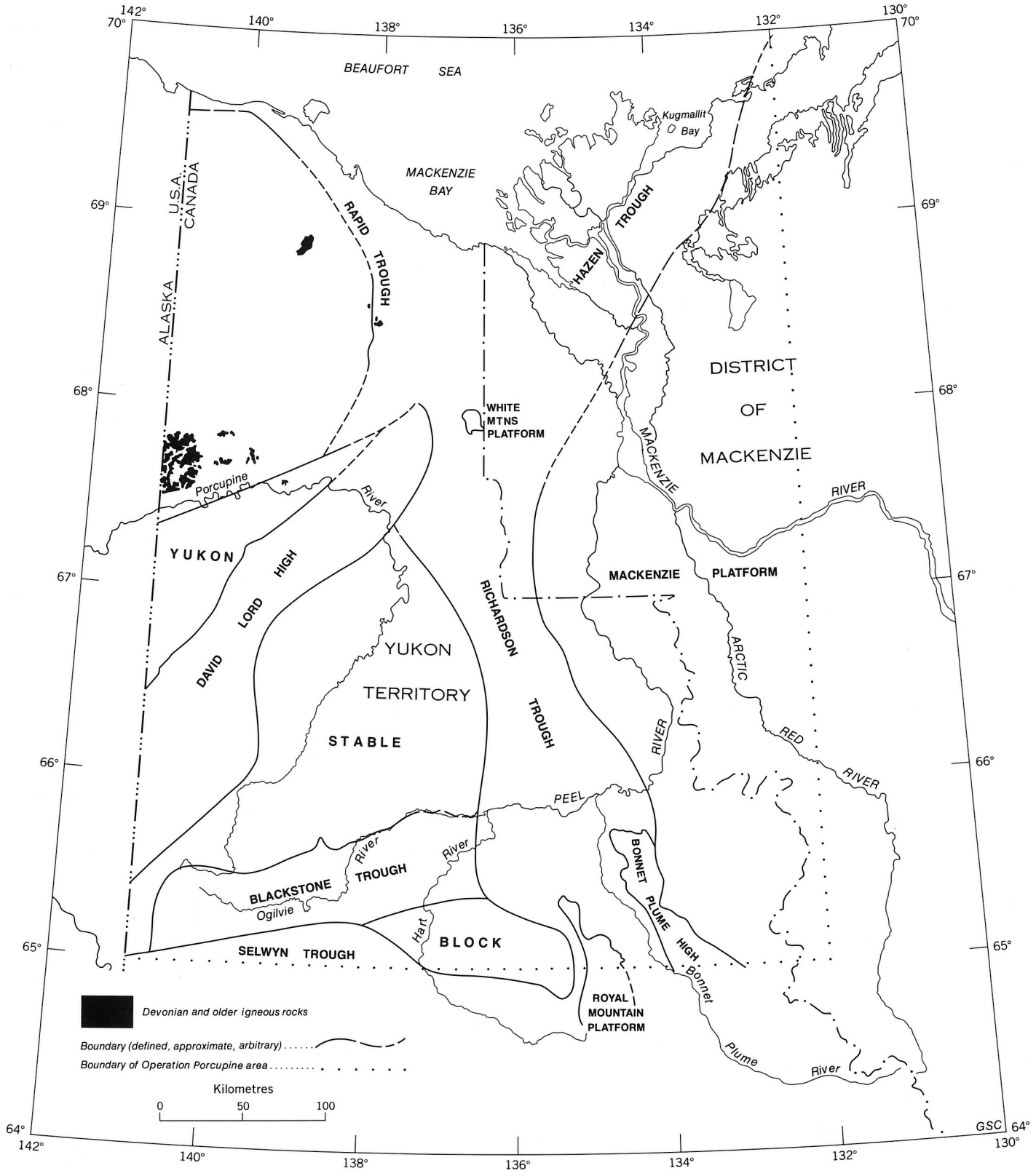

FIGURE 9. *Paleophysiographic subdivisions of the report area.*

White Mountains Platform

The name White Mountains Platform is here introduced to apply to the area of carbonate deposition that occurs immediately north of the north end of the Richardson Trough. The area coincides with the White Uplift of D.K. Norris (1983), and appears to be a small, local, carbonate platform surrounded by basinal shale (see Fig. 9). In spite of being separated by shale from the Mackenzie Platform to the east and Yukon Stable Block to the west, the Silurian and Devonian carbonates appear to be closely related to those of the Yukon Stable Block. Lower Cambrian to Middle Devonian carbonates occur on this platform. Upper Silurian sediments, consisting of dark argillaceous limestone, are separated by an erosional unconformity from underlying Silurian carbonate. Lower Devonian sediments consist of dolomite, and the lower Middle Devonian sediments consist of limestone.

Royal Mountain Platform

The name Royal Mountain Platform is here applied to the small area of carbonate rocks surrounded by basinal shale that is located at the south end of the Richardson Trough, immediately south of the Bonnet Plume Basin. This area was formerly included by Lenz (1972, Fig. 3, p. 328) in the eastern part of the southern segment of the Yukon Stable Block. The distribution of this platform south of 65°N latitude has been shown in part by Lenz (1977a, Fig. 1, p. 39), and additional control is provided by sections 9 and 36 within the platform, and by sections 8 and 38 in the shale sequence immediately west of the platform. Cambrian, Ordovician, Silurian and Lower Devonian carbonate sediments were deposited on this platform.

Richardson Trough

The Richardson Trough is marked approximately by the extent of the present Richardson Mountains. This north-northwest trending trough was the site of basinal shale sedimentation from Late Cambrian to Middle Devonian time. Its extent in Devonian time was shown approximately by A.W. Norris (1968b, Fig. 7, p. 53), by the distribution of the Prongs Creek Formation (now included in the Road River Formation). The extent of the trough coincides with the Richardson Anticlinorium as delineated by D.K. Norris (in press). D.K. Norris (in Norris and Yorath, 1981, p. 82) has pointed out that the Richardson Trough, a fault-bounded intracratonic depression, is a taphrogeosyncline in the sense of Kay (1945, p. 1172). It is also an aulacogen in the sense of Shatsky and Bogdanoff (1960), as first suggested by Churkin (1975, p. 454). It is readily apparent that the shale-carbonate interfaces along some margins of the Richardson Trough oscillated laterally with time, and such movement resulted in intertonguing of the two facies. To the south, the Richardson Trough was connected with the Selwyn Trough by a narrow channel between the southern segment of the Yukon Stable Block and Royal Mountain Platform. On its southwest side there was intermittent connection with the Blackstone Trough as delineated by Lenz (1972, Fig. 3, p. 328). To the north, the Richardson Trough splayed around the White Mountains Platform to connect in the northeast with the Hazen Trough, as suggested by Miall (1976, Fig. 6, p. 1606); and in the northwest with the British-Barn Mountains Trough of Lenz (1972, Fig. 3, p. 328), the Ancestral Brooks Geosyncline of Miall (1976, Fig. 6, p. 1606), or the Rapid Trough of this report.

Blackstone Trough

The name Blackstone Trough was introduced by Lenz (1972, p. 331, Fig. 3, p. 328) and applied to an area marked by basinal shale that extends west and southwest of the southwest margin of the Richardson Trough. It was connected with the northern edge of the Selwyn Trough in the southwestern part of the report area. The extent of the Blackstone Trough was delineated by A.W. Norris (1968b, Fig. 7, p. 53), who illustrated the extent of the Michelle Formation, the base of which marks the top of basinal shale deposition in the trough in early Zlichovian (Early Devonian) time. The trough developed during late Early to early Middle Ordovician time (Lenz, 1972, p. 331), and, as indicated above, persisted until Early Devonian time. Sediments in the trough consist mainly of shale; calcareous shale; dark, variably argillaceous limestone; and minor chert and siliceous shale.

Selwyn Trough

In the southwestern part of the report area, beginning in earliest Ordovician time and continuing through to the end of the Middle Devonian, a trough existed, characterized by deep water shale, chert and some carbonate deposition. Although the name Cordilleran Trough was used by Lenz (1972, Fig. 3, p. 328, 332-333), the name Selwyn Trough or Basin, as used by Gabrielse (1967, Fig. 1, p. 272), seems a more appropriate term to apply to this area of deep water sedimentation. The Selwyn Trough occupies a very narrow belt in the Nation River area of east-central Alaska (Churkin and Brabb, 1965) and in the adjacent Yukon Territory (Green and Roddick, 1962; Green, 1972). From this area straddling the International Boundary, the belt widens rapidly in a south-easterly direction to about 60°N latitude. The southwestern margin of the Selwyn Trough is marked by the Tintina Trench (Gabrielse, 1967, Fig. 1, p. 272).

Rapid Trough

Widely scattered remnants of pre-Carboniferous, Paleozoic, deep water sediments in the northwestern part of the Operation Porcupine area strongly suggest the existence of a Paleozoic trough in that region. This trough has been referred to by Jeletzky (1962) as the Brooks Range Geosyncline, by Lenz (1972, Fig. 3, p. 328, 331-332) as the British-Barn Mountains Trough, by Churkin (1975) as the Neruokpuk Geosyncline, and by Miall (1976, Fig. 6, p. 1606) as the Ancestral Brooks Geosyncline. This area forms the left branch of the splay at the north end of the Richardson Trough. Remnants of Road River-like basinal sediments are

known from three main localities in the area as follows: (1) at the headwaters of Johnson Creek; (2) in the Barn Uplift and nearby localities; and (3) in a very small area near the arctic coast, 12.6 miles (20.3 km) east-southeast of Clarence Lagoon. These occurrences are within or very near the western margin of the Rapid Depression as delineated by D.K. Norris (1983) and, therefore, the name Rapid Trough is suggested as a more appropriate term to apply to this northwestern extension of the Richardson Trough. The condensed sequence of Road River sediments on the Dave Lord High at Section 13 on the Porcupine River strongly suggests a connection between the northwestern part of the Richardson Trough and southern part of the Rapid Trough.

The sediments exposed at the headwaters of Johnson Creek consist of a thick sequence of dark, noncalcareous shale mapped as part of the Road River Formation by D.K. Norris (1981). The Early Devonian graptolite, *Monograptus yukonensis* Jackson and Lenz, has been identified by B.S. Norford from a sample (GSC loc. C-4236) collected by D.K. Norris (1970, p. 231) from near the western edge of the area of outcrop, at a level near the top of the sequence.

The pre-Carboniferous sediments exposed in the core of the Barn Uplift consist of a thick sequence of isoclinally folded and faulted, weakly metamorphosed shale, siliceous shale, argillite, bedded chert, quartzite, and minor amounts of limestone. From thin, dark shale bands within the sequence, graptolites of Ordovician and Silurian age have been recovered by Martin (1959), Norford (1964), Lenz and Perry (1972), and others. From light olive-green argillite beds, A.W. Norris in 1970 collected the trace fossil *Oldhamia* sp. from numerous levels in two measured sections in the Barn Uplift. This trace fossil has been reported by Churkin and Brabb (1965) from Lower Cambrian beds in four areas in Alaska, and by Hofmann and Cecile (1981) from Lower Cambrian beds in the Selwyn Mountains of the Yukon Territory. Although the ichnogenus *Oldhamia* is considered to be a guide fossil to the Lower Cambrian, it has been recovered from rocks as old as the Hadrynian and from rocks as young as Middle Ordovician (Hofmann and Cecile, 1981, Table 40.1, p. 284-285). Furthermore, these authors indicate that *Oldhamia* is invariably associated with sediments that suggest a deep ocean environment. The sequence of Paleozoic rocks in the core of Barn Uplift is without a name, as a result of the name Neruokpuk Formation being currently restricted to Proterozoic rocks of the area (see GSC geological maps 1514A and 1516A, D.K. Norris, 1981a, c).

The small area of Road River sediments near the arctic coast in the northwestern part of the report area (see GSC geological map 1514A, D.K. Norris, 1981a) comprises a relatively thin sequence of dark shale from which Silurian graptolites have been recovered. The graptolites were identified by B.S. Norford (GSC Internal Report No. S8-BSN-1975; GSC loc. C-41895; 69°32'30"N, 140°19'00"W) and were assigned to the *Monograptus transgrediens* Zone or *M. chelmiensis* Zone of Jackson and Lenz (1971), of latest Late Silurian (Pridolian) age.

Dave Lord High

This paleotectonic feature has been referred to variously as the Dave Lord Ridge by Martin (1959, 1961), the Aklavik Arch by Jeletzky (1962), the Dave Lord Creek Arch by Gabrielse (1967), the Dave Lord High by Lenz (1972), the Aklavik Arch Complex by D.K. Norris (1973, 1983) and by D.K. Norris and Yorath (1975). In a paleophysiographic sense, the name Dave Lord High, as used here, closely follows that of Lenz (1972). It is a long, narrow, arcuate structure, trending northeast-southwest and extending from the big bend of the Porcupine River in the report area southwestward into east-central Alaska. It cuts across the Yukon Stable Block to subdivide it into northwestern and central segments. The southwestern part of the high was positive through Late Ordovician to Pragian time, submerged during Zlichovian, Dalejan, Eifelian and Givetian times, and strongly positive throughout Frasnian and Famennian time. The northeast end of the Dave Lord High was positive throughout most of the Silurian, negative in latest Silurian (Pridolian) to Early Devonian (Lochkovian and Pragian) time, and strongly positive throughout the remainder of Devonian to Pennsylvanian or later time.

Bonnet Plume High

The name Bonnet Plume High was introduced by Lenz (1972, p. 327-328) to apply to a narrow, north-south trending area covering the Knorr Range and its southern extension into the Wernecke Mountains. This high is in linear continuity with the southeastern end of the Richardson Trough. Lenz (1972, p. 328) indicated that this area was emergent from at least Early Ordovician to early Siegenian and from late Emsian to Givetian time. His main evidence was his Section L-20 (Lenz, 1972, Table, p. 325), which corresponds to Section 7 of this report. Until the faunas of Section 7 are more thoroughly studied, the precise durations of the two hiatuses indicated by Lenz (1972) will remain in doubt. At the present time, the evidence for the hiatus from late Emsian to Givetian time is more firmly established on the basis of other sections near the Bonnet Plume High.

Devonian igneous intrusions

The igneous intrusions within and adjacent to the Operation Porcupine area have been summarized by D.K. Norris and Yorath (1981, p. 46, Table II, p. 47) and D.K. Norris (1983). In composition, the intrusions range from granite through quartz monzonite to syenodiorite, and occur as isolated stocks or cupolas of small areal extent and as batholiths outcropping discontinuously over hundreds of square kilometres. On the Geotectonic Correlation Chart 1532A of D.K. Norris (1983), the maximum radiometric values, which indicate the minimum ages of plutonism for each intrusion, are presented. He has shown the beginning of the Devonian Period as extending from 395 to 345 Ma, with a duration of 50 Ma. The bases of the Middle and Late Devonian are indicated as 370 and 359 Ma, respectively; so that the durations of the Early, Middle, and Late Devonian are 25, 11, and 14 Ma, respectively.

On the chart, the intrusion at Mount Fitton in the Rapid Depression is dated as 370 Ma; at Mount Sedgwick in the Romanzof Uplift as 355 Ma; the large intrusion in the vicinity of Old Crow in Old Crow-Babbage Depression as 354 Ma; the Hoidahl intrusion in Barn Uplift as 406 Ma; and the small intrusion in the Keele Block as 372 Ma. The spread of these radiometric ages varies from Silurian to Late Devonian. The

dating of the Ellesmerian Orogeny in the area is placed by Norris (in D.K. Norris and Yorath, 1981, p. 46) at about 350 ± 10 Ma, which is within Late Devonian time. This dating marks approximately the interval bracketed by the deformed clastic rocks of the Upper Devonian Imperial Formation and the coarse conglomerate of the Lower Carboniferous Kekiktuk Formation.

PALEOGEOGRAPHY

Ludlovian and Pridolian (Upper Silurian) (Figure 10)

Rocks of Ludlovian and Pridolian (Late Silurian) age are recognizable in the graptolite facies by the presence of *Monograptus nilssoni* through the *Monograptus transgrediens* Zones (Lenz and Jackson, 1971); and in the carbonate facies by such brachiopods as *Kirkidium*, *Atrypella* and *Gracianella* (Lenz, 1972, p. 341).

Although Upper Silurian deposits are absent throughout most of the Mackenzie Platform, they are known from the Snake River area at and near Locality L-19. From this area, Dineley (1964) and Broad and Lenz (1972), have described a Late Silurian ostracoderm fauna occurring in a narrow belt of orange weathering dolomite near the base of the Bear Rock Group. In this area immediately east of the Bonnet Plume High, the Late Silurian beds are separated from older Silurian carbonate rocks by an unconformity.

In the White Mountains Platform, at localities 30 and 47, an *Atrypella* fauna occurs in an unnamed, dark, argillaceous limestone unit, which underlies the Kutchin Formation and is separated from the underlying Vunta Formation by an erosional unconformity.

Carbonate rocks beneath the Mackenzie Delta are probably continuous with those exposed in the Campbell Uplift. This is inferred from the Silurian fauna reported by Norford et al. (1971, p. 22) from the I.O.E. Stoney I-50 well (67°29'49"N, 135°22'46"W) between depths of 8944 to 8962 feet (2726.1 to 2731.6 m).

Carbonate rocks bearing *Atrypella*? sp. have been recorded by Norford (in Norford et al., 1971, p. 22) from the subsurface in the Yukon Stable Block, in the Socony Mobil W.M.S. Tuttle Y.T. N-05 well (66°24'51.2"N, 136°46'22.7"W; =Loc. L-34) between depths of 8339 to 8340 feet (2541.8 to 2542.1 m). These rocks are probably continuous with the *Atrypella*-bearing beds recorded by Norford (1964) from at and near Locality L-83 in the Keele Range, and with probable Upper Silurian carbonate beds in the Eagle Plain No. 1 well (Loc. L-79). These carbonate beds occur on the flanks of the Dave Lord High on its northwest, north and east sides.

The presence of Upper Silurian graptolitic shale on Porcupine River (Loc. 13) and near Clarence Lagoon on the arctic coast (Loc. 69°32'N, 140°21'W; GSC loc. C-41895 on GSC Map 1514A of D.K. Norris, 1981a) suggests that the Richardson Trough was connected to the northwest with the Rapid Trough. Shale of the Road River Formation in the vicinity of Locality L-26 suggests that the Richardson Trough was connected with the Hazen Trough to the north and northeast. Shale in this area suggests that the White Mountains Platform probably was surrounded by trough deposition and separated from carbonate rocks of both the Mackenzie Platform to the east and the Yukon Stable Block to the southwest.

Upper Silurian carbonate, about 2000 feet (609.6 m) thick, and containing *Kirkidium* sp. and other pentamerids, was reported by Lenz (1972, p. 342) from Locality L-39 (=Loc. 9) on Royal Mountain Platform. This succession is part of the same carbonate sequence exposed on Royal Mountain a short distance to the south.

During this time, a narrow shale trough connected the Royal Creek area (locs. 38 and L-42) with the Blackstone Trough to the northwest and Selwyn Trough to the south.

A small carbonate platform, similar to the White Mountains Platform, occurs in the vicinity of Locality L-50 (Lenz, 1972, p. 342). On the west side of this small platform, a narrow positive area connects westward with the Dave Lord High.

Lochkovian, Pragian, and Lower Zlichovian (Lower Devonian) (Figure 11)

Rocks of this age in the carbonate facies are characterized by the presence of such brachiopods as *Gypidula pelagica* (lower Lochkovian); *Spirigerina supramarginalis* and *Toquimaella kayi* (upper Lochkovian); *Cortezorthis*, *Plicocyrtina*, *Davidsoniatrypa*, and other forms (Pragian) (Lenz, 1966, 1968, 1972, 1977a, b). In the graptolite facies they are characterized by *Monograptus uniformis* and *M. aequabilis* (lower Lochkovian); *M. hercynicus* (upper Lochkovian); and *M. telleri*, *M. thomasi* and *M. yukonensis* (Pragian) (Lenz and Jackson, 1971; Jackson, Lenz and Pedder, 1978). The trilobite, *Warburgella rugulosa*, is an important element in the lower Lochkovian. The more significant cricoconarids include *Nowakia bohemica*, which occurs rarely in the middle Lochkovian, and *N. acuaria*, which is widespread in the upper Lochkovian and Pragian. Brachiopods of the *Sieberella-Nymphorhynchia pseudolivonica* fauna, commonly associated with conodonts of the *dehiscens* Zone, characterize the lower Zlichovian (Lenz, 1977a, b) in open marine facies. The giant ostracode, *Moelleritia canadensis*, appears at this level in restricted marine carbonate facies.

Shallow water, restricted marine dolomite and dolomitic limestone, formerly assigned to the Gossage Formation of Tassonyi (1969), but here placed in the Unnamed carbonate unit, occur on the Mackenzie Platform. These rocks appear to be missing by erosion on the Campbell Uplift (locs. 31 and 32) where a hiatus separates the base of the Cranswick Formation from Silurian dolomite.

Similar restricted marine dolomite and dolomitic limestone, here named the Kutchin Formation, occurs on the White Mountains Platform (locs. 30 and 47) and on the Yukon Stable Block, flanking the east and southwest sides of the Dave Lord High (locs. 23a, 24, 25, 26, 27, 28, 45). Most of these rocks are completely barren of megafossils with the exception of the upper parts of some sequences where the ostracode, *Meolleritia canadensis*, makes its appearance. A condensed sequence of the Kutchin Formation occurs at Mount Burgess (Loc. 24) where the Upper Ordovician, Silurian and part of the Lower Devonian are missing. A short distance north of Mount Burgess, the Kutchin Formation and Middle Ordovician are also missing. These localities are on the east flank of the Dave Lord High, where the influence of this positive area is most pronounced.

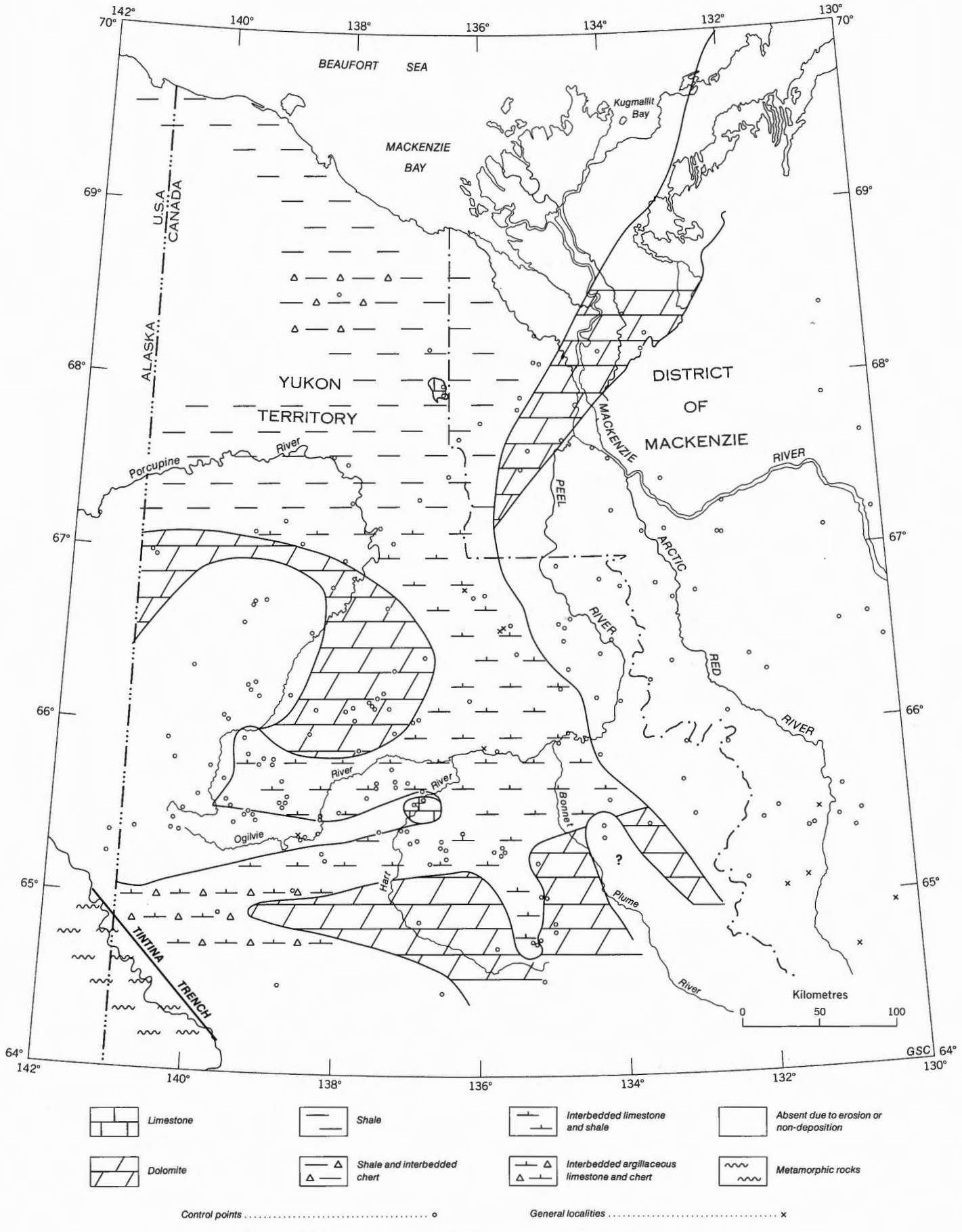

FIGURE 10. *Ludlovian and Pridolian (Upper Silurian) lithofacies.*

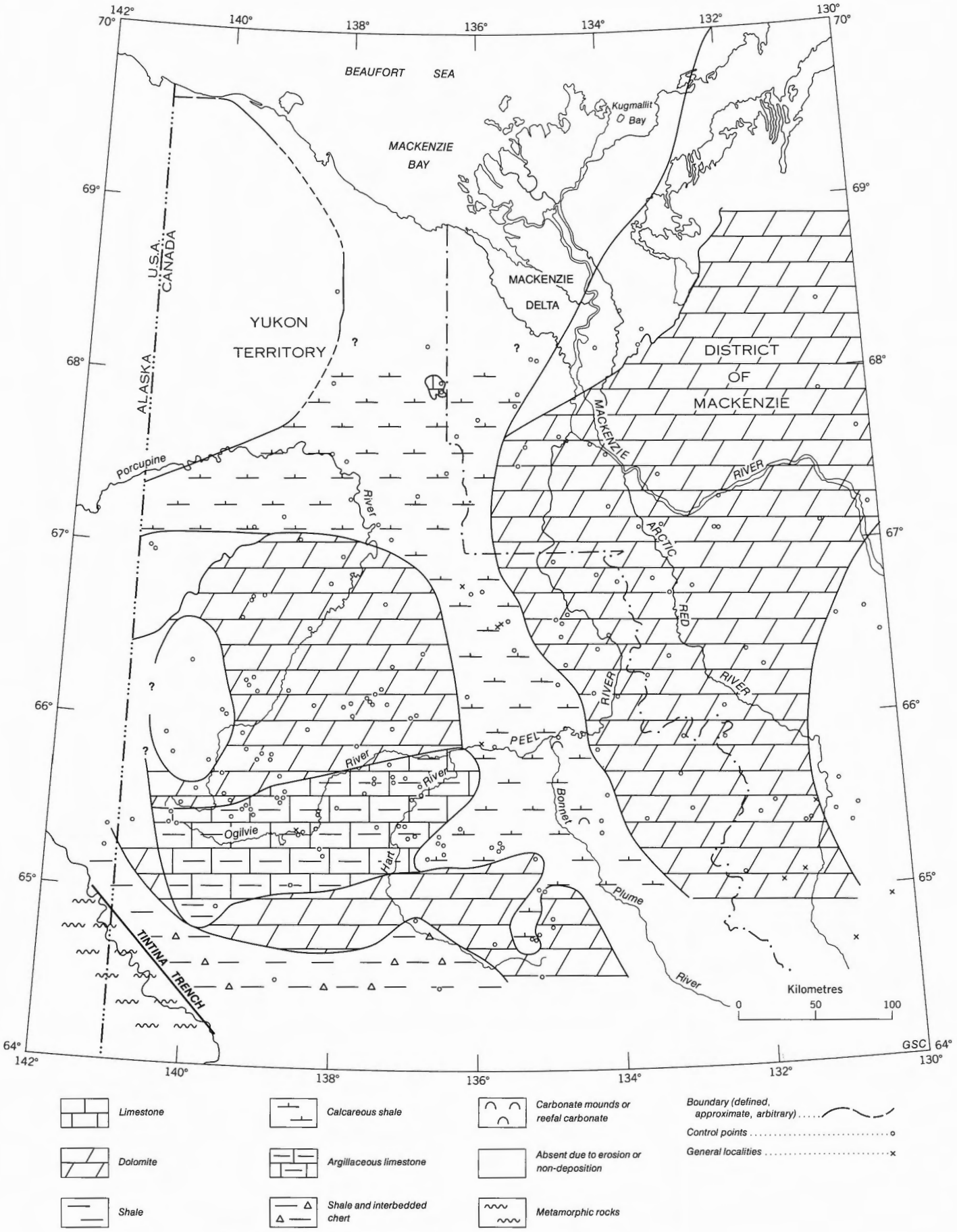

FIGURE 11. *Lochkovian, Pragian and lower Zlichovian (Lower Devonian) lithofacies.*

The position of the Blackstone Trough during this time interval was marked by deposition of the Road River and Michelle formations, with the latter formation representing a transition between shale basin and carbonate platform deposition. The Michelle Formation, although relatively thin, is one of the most fossiliferous in the report area. Its diverse faunas have been studied by Ludvigsen (1970, 1972), Ormiston (1971), Berdan and Copeland (1973), and others. Some of its more diagnostic elements include conodonts of the *dehiscens* Zone, cricoconarids of the *strangulata* Zone, the trilobite *Lacunoporaspis norrisi*, and brachiopods representative of the *Sieberella-Nymphorhynchia pseudolivonica* fauna.

At this time, the Richardson Trough extended southward as a narrow channel through the headwaters of Royal Creek (locs. 8, 38, and L-42) to connnect with the Selwyn Trough. The rich faunas of the Road River Formation at the headwaters of Royal Creek have been studied in detail by Lenz (1968, 1977a, b). To the north, the Richardson Trough widened to cover the lower Porcupine River area (Loc. 13) where *Monograptus thomasi* and *M. yukonensis* have been recovered from the Road River Formation (Jackson and Lenz, 1969). From Locality 13, the trough extended westward into the Salmontrout River area of east-central Alaska (Loc. L-84; Lane and Ormiston, 1979) where *M. hercynicus* has been recovered from the upper part of the Road River Formation.

From the lower Porcupine River area (Loc. 13) the Richardson Trough appears to have been connected to the north with the Rapid Trough. This interpretation is based on the presence of shale of the Road River Formation at the headwaters of Johnson Creek (Loc. L-81) from which *Monograptus yukonensis* has been recovered (D.K. Norris, 1970).

Upper Zlichovian and Dalejan (upper Lower Devonian) (Figure 12)

Rock units included in the upper Zlichovian and Dalejan (upper Lower Devonian) interval include: the upper part of the Bear Rock Formation of Bassett (1961) on the eastern Mackenzie Platform east of the report area; the Cranswick Formation on the western part of the Mackenzie Platform; part of the Road River Formation in the southwestern part of the Richardson Trough; the lower parts of the Ogilvie Formation and Unnamed shale unit on the Yukon Stable Block; and the lower part of the Ogilvie Formation on the White Mountains Platform. Rock units included in this interval in adjacent Alaska comprise a large part of the Limestone and shale member of the McCann Hill Chert of the Nation River area; and the upper part of the Salmontrout Formation of the Salmontrout River area.

Conodonts represented in this interval comprise the *gronbergi*, *inversus* and *serotinus* Zones. Brachiopods of the *Carinatina lowtherensis* fauna occur in the Zlichovian interval. The ubiquitous 'two-hole' echinoderm ossicle, *Gasterocoma*? *bicaula*, appears in abundance immediately above beds containing the conodont *dehiscens* Zone and ranges upward into beds immediately below the conodont *costatus costatus* Zone. In restricted marine carbonate facies the conodont *Pandorinellina* sp. A of Uyeno and Mason (1975) is reported by Chatterton (1978) to be associated with conodonts of the *serotinus* and *costatus costatus* Zones. *Pandorinellina* sp. A appears also to overlap the upper range of the giant ostracode, *Moelleritia canadensis*, which occurs also in a restricted marine carbonate facies.

During this interval the Bonnet Plume High was emergent, and separated two areas of deep water shale and limestone deposition immediately to the east and west. Evidence from various control points within the southern two thirds of the area formerly occupied by the Richardson Trough indicates that a part of this trough was emergent for at least part of this interval. An unconformity clearly separates the top of the Road River Formation from the Canol Formation in at least three localities, cited by Lenz (1972, p. 347) as follows: Rock River (Loc. L-33); lower canyon of Peel River (Loc. L-23); and the upper canyon of Peel River (Loc. L-36). Other localities in the trough where the unconformity is apparent are as follows: Locality 6 of Uyeno and Mason (1975) on Road River; Locality 35 of this report on Trail River; the Bassett and Stout (1968, p. 744) locality at 65°54'N, 135°56'W on Peel River; and Locality S-12 of Perry et al. (1974) on lower Peel River.

On the Yukon Stable Block, the Zlichovian to Dalejan interval is represented by the lower part of the Ogilvie Formation, containing the *Polygnathus perbonus perbonus* "late form" and the *P. perbonus* n. subsp. D faunas of Klapper (in Perry et al., 1974), which are aligned by Klapper (1977, Fig. 2, p. 35) with the *inversus* Zone and the *serotinus* Zone, respectively. For some reason, the *gronbergi* Zone has not yet been recognized in the Yukon Territory. One would expect to find the zone in the lower part of the Ogilvie Formation, above the *dehiscens* Zone, which is present in the Michelle Formation, and below the *inversus* Zone in the Ogilvie Formation. The *gronbergi* Zone has been recorded, however, by Lane and Ormiston (1979) in the Salmontrout Limestone of east-central Alaska.

The Ogilvie Formation is overlain by shales of the Unnamed shale unit throughout a large southern part of the Yukon Stable Block where the contact between the two rock units is extremely diachronous. Fossils in the Unnamed shale unit are exceedingly sparse and have been found only in the lower part of the unit. Dacryoconarids suggestive of the *Nowakia holynensis* Zone of Dalejan (late Early Devonian) age have been recovered from the lower part of the shale at localities S-3, S-13 and S-25 of Perry et al. (1974).

Within the shale of the Road River Formation, near Locality 7 and near the southeastern margin of the Richardson Trough, is a series of small carbonate mound-like bodies which have been designated by Lenz (1972, p. 344) as small reefs, and which have been described in more detail by Macqueen (1974). Fossils in the carbonate mounds indicate that they are about the same age as the Michelle Formation, according to Lenz (1972, p. 344).

Perry (in Perry et al., 1974, p. 1058) reported somewhat similar bodies of limestone in the Road River Formation from a locality a short distance to the west. He indicated that at Locality S-12, near the mouth of lower Peel River Canyon, the upper part of the Road River Formation consists of calcareous shale and contains large exotic blocks of limestone, 50 to 100 feet (15-30 m) in diameter. The top of the Road River Formation is a limestone breccia containing abraded stromatoporoids, corals, and cobbles of crinoid encrinite with *Gasterocoma*? *bicaula*. Conodonts from the breccia indicate assignment to the *Polygnathus perbonus perbonus* fauna of Klapper (in Perry et al., 1974, p. 1058) and correlation with the lower beds of both the Cranswick and Ogilvie formations. Perry (in Perry et al., 1974, p. 1058) indicated that a similar *G.*? *bicaula*-bearing breccia occurs at the top of the Road River Formation on Solo Creek (65°51'25"N, 134°15'30"W). The detrital limestone blocks in these breccias were derived most probably from the Cranswick Formation of the Mackenzie Platform and transported westward by slumping into the Richardson Trough. The brecciated beds are abruptly overlain by the

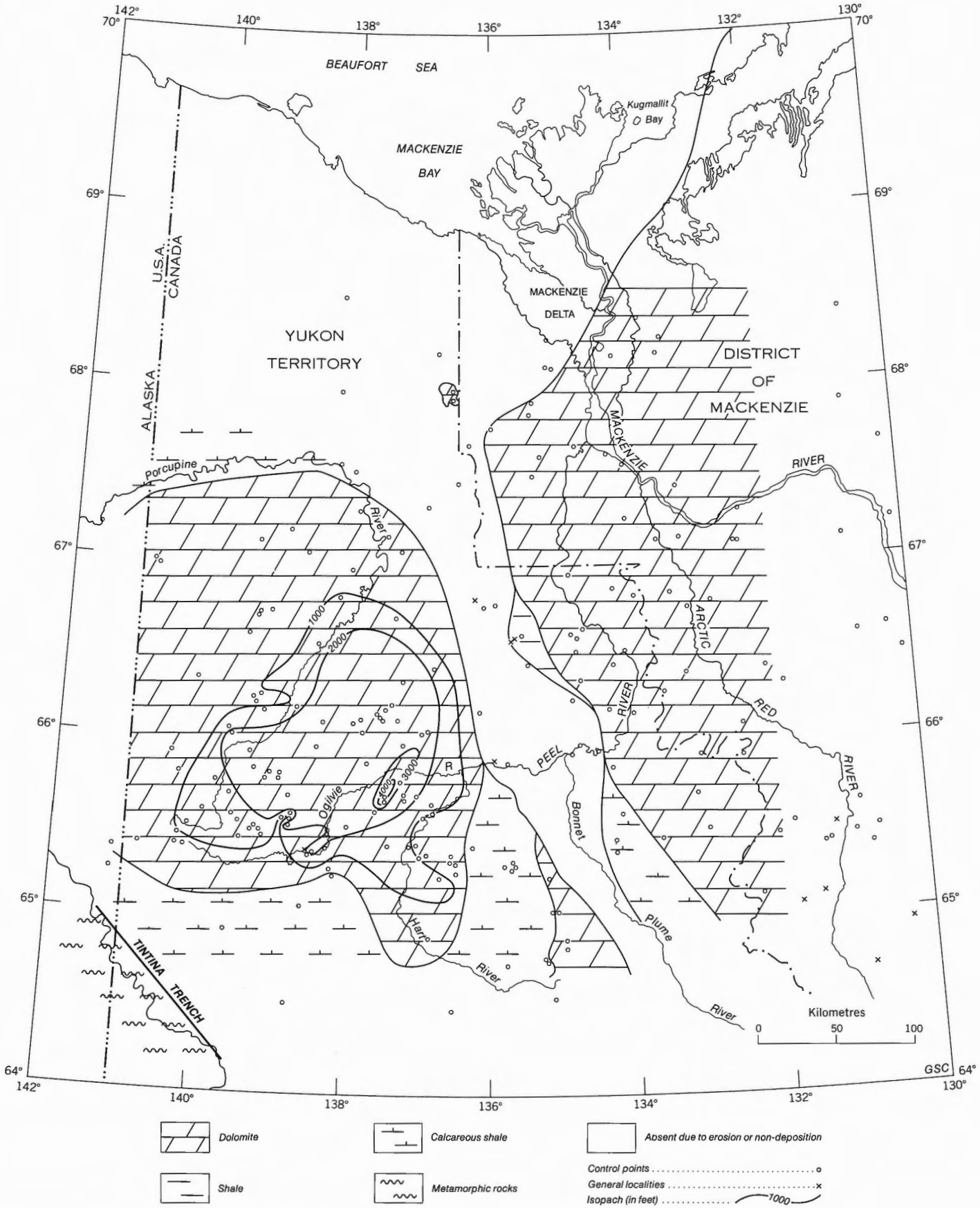

FIGURE 12. *Upper Zlichovian and Dalejan (upper Lower Devonian) lithofacies.*

Canol Formation, indicating a hiatus of considerable magnitude. The evidence suggests that the southern end of the Richardson Trough was a positive area throughout late Early and Middle Devonian time.

During Zlichovian and Dalejan time, the southwestern part of the Richardson Trough formed a broad connection with the Selwyn Basin to the southwest. The Selwyn Basin during this time extended into the Nation River area of east-central Alaska.

Eifelian (lower Middle Devonian) (Figure 13)

Throughout a large part of the Mackenzie Platform, rocks consisting of evenly bedded and nodular limestone, argillaceous limestone, calcareous shale and some dolomite are assignable to the Hume Formation of Bassett (1961). From the Hume Formation at Powell Creek, Uyeno (1979) identified conodonts indicative of the *australis* and *kockelianus* Zones. Undescribed collections suggest that the *costatus costatus* and *ensensis* Zones may be present as well (T.T. Uyeno, pers. comm., July 8, 1982).

The more argillaceous limestone beds of the Hume Formation contain an exceedingly rich megafauna, within which two broad faunal associations have been recognized by various workers. The lower, *"Schuchertella" adoceta* Zone, is commonly associated with conodonts of the *australis* Zone. According to Pedder (1975, p. 572), most of the associated brachiopods of this zone range upward into overlying zones, but he considered the corals *"Microcyclus" multiradiatus* (Meek), *Radiastraea trichomisca* (Crickmay), *R. verrilli* (Meek), and *Taimyrophyllum triadorum* Pedder as diagnostic of the zone. The upper, *Carinatrypa dysmorphostrota* Zone is associated with conodonts of the *kockelianus* Zone. Associated diagnostic megafossils in the zone comprise (Pedder, 1975, p. 572): *Spinatrypa borealis* (Warren), *S. andersonensis* (Warren), *S. coriacea* Crickmay, *Radiastraea tapetiformis* (Crickmay), *Taimyrophyllum stirps* (Crickmay), *Aphroidophyllum howelli* Lenz, *A. meeki* Pedder, and *Mackenziephyllum insolitum* Pedder.

Beds of the Hume Formation can be traced westward on the Mackenzie Platform into the southeastern part of the report area where they are present at sections 1, 2 and 3.

The upper part of the carbonate Cranswick Formation on the Campbell Uplift (Sec. 31) contains conodonts originally assigned by Uyeno and Mason (1975) to the *costatus costatus* Zone, but which were later placed by Klapper and Johnson (1980) in the *australis* Zone, indicating that this area was a part of the Mackenzie Platform at this time.

Megafossils indicating correlation with the lower Hume Formation occur in the upper part of the argillaceous Mount Baird Formation the Snake River area (Sec. 6). The presence of predominantly calcareous shale, with minor amounts of limestone of the Mount Baird Formation, at this section suggests that it is a slope deposit showing a transition from carbonate platform in the east to basinal shale deposition in the west. Influence of the Bonnet Plume High is evident because of the unconformity separating the top of the Mount Baird Formation from the overlying Canol Formation at Section 6.

On the Yukon Stable Block, rocks of Eifelian age are represented by parts of the carbonate Ogilvie Formation and shales of the Unnamed shale unit. There is a problem depicting these two rock units on a paleogeographic map, because of the extremely diachronous contact between the units and the lack of fossils throughout most of the upper part of the Unnamed shale unit. Two conodont faunal units of Eifelian age were recognized by Klapper (in Perry et al., 1974, Fig. 4, p. 1062) within the Ogilvie Formation. These comprise the *Polygnathus costatus costatus* and the *Polygnathus pseudofoliatus* faunal units which are currently aligned by Klapper (1977, Fig. p. 35) with the *costatus costatus* Zone, and the *australis* and *kockelianus* Zones, respectively. Elements of the *Polygnathus costatus costatus* faunal unit have been recovered from the Ogilvie Formation at localities S-3, S-8 and S-10; and the *P. pseudofoliatus* faunal unit at Section S-5 (Perry et al., 1974, p. 1065).

Brachiopods of Eifelian age are sparse in the Ogilvie Formation; however, those recovered comprise: *'Productella'* sp., *Spinulicosta* sp., and *?Vallomyonia devonica* (Walcott) from Section S-5; *Pentamerella* sp. and *Najadospirifer* sp. from Section S-19; and *Warrenella kirki* (Merriam) from Section S-9 (Perry et al., 1974, p. 1060-1061).

Eifelian corals in the Ogilvie Formation identified by A.E.H. Pedder (in Perry et al., 1974, p. 1066) comprise *Taimyrophyllum* sp. from Section S-18, and *Radiastraea verrilli* (Meek) from Section S-6.

The trilobite *Dechenella* (*D.*) *maclareni* Ormiston of probable Eifelian age has been identified by Ormiston (in Perry et al., 1974, p. 1067) from the Ogilvie Formation at Section S-5. This form occurs also in the Mount Baird Formation at Section 6.

A relatively thin sequence within the Ogilvie Formation at Mount Burgess (Sec. 24) contains a rich coral fauna of late Eifelian age (*dysmorphostrota* Zone) recently described by Pedder (1980). The more diagnostic Rugosa of this fauna comprise (Pedder, 1980, p. 595): *Radiastraea tapetiformis* (Crickmay), *R. norrisi* Pedder, *Tawuphyllum* n. sp, *Psydracophyllum lonsdaleiaforme* Pedder, *Gaynaphyllum hyperbolicum* (Crickmay), *Sociophyllum glomerulatum* (Crickmay), and *Microplasma caespitosum* (Schlüter).

The interbedded, grey, crinoidal packstone and dark brown, siliceous and calcareous siltstone of the Old Camp Formation of the Salmontrout River area of east-central Alaska contain Eifelian conodonts of the *costatus costatus*, *australis* and (possibly) *kockelianus* Zones (Lane and Ormiston, 1979). The description of this formation suggests some similarity to the Limestone and shale member of the McCann Hill Chert of the Nation River area, Alaska. Eifelian conodonts suggestive of the *australis* and *kockelianus* Zones occur also in the upper part of the Limestone and shale member of the McCann Hill Chert at the Nation River locality (Lane and Ormiston, 1979).

Dark shale and chert, here assigned to the Unnamed shale unit, overlie a shaly and dolomitic Ogilvie Formation in the subsurface of the Inexco Porcupine G-31 well (66°20'22"N, 140°06,13"W), between depths of 4095 to 3200 feet (1248.2 to 975.4 m). This suggests that shale deposition in the Selwyn Basin encroached northward to overlap the southern and western sides of the Yukon Stable Block during Eifelian time, in the report area.

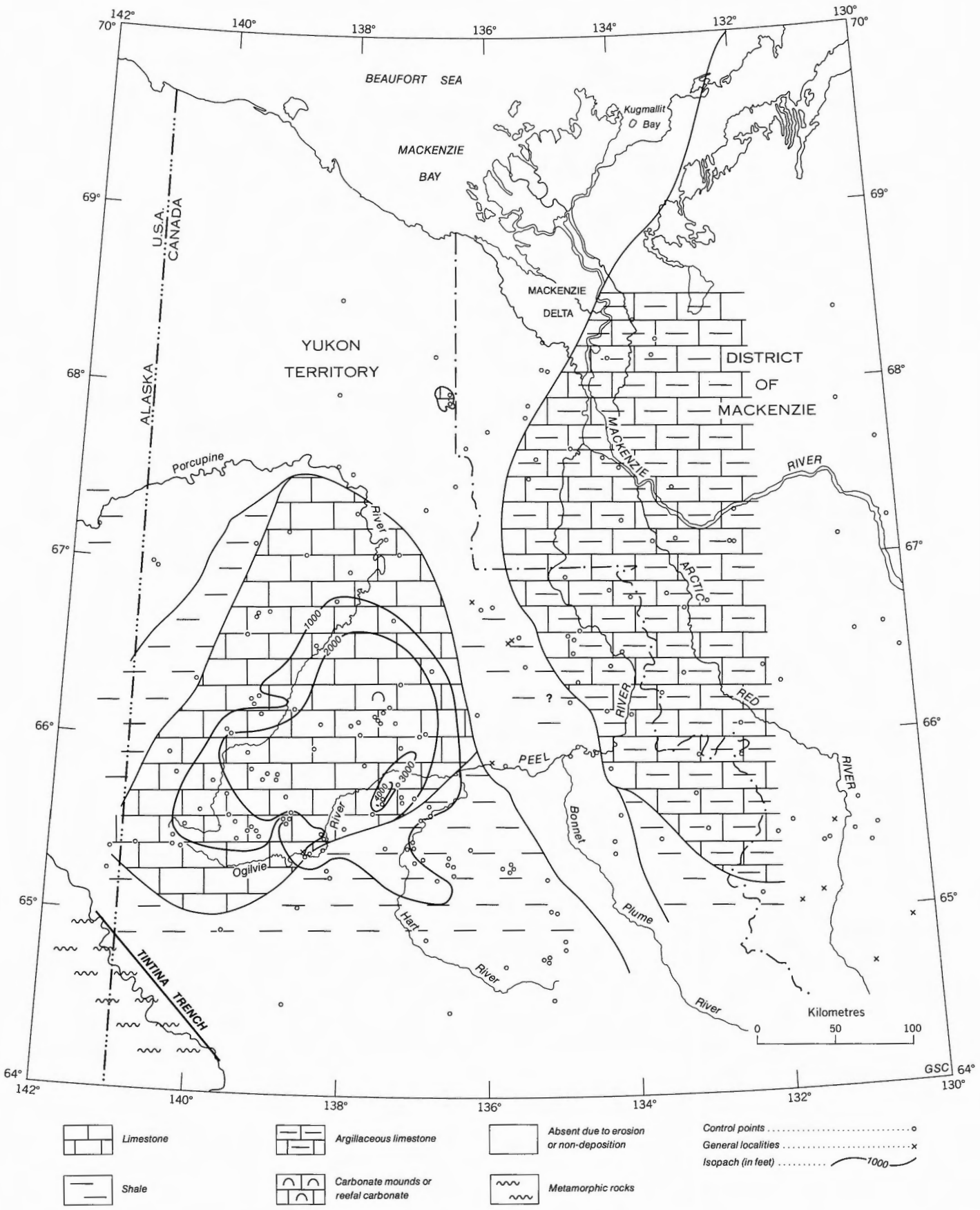

FIGURE 13. *Eifelian (lower Middle Devonian) lithofacies.*

Reef-like carbonate at the top of the Ogilvie Formation in the subsurface, between depths of 8250 and 7476 feet (2514.6 and 2278.7 m) in the Chevron North Parkin Y.T. D-61 well (56°20'12"N, 137°13'01"W) has been recorded by Pugh (1983, Fig. 27a). The reef was located near the eastern margin of the Yukon Stable Block during a time when the adjacent Richardson Trough was possibly emergent.

Givetian (upper Middle Devonian) (Figure 14)

Rocks of Givetian age on the Mackenzie Platform adjacent to the Mackenzie Valley are recognized from elements of the following megafaunas, in ascending order: *Leiorhynchus castanea*, *Ectorensselandia laevis*, *Stringocephalus aleskanus*, *Leiorhynchus hippocastanea*, and *Grypophyllum mackenziense* Zones (Pedder, 1975).

In this area, faunal elements of these zones are represented in the calcareous shale, argillaceous limestone and noncalcareous shale of the Hare Indian Formation (Tassonyi, 1969; Pedder, 1975); in an unnamed sandstone unit in the Grandview Hills area, referred to as Map-unit 4 by Cook and Aitken (1975) and recently described by MacKenzie, Pedder and Uyeno (1975) and by Uyeno (1978); and in the bedded platform and reefal parts of the Ramparts Formation (Tassonyi, 1969; Pedder, 1975).

In the southwestern extension of the Richardson Trough and in the Selwyn Basin, rocks considered to be of Givetian age are represented by shale of the Road River Formation.

On the Yukon Stable Block, rocks of Givetian age are represented by part of the limestone of the Ogilvie Formation and by part of the shale, siliceous shale and chert of the Unnamed shale unit.

Traced westward from the Norman Wells-Fort Good Hope area, rocks of the lower Hare Indian Formation containing fossils of the *castanea* Zone are last seen at Section 1 near Arctic Red River immediately east of the Operation Porcupine area. The western feather edge of the Hare Indian Formation is apparent also in the subsurface as shown in cross-section by Pugh (1983, Fig. 27b). The absence of rocks of Givetian age throughout most of the Richardson Trough and western part of the Mackenzie Platform suggests that this area was uplifted and truncated by erosion prior to deposition of the upper Middle Devonian Canol Formation. The truncation of pre-Canol rock units gradually increases westward and reaches a maximum in roughly the southern half of the Richardson Trough area. The hiatus at Section 1 is between rocks of the lower Hare Indian Formation bearing fossils of the *castanea* Zone (approximately equivalent to the conodont *ensensis* Zone), and the Canol Formation containing spathiocarids aligned with the Lowermost *asymmetricus* Zone. The hiatus at a section on Peel River (65°54'N, 135°56'W) reported by Bassett and Stout (1968, p. 744) is between shale of the Road River Formation, containing the graptolite *Monograptus yukonensis* of Pragian age, and the Canol Formation containing the conodont *Palmatolepis*, which indicates a Lowermost *asymmetricus* Zone or younger age.

On the Yukon Stable Block, during Givetian time, the carbonate Ogilvie Formation (with a few exceptions) was almost completely overlapped by dark shale, siliceous shale, and dark interbedded chert of the Unnamed shale unit.

The index brachiopod for the lower Givetian, *Leiorhynchus castanea* (Meek), has been reported by Perry (in Perry et al., 1974, p. 1094) from the top of the Ogilvie Formation at his Section S-21, and by Lenz (1972, p. 352) from near the base of dark shale of the Unnamed shale unit, overlying the Ogilvie Formation near his Locality L-71.

Norris (1968a, b) showed that stringocephalids, including *Stringocephalus* sp. cf. *S. obesus* Grabau, occur at scattered levels within the upper 1020 feet (310.9 m) of the Ogilvie Formation at Section 24 on Mount Burgess. Conodonts of undifferentiated *varcus* Zone (Klapper, in Perry et al., 1974) have been recovered from the upper part of the Ogilvie Formation at this locality. Overlying sediments of the Unnamed shale unit are very thin or absent in the vicinity of Mount Burgess.

Fossils identified by C.R. Stelck (listed in an unpublished company report) suggest that a thin upper part of the Ogilvie Formation, in the Eagle Plains No. 1 well, (66°48'54"N, 138°08'30"W) may be of Givetian age.

A lower part of the Chert and shale member of the McCann Hill Chert of the Nation River area of east-central Alaska is of probable Givetian age. This conclusion is based on the evidence of conodont identifications from the upper part of the Limestone and shale member, which suggest an Eifelian age (Lane and Ormiston, 1979), and spores from the upper part of the Chert and shale member of the McCann Hill chert, which indicate a Late Devonian age (Scott and Doher, 1967).

In the subsurface of the Socony North Cath. Y.T. B-62 well (66°11'14"N, 138°41'53"W) where the base of the Canol Formation can be positively placed at 1358 feet (413.9 m), and the top of the Ogilvie Formation at 2661 feet (811.1 m) depth, the Unnamed shale unit is 1303 feet (397.2 m) thick. The "true" Canol Formation in this well is 108 feet (32.9 m) thick and contains spathiocarids similar to those that occur in the Canol Formation in the Arctic Red River area (Sec. 1) and are of late Givetian (late Middle Devonian) age. The Unnamed shale unit in this well consists of a thin sequence of dark shale at the base, which Pugh (1983, Fig. 27a) referred to the Canol Formation, overlain by a succession of shale, siltstone and sandstone that Pugh (1983, figs. 27a and 34) referred to the Imperial and Ford Lake formations. Considering the age of the "true" Canol Formation in this well, it is very likely that an upper part of the Unnamed shale unit is of Givetian age. The appearance of siltstone and sandstone in the Unnamed shale unit indicates that coarse clastic sedimentation started in Middle Devonian time in this western part of the report area.

On the Mackenzie Platform, the western edge of the unnamed sandstone unit described by MacKenzie, Pedder and Uyeno (1975) seems to coincide approximately in the subsurface with the western truncated edge of the Hare Indian Formation (see Pugh, 1983).

Uppermost Givetian (upper Middle Devonian) and Frasnian and Famennian (Upper Devonian) (Figure 15)

Rocks of the upper Givetian, Frasnian and Famennian interval in the report area comprise the Canol and Imperial formations as well as a part of the Tuttle. For convenience, Figure 15 illustrates the Canol and Imperial formations; a separate Figure 16 and a discussion will deal with data pertaining to the Tuttle Formation.

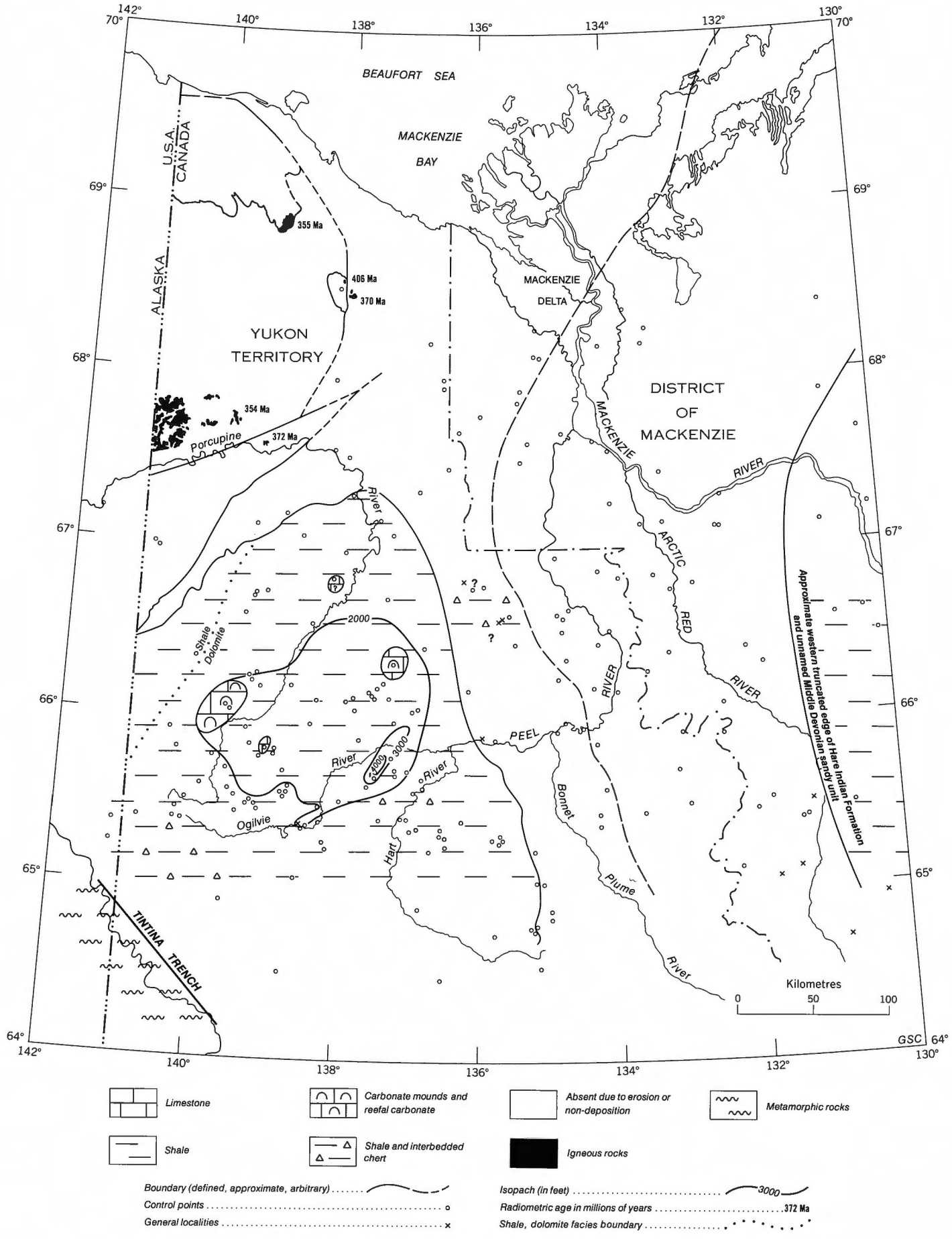

FIGURE 14. *Givetian (upper Middle Devonian) lithofacies.*

The Canol Formation is a relatively thin unit that generally consists of black, extremely fissile, bituminous, and in places siliceous shale. The unit is commonly coated with a yellowish green powdery patina, and it commonly contains orange weathering clay ironstone nodules. At Powell Creek in the eastern part of the Mackenzie Platform, Uyeno (1978) obtained conodonts from the Canol Formation, which he assigned to the Lowermost or Lower *asymmetricus* Zone but which are now placed in the upper part of the *disparilis* Zone by Klapper and Johnson (1980, p. 446) (that is, Lowermost *asymmetricus* Zone) of the upper Middle Devonian. At this locality, the Canol Formation overlies the Allochthonous beds of MacKenzie (1970), which contain megafossils of the *Tecnocyrtina billingsi* Zone (Pedder, 1975) and conodonts assigned to the Lowermost *asymmetricus* Zone (Uyeno, pers. comm., November 6, 1981).

The boundary between the Middle and Upper Devonian is still undecided, but both the base of the conodont *disparilis* Zone and base of the conodont Lower *asymmetricus* Zone are levels that are about equally favored, by members of the Subcommission on Devonian Stratigraphy, to mark the base of the Upper Devonian[1].

The preponderance of faunal evidence suggests that the Canol Formation throughout its area of distribution may be assigned to the Lowermost *asymmetricus* Zone. The unconformity at the base of the Canol Formation has been well documented by various workers (e.g., Tassonyi, 1969; Braun, 1977; Pedder, 1975; Bassett and Stout, 1968; Norris, 1968a, b) with the hiatus increasing westward up to the south end of the Richardson Trough, beyond which the hiatus has not been demonstrated. Rocks of the Canol Formation are recognized throughout the Mackenzie Platform, and along the eastern and western flanks of the Richardson Anticlinorium. In the southwestern part of the Richardson Trough it has, in some sections, been included in the upper part of the Road River Formation, and on the Yukon Stable Block it has been included in the upper part of the Unnamed shale unit. The thin, even bedding of the black, carbonaceous and siliceous shale and lack of benthonic shelly fossils, suggest deposition in a deep water, euxinic environment.

The sediments and sedimentary pattern of the Imperial Formation, of Frasnian and Famennian age, differ considerably from all rock units previously discussed. In the southeastern part of the area, the Imperial Formation consists of fine clastics and lesser amounts of carbonate of shallow water marine origin, and contains marine macrofossils in its upper part. The sequence with marine megafossils can be traced westward from the Mackenzie River to the Arctic Red River areas. Generally, the only fossils found in the Imperial Formation in the report area are macerated plant fragments and spores. Hills and Braman (1978) consider that the lower part of the Imperial Formation in the Arctic Red River area (Sec. 1) is of turbidite origin, in contrast with Section 35 on Trail River to the northwest, where the entire formation appears to be of turbidite origin. On the west side of the Richardson Anticlinorium, the sediments of the Imperial Formation consist of relatively coarse grained greywacke and flysch-like siltstone and shale, in places containing fragmentary plants. A few spores have been recovered from this sequence in the subsurface, but they are generally so extremely carbonized and corroded that they are difficult to identify and date.

Hills and Braman (1978) report that paleocurrent evidence within the turbidite sequence on Trail River indicates transport of sediments toward the south and derivation of the clastic material from an uplifted area in the north. Other workers, including Glennie (1963), A.W. Norris (1968b), and industry geologists in unpublished reports, have come to the same conclusion. The maximum recorded thickness of about 6300 feet (1920.3 m) for the Imperial Formation occurs in the subsurface at the northeastern end of the Richardson Anticlinorium, suggesting a depocentre in that area (Pugh, 1983, Fig. 17).

The sediments of the Nation River Formation of east-central Alaska are obviously similar to those of the Imperial and Tuttle formations of the report area, as indicated by Nilsen, Brabb and Simoni (1976). The Nation River Formation has been dated as Late Devonian on the basis of spores (Scott and Doher, 1967). It is 2000 to 4000 feet (610 to 1220 m) thick, and consists of intermixed chert-pebble conglomerate, chert-quartz arenite, siltstone, mudstone, shale and pebbly mudstone. Although formerly considered a nonmarine deposit, Nilsen, Brabb and Simoni (1976) point out that evidence from sedimentary structures, lithofacies, paleocurrents, and stratigraphic relationships, suggests deposition as a deep-sea fan complex, with paleocurrents that indicate transport of sediments toward the west, and a source area located in the east or northeast.

The Nation River Formation rests conformably on the McCann Hill Chert, the upper part of which is of Late Devonian age, and is overlain conformably by the Ford Lake Shale of Late Devonian to early Late Mississippian age (Nilsen, Brabb and Simoni, 1976, p. E4).

Dark grey, slaty argillites, containing poorly preserved plant fragments, have been reported by D.K. Norris (1972, p. 93) to outcrop in the vicinity of Ammeran Mountain on the flank of the Old Crow Basin near the Yukon-Alaska boundary. The plant fragments are assigned to the genus *Archaeopteris* and suggest a late Givetian to Famennian age. This genus has been recovered from two GSC localities at 68°21'N, 140°52'W and 68°26'N, 140°52'W, from rocks originally thought to belong in the Proterozoic Neruokpuk Formation. These plant-bearing, continental, Devonian beds were probably much more widely distributed in the area before being affected by the Ellesmerian Orogeny and being largely removed by erosion.

South of the report area, sediments of presumed Frasnian and Famennian age consist of dark shale described by Green and Roddick (1962) and Green (1972).

Uppermost Upper Devonian and Lower Carboniferous (Figure 16)

Pugh (1983) has introduced the name Tuttle Formation to apply to an alternating succession of coarse- to fine-grained clastic rocks unconformably overlying the Imperial Formation and conformably underlying Carboniferous rocks and, also, unconformably underlying Mesozoic rocks in the

[1]After this report had been completed, members of the Subcommission on Devonian Stratigraphy meeting at Frankfurt on Main, West Germany, August 22-23, 1982, voted in favor of the base of the conodont Lower *asymmetricus* Zone to mark the base of the Upper Devonian internationally. This decision means that, in the Operation Porcupine area, the base of the Upper Devonian probably occurs at or near the base of the Imperial Formation, rather than at the base of the Canol Formation.

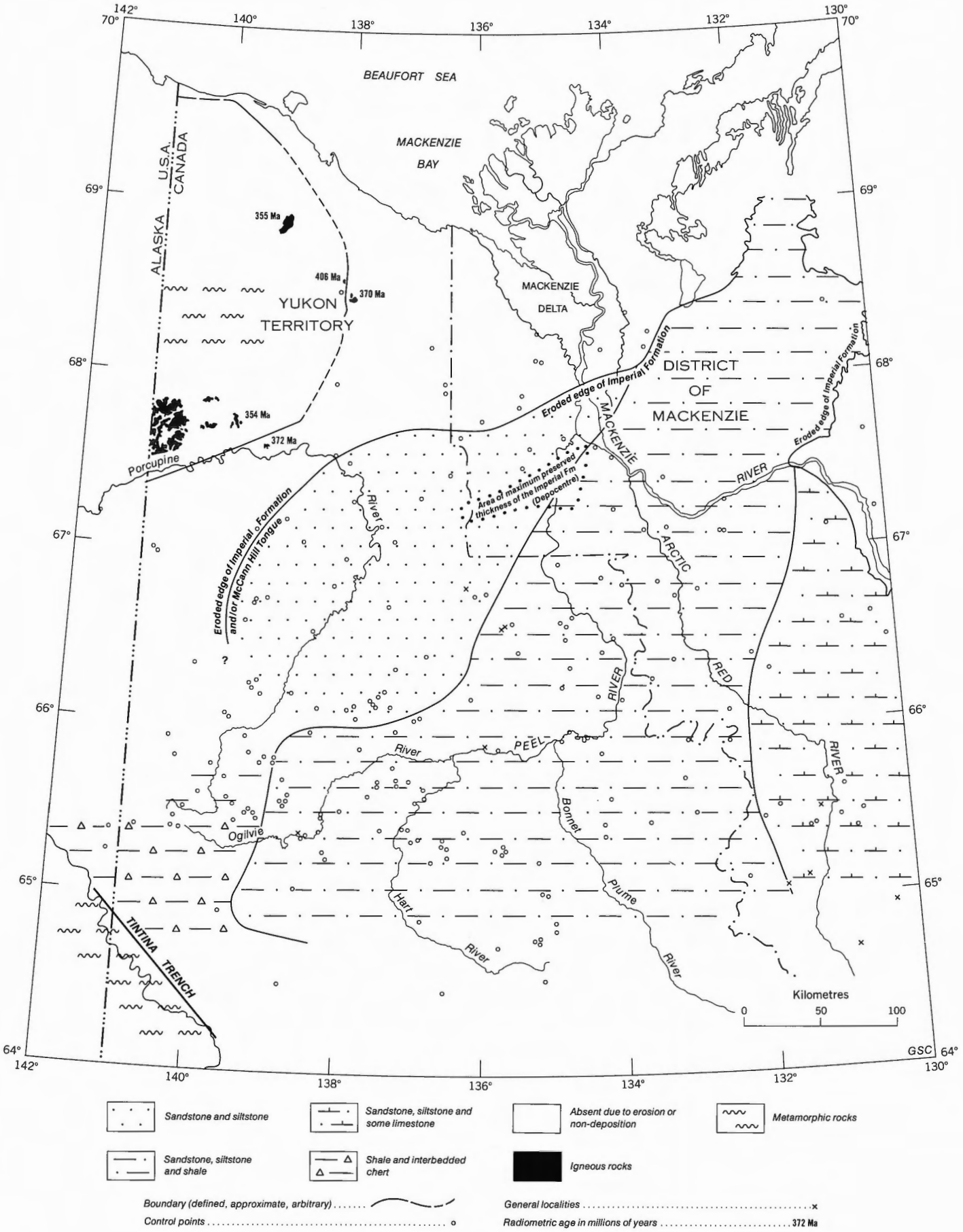

FIGURE 15. *Frasnian and Famennian (Upper Devonian) lithofacies.*

area flanking the Richardson Anticlinorium. It is not known if the unconformable relationship between the Imperial and Tuttle formations on Trail River is of local or regional extent. The coarse clastic rocks, including chert-pebble conglomerate and conglomeratic sandstone of the Tuttle Formation, formerly were considered by Norris (1968a, b) to be an upper member of the Imperial Formation. The Tuttle Formation is dated by palynomorphs (D.C. McGregor, this report; Braman, 1981) as late Famennian (late Late Devonian) at the base, to early Carboniferous at the top. In the western part of the report area, the Tuttle Formation passes southwestward into finer clastic rocks of the Ford Lake Shale that occur typically in the Nation River area of east-central Alaska (Churkin and Brabb, 1965). The sedimentary and lithological features of the Ford Lake Shale are interpreted by Nilsen, Brabb and Simoni (1976, p. E4) as deep-marine sediments.

From the isopach map prepared by Pugh (1983, Fig. 18) the depocentre of the Tuttle Formation appears to have been located near the north end of the Richardson Anticlinorium. The same illustration shows also that grade size of sediments ranges from conglomerate at the northeast end of the Richardson Anticlinorium to very fine grained sandstone and coarse siltstone southeastward along the east flank of the anticlinorium. Along the west side of the anticlinorium, the Tuttle sediments are referred to by Pugh (1983) as conglomeratic greywacke. Hills and Braman (1978, p. 36) consider that the sediments of the upper part of the Imperial Formation on Trail River, here assigned to the Tuttle Formation, are of turbidite origin. These authors indicate also that load casts, flute structures, and tool marks indicate that these turbidites were derived from the north. Lutchman (1977) interpreted the sediments of the Tuttle Formation as a southward advancing Mississippian clastic wedge of fluvio-deltaic origin. Lutchman (1977) envisaged successive delta systems that initially were confined to the northern part of the area, and which moved southward to progressively fill a basin. Traces of coal in the Tuttle sequence, noted by Pugh (1983, Fig. 18) at two localities near the eastern margin of the formation, would tend to support Lutchman's (1977) interpretation.

At the north end of the Richardson Anticlinorium, two sections (33, 34) show the Imperial Formation unconformably overlain by coarse grained clastic rocks of Permian age. In places, as on Sheep Creek near Section 33 (67°41'N, 136°15'W), an angular unconformity separates the Imperial Formation from the Permian (Norris, 1968b, Pl. 11, p. 282); and in places in the same general area near Sheep Creek (67°40'N, 136°15'W), beds of the Imperial Formation have been tightly folded (Norris, 1968b, Pl. 9, p. 280). The deformation is presumed to have coincided in part with the Ellesmerian Orogeny of the Arctic Archipelago (Thorsteinsson and Tozer, 1960).

Numerous authors have commented on the thick deposits of marine and nonmarine clastic sediments of Late and Middle Devonian age that are present at numerous localities around the North American side of the Arctic Ocean Basin. In the most recent comprehensive study of these clastic rocks, by Embry and Klovan (1976), the authors concluded that the Devonian clastic strata of the Arctic Islands were derived from source areas to the north and east. Embry and Klovan (1976, p. 602) suggested also that the Devonian clastic strata of the mainland (Imperial and Tuttle formations of the report area) are the southwestern extension of the Arctic Islands clastic wedge, and also may have been derived from the same source areas.

ECONOMIC GEOLOGY OF DEVONIAN ROCKS

Introduction

For detailed information on mineral and fuel occurrences of northern Canada, including the northern Yukon Territory, the reader is referred to Geological Survey of Canada Open File reports 691, 716 and 760, which were released in 1980 and 1981. All known mineral and fuel occurrences in the Operation Porcupine area have been plotted on sixteen Geological Survey of Canada maps covering the area, and prepared by D.K. Norris (1981a, 1982, 1983 and in press) at a scale of 1:250 000.

The modern era of exploration for hydrocarbons in the Operation Porcupine area began in 1953 with the helicopter supported geological investigation by Peel Plateau Exploration Ltd., headed by the late R.G. Perry (Perry, 1954). More recent, detailed accounts of the oil and gas potential of the Operation Porcupine and adjacent areas have been presented by: Martin (1973) for the Eagle Plain area; by Lawrence (1973) for the Old Crow Basin; by Lerand (1973) and D.K. Norris (1977) for the Beaufort Sea and adjacent mainland area; by Kunst (1973) for the Peel Plateau area; by Tassonyi (1969) for the Lower Mackenzie River and Anderson River area; by Gilbert (1973) for the Anderson Plain area; and by Aitken et al. (1982) for the Upper Ramparts River map area.

Industrial materials

Much of the crushed rock used in the construction of the road bed of the Dempster Highway was derived from local bedrock exposures along the highway. This road, which is about 750 km (465 miles) in length, was officially opened in 1979, and connects Dawson City on the Klondike Highway in the southwest, with Inuvik on the Mackenzie Highway in the northeast. Devonian rocks from the Operation Porcupine area, used in the construction of the road, include the Michelle, Ogilvie, Road River, Canol and Imperial formations. Although most of these rocks are suitable for the construction of road beds, the hard, siliceous, splintery shale derived from the upper part of the Road River Formation and/or Canol Formation is reported to cause severe wear and damage to rubber tires.

Carbonate rocks here assigned to the Cranswick Formation were quarried near Inuvik to supply metal for the construction of local roads (Norris, D.K., and Calverley, 1978). Carbonate rocks of the Ramparts Formation and also some of the overlying shale of the Canol Formation are quarried near the airport at Norman Wells for local road construction and, more recently, have been used to construct an artificial island in the Mackenzie River to serve as a drilling platform.

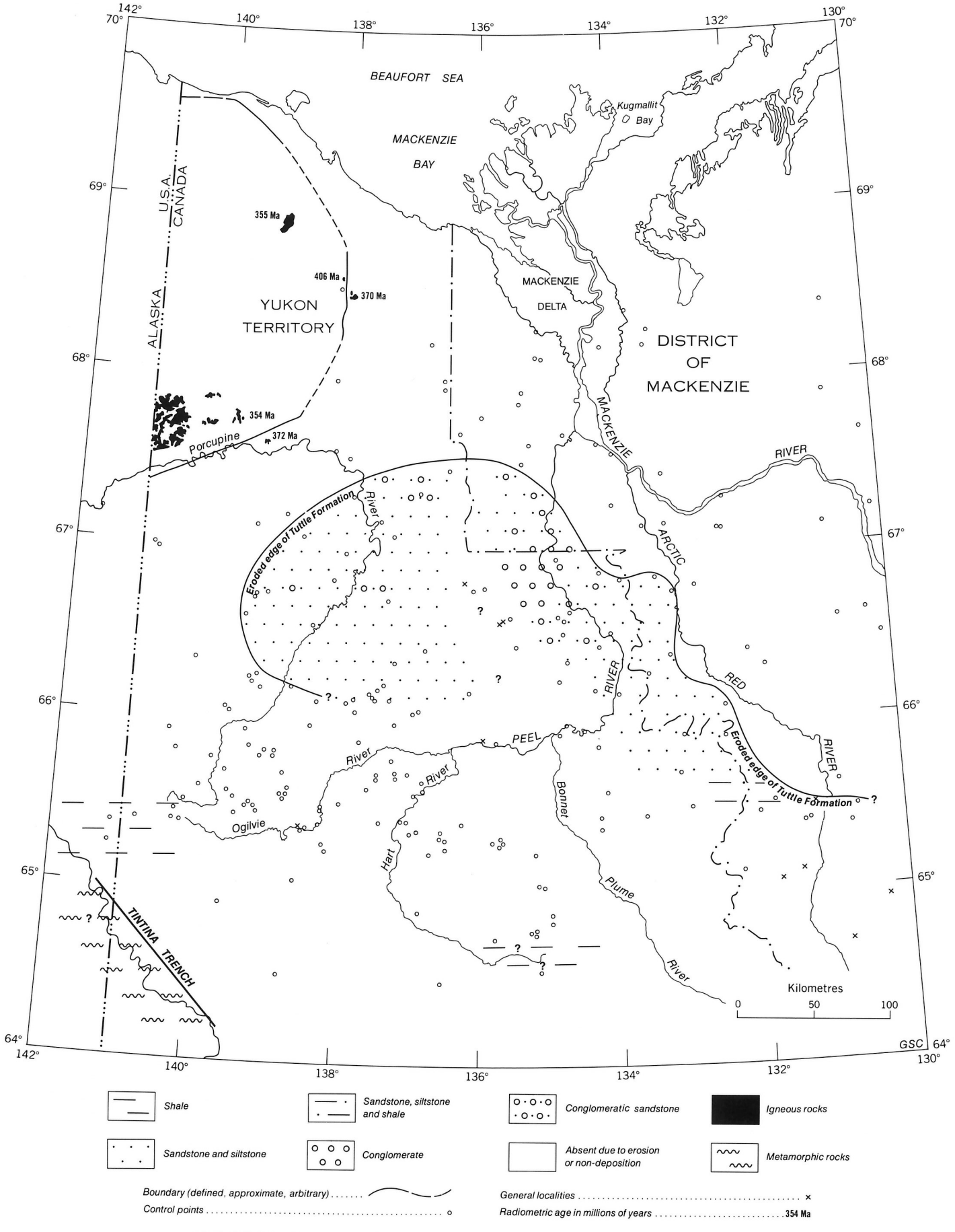

FIGURE 16. *Uppermost Upper Devonian and Lower Carboniferous lithofacies.*

Minerals

Minor amounts of tungsten (scheelite and wolframite) and, locally, some copper, molybdenum and uranium are associated with granitic intrusions, dated radiometrically as Devonian and older, which occur at Mount Sedgwick, Mount Fitton and near Old Crow. The tungsten occurs mainly as placer deposits in creeks draining the intrusive area, but bedrock showings are also known, notably near Mount Fitton (Geological Survey of Canada, Open File 760, p. 7; Gleeson, 1963). Lead and zinc, in the form of galena and sphalerite with quartz, are reported by Green and Godwin (1964, p. 18) to occur in granitic rocks of the Old Crow Batholith, west of Old Crow near the Yukon-Alaska border. Minor amounts of placer gold are known also in the creeks draining the areas underlain by the plutons (Gleeson, 1963).

Lead, zinc and some barite, occurring in shale and carbonate host rocks of the Selwyn Basin and Mackenzie Arch, have been described by Dawson (1975), Brock (1976), and others. Almost all of these occurrences are south of latitude 65°N, and east of longitude 134°W, that is south and east of the Operation Porcupine area. All of the occurrences are in strata older than Late Devonian and most of the more significant deposits have been found in dolomite of Early Cambrian age (Dawson, 1975, p. 239). Only those deposits occurring in host rocks of Devonian age will be mentioned here.

On Twitya River (64°02'N, 129°25'W) zinc-lead-copper deposits occur, mainly in brecciated dolomites of the Upper Silurian to Lower Devonian Whittaker, Delorme and Camsell formations (Dawson, 1975, p. 240). A somewhat similar deposit at 63°58'N, 129°16'W shows sparry white dolomite and yellow sphalerite occurring in beds of intraformational breccia within black dolomite of the "Middle" Devonian Arnica Formation (Dawson, 1975, p. 240). Three showings of secondary lead and zinc minerals occur at 63°51'N, 129°12'W along a fault zone 1000 feet (305 m) long in dolomites of the "Middle" Devonian Arnica and Landry formations (Dawson, 1975, p. 240). Minerals present in these showings include smithsonite, barite, cerussite and hydrozincite.

Regional surficial geochemistry testing of the Road River Formation in the vicinity of Barn Uplift, Driftwood High and the northern margin of the Old Crow Basin, show that these shales are anomalous in Zn, Pb, Ag, Mo, U, F, Ba, Mn and Fe (Geological Survey of Canada, Open File 760, 1981, p. 13). It was suggested that Pb-Zn mineralization similar to that occurring in the Road River Formation of the Selwyn Basin (described by Brock, 1979, p. 12), may occur in these northern areas. Other analogous dark shales of the Operation Porcupine area that deserve special attention are those of the Unnamed shale unit and the Canol Formation.

Oil and gas

Kutchin Formation

The Kutchin Formation (new name) forms the basal Devonian carbonate unit on the carbonate platforms within the Yukon Stable Block and White Uplift. The formation is lithologically atypical and anomalously thin or missing in the Mount Burgess area on the eastern flank of the Dave Lord High. To the south, the Kutchin Formation grades into the argillaceous Michelle and Road River formations of the Blackstone Trough, and to the east it grades into the Road River Formation of the Richardson Trough.

Where this formation has been penetrated in the subsurface, as in the SMWM N Cath YT B-62 (66°11'14"N, 138°41'53"W) well, Martin (1973, p. 286) reported that no porosity was observed, although carbonate infilled fractures were encountered. In the Peel Plateau Eagle Plain No. 1 (N-49) (66°48'54"N, 138°08'31"W) well in the northern part of the platform, fracture and vuggy porosity were noted in the upper 450 feet (137.2 m) of the formation. The latter well was drillstem tested, and some salt water was recovered (Martin, 1973, p. 286). On the eastern side of the platform, in the SMWM S Tuttle YT N-5 (66°24'51"N, 136°16'23"W) well, some zones of vuggy porosity were noted in the lower 1500 feet (457.2 m) of the formation, and a drillstem test near the base of the section showed a trace of gas and no water (Martin, 1973, p. 286-288). Core samples from the Kutchin Formation in the SOBC Blackstone YT D-77 (65°46'11"N, 137°14'55"W) well, were reported by Pugh (1983) to contain bitumen. The pinch-out of the Kutchin carbonate eastward within shale of the Road River Formation could result in stratigraphic traps, but the porosity development within the Kutchin Formation is not particularly promising.

Unnamed carbonate unit

The carbonate rock of the Unnamed carbonate unit forms the basal Devonian unit of the Mackenzie Platform east of the Richardson Trough. Westward, this carbonate unit intertongues with shale of the Road River Formation. Primary fluid migration is postulated by Kunst (1973, p. 270) to have been toward the east. Barriers to upward fluid migration are provided by the dense, pellet limestone of the Cranswick Formation or by the lower, argillaceous limestone member of the Hume Formation. Kunst (1973, p. 270) reported that, in places, the carbonates are highly bituminous, and are oil stained in outcrops below the lower canyon of Peel River, at Powell Creek, Mountain River and on the Imperial Anticline. He further stated that the oil seep at Rond Lake, as well as the Cretaceous oil sands at Lac des Bois and Lac Belot, to the east of Fort Good Hope, are believed to have had their source in the Bear Rock Formation.

In the subsurface of the Mackenzie Platform, the dolomites of the Bear Rock Formation were reported by Pugh (1983) to be in part a dark brown colour, show high intercrystalline porosity, and to be commonly oil stained or have an oily odour. He reported that, in the Arco Mountain River H-47m (65°46'23"N, 129°07'57"W) well, tests of the dolomite of the Bear Rock Formation revealed some gas at the surface. He reported also that two wells in the Arctic Red River area, At. Ontaratue H-34o (66°23'23"N, 132°05'59"W) and McI. Taylor Lake YT K-15t (66°54'39"N, 133°03'00"W), recovered gas-cut mud or water from the Bear Rock Formation. In both of the wells, the dolomite is sealed both above and below by limestone.

Road River Formation and Tongue

Basinal shale of the Devonian part of the Road River Formation was developed in the Richardson, Blackstone, Rapid and Hazen troughs of the report area. The shale sequence is relatively thick and, in part, is sooty and carbonaceous, and may be considered an excellent source rock. On the flanks of the troughs, where the shale interfingers with carbonate of the platform successions, the shale would serve as an effective seal for the entrapment of hydrocarbons in the carbonate rocks.

On the east flank of Knorr Range, near the southeastern margin of the Richardson Trough, about twenty discrete carbonate banks or biostromes, which developed within the upper third of the Road River Formation, have been described by Lenz (1972, p. 328) and by Macqueen (1974). In addition, very large exotic blocks of detrital limestone in the upper part of the Road River Formation, occurring in the lower Peel River Canyon and on Solo Creek, have been described by Peel et al. (1974, p. 1058). These limestone blocks are thought to have been derived from the Cranswick and/or Ogilvie formations and transported by slumping into the shale basin. During the early 1960's, these various carbonate bodies within the Road River Formation were of considerable interest to exploration geologists.

Michelle Formation

The Michelle Formation is a relatively thin but distinctive rock unit that developed in the Blackstone Trough in the southwestern part of the report area. It represents a transitional facies between basinal shale of the underlying Road River Formation and platform carbonate of the overlying Ogilvie Formation. Where penetrated in the subsurface by the SOBC Blackstone YT D-77 (65°49'11"N, 137°14'55"W) well, Martin (1973, p. 286) reported that the Michelle is 427 feet (130.2 m) thick, and consists largely of medium grey-brown, argillaceous limestone with abundant skeletal debris and some oolitic zones, and black bituminous shale. The latter rock type comprises about 10 per cent of the section.

The reservoir properties of the Michelle Formation are negligible, and can only be considered as a possible source rock.

Cranswick Formation

The Cranswick Formation, consisting mainly of limestone, was deposited on the Mackenzie Platform east of the Richardson Trough, where it outcrops along the Mackenzie front in the south, and on Campbell Uplift in the north. It appears to be equivalent to the upper, pellet limestone member of the Gossage Formation of Tassonyi (1969), and to the Landry Formation of Pugh (1983). Westward, the carbonate of the Cranswick Formation passes into shale of the Road River Formation in the Richardson Trough.

The gross features of this formation, such as fine textures seen in outcrop, suggest low porosity and permeability for the unit. However, both Tassonyi (1969) and Kunst (1973) indicate that local leaching of the upper part of the pelletoidal facies has improved the porosity within the unit in some areas.

Pugh (1983) reported that rocks of the Cranswick Formation in the Mobil Peel YT H-71 well (66°20'29"N, 134°43'35"W) produced gas while being drilled. This well is within the carbonate-shale transition zone between the Mackenzie Platform to the east and the Richardson Trough to the west. Tassonyi (1969, p. 143) reported that sulphurous salt water was recovered in drillstem tests from the Cranswick Formation in the ROC et al. Grandview Hills No. 1 (A-37g) well (67°06'12"N, 130°52'30"W), and oil bleeding was observed in several cores. He reported also that ¼ Mmcf. gas (est.) was obtained by drillstem test from the Cranswick Formation in the Glacier et al. Ramparts No. 1 (I-55) well (66°14'44"N, 129°39'47"W). Oil has been reported by Lerand (1973, p. 376) and by Oilweek (1972, p. 6) from about the 9400-foot (2865.2 m) level in the IOE Mayogiak J-17 well (69°26'43"N, 132°48'12"W). This well is located on the east side of the Mackenzie Delta and near the western margin of the Mackenzie Platform. The top of the Devonian in this well is at a depth of 9334 feet (2845 m) and the lithology of the interval from 9544 to 9544.5 feet (2909 to 2909.2 m), as well as the contained fossils comprising *Amphipora* sp. and *Spongonaria* sp. cf. *S. filicata* Crickmay, identified by A.E.H. Pedder (GSC Loc. C-12553), indicate assignment to the Cranswick Formation.

Ogilvie Formation

Carbonates of the Ogilvie Formation were deposited on the Yukon Stable Block and on the White Mountains Platform. Although a large part of the Ogilvie Formation consists of aphanitic to fine grained, nonporous limestone, parts of the sequence consist of coarser grained encrinite that is porous, fetid, and contains pyrobitumen. In the Blackstone-Hart rivers area and in the southern Nahoni Range area, dolomite beds are present in the lower part of the formation, and some of these exhibit intercrystalline and vuggy porosity with pyrobitumen present in some of the vugs.

Martin (1973, p. 288) indicated that, in the subsurface of Eagle Plain, the Ogilvie Formation was penetrated by the SMWN S Tuttle YT N-5 well (66°24'51"N, 136°16'23"W) and that a drillstem test in this unit recovered 2440 feet (743.7 m) of gas-cut salt water. Martin (1973, p. 288) reported also that, in the SOBC Blackstone YT D-77 well (65°46'11"N, 137°14'55"W), salt water was recovered from the lower, dolomitized part of the Ogilvie Formation.

Pugh (1983) reported that the Ogilvie Formation tested gas to surface in both the WM North Hope YT N-53 (66°32'54"N, 135°25'30"W) and Eagle Plains YT No. 1 (N-49) (66°48'54"N, 138°08'30"W) wells, which are located on a structural high. Reefal limestone in the upper part of the Ogilvie Formation, presumably similar to that occurring at Mount Burgess, was reported by Pugh (1983) to have been penetrated by four boreholes, comprising the Eagle Plains YT No. 1 (N-49) (66°48'54"N, 138°08'30"W), SOBC Shaeffer Creek YT O-22 (66°41'54"N, 137°18'40"W), Chevron North Parkin YT D-61 (56°20'12"N, 137°13'01"W), and SOBC Blackstone YT D-77 (65°46'11"N, 137°14'55"W) wells. This reefal limestone appears to be tight, but at well O-22, some gas was tested to surface.

Unnamed shale unit

Shales of the Unnamed shale unit overlie the diachronous top of the Ogilvie Formation and underlie relatively resistant clastic and carbonate rocks of Mississippian and younger ages on the Yukon Stable Block west of the Richardson Trough.

Martin (1972, 1973, p. 290) recorded analyses for organic carbon from shale samples from the Unnamed shale unit in the SMWM Blackie YT M-59 (65°58'55"N, 137°11'11"W) and the SOBC Blackstone YT D-77 (65°46'11"N, 137°14'55"W) wells. Organic carbon values recorded were 0.69 and 7.24 per cent, respectively, which suggests that these shales are good source rocks. However, spores from all but one or two samples from outcrops of this unit are generally so extremely carbonized and corroded that they are difficult to determine even at the generic level. This may suggest that the shales of this unit are overmature.

Martin (1973, p. 290) reported that, in the SOBC Blackstone D-77 well, there are two intervals of sandstone, each about 10 feet (3 m) thick, in the upper half of the Unnamed shale unit, that are porous and have a light oil stain.

Mount Baird Formation

The calcareous shale and argillaceous limestone beds of the Mount Baird Formation are confined to a narrow belt flanking the southeastern margin of the Richardson Trough. They appear to be shelf slope deposits that are transitional between shallow water carbonate shelf to the east, and deep water, noncalcareous shale basin to the west. Rocks of the Mount Baird Formation exhibit little porosity, but are in part bituminous, very fossiliferous and, probably, are good source rocks.

Hume Formation

The limestone and shale of the Hume Formation are developed on the Mackenzie Platform east of the Richardson Trough, and are considered to be potential source rocks. With few exceptions, porosity within the formation is rather limited. Kunst (1973, p. 270) mentioned biostromal carbonates with locally developed porosity and local bioherms in the Fort Good Hope area. Hume and Link (1945, p. 19) reported that limestones of the Hume Formation are in part petroliferous on the east flank of the Imperial Range on Mountain River. Tassonyi (1969, p. 145) indicated that a trace of oil bleeding had been noted in core from the Hume Formation in the ROC et al. Grandview Hills No. 1 (A-37g) well (67°06'12"N, 130°52'30"W).

Hare Indian Formation

The Hare Indian Formation, consisting mainly of shale, was developed on the Mackenzie Platform. In the area west and northwest of Norman Wells, the formation has been uplifted and truncated by pre-Canol erosion. Westward, the truncated edge of the formation is last seen in outcrop along the Mackenzie Mountain front in the vicinity of Arctic Red River. The lower part of the Hare Indian Formation, consisting largely of dark bituminous shale, is considered an excellent source rock for petroleum. Tassonyi (1969, p. 146) reported oil-stained and gassy, water-bearing, calcareous, fine grained sandstone in the uppermost part of the formation in the ROC et al. Grandview Hills No. 1 (A-37g) well (67°06'12"N, 130°52'30"W). Small patch reefs, within shale of the formation, were reported by Mackenzie (1969, p. 238) to occur some distance to the east on Anderson River within the Anderson Plain.

Canol Formation

In outcrops within the report area, the Canol Formation can be traced along the east and west flanks of the Richardson Anticlinorium and along the front of the Mackenzie Mountains to the east. It is considered to be an important source rock because of its high organic and bituminous content, and serves also as an impervious cap-rock. Oil (in fracture zones of the Canol Formation) that was derived from the underlying Ramparts Formation has been reported by Tassonyi (1969, p. 147), Kunst (1973, p. 270), and others as occurring in several wells in the Norman Wells area. Kunst (1973, p. 270) reported also a blow of sweet gas from the Canol Formation in the IOE Tree River H-38 well (67°17'21"N, 133°21'00"W). He postulated that the source of the gas could be either a siltstone in the Imperial Formation, or a fracture zone in the Canol Formation.

Imperial Formation

The sandstones of the Imperial Formation are commonly argillaceous, so that the porosity is generally very poor. However, Tassonyi (1969, p. 147, 148) and Kunst (1973, p. 271) have reported on the minor oil production, seeps, and saturated sandstones in the lower and upper parts of the Imperial Formation in the Norman Wells oil area. In all of these occurrences, the oil has been derived from the underlying Ramparts Formation. Stelck (1944) and Perry (1954, p. 88) indicated that the basal sandstones of the Imperial Formation in the Peel River area were locally oil-stained and cut by thin albertite dykes. A.W. Norris (1968b, p. 60) reported a strong, wet gas seep from clastic beds of the Imperial Formation, on Swan Lake, south of the Arctic Red River Settlement. People who have investigated this gas seep in recent years found that it appears to be no longer active.

Tuttle Formation

Porosity within the sandstone beds of the Tuttle Formation throughout most of its area of distribution is generally poor, because of the infilling of pore spaces by argillaceous material, kaolinite, or quartz overgrowths. More favorable reservoir rocks within the Tuttle Formation have been indicated by Pugh (1983) toward the southern end of its area of distribution where the sandstones are better sorted, more quartzose, less kaolinitic, and appear to contain some gas. Lutchman (1977, p. M9-M10) has recommended that the sandstone bodies within the Tuttle Formation warrant further investigation. Pugh (1983) recorded a show of gas from the Tuttle Formation in the Socony Ellen YT C-24 well (66°38'09"N, 137°50'08"W), west of the Richardson Trough.

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APPENDIX 1: Index of Localities

Sec. No.	Locality			
1	Immediately east of Arctic Red River (106G-1) at approximately 65°21'N, 130°46'W (This report, Fig. 4).			
	Imperial Fm.	1765 ft	(538.0 m)	incomp.
	Canol Fm.	470 ft	(143.3 m)	
	Hare Indian Fm.	2 ft	(0.6 m)	
	Hume Fm.	36 ft	(11.0 m)	incomp.
2	Immediately west of Arctic Red River (106G-2) at approximately 65°24'N, 131°21.5'W (This report, Fig. 4).			
	Canol Fm. approx.	50 ft	(15.2 m)	incomp.
	Hume Fm.	398 ft	(121.3 m)	
	Cranswick Fm.	410 ft	(125.0 m)	
2a	On ridge immediately west of a small lake, west of Arctic Red River (106G-3) at approximately 65°23'N, 131°24'W (This report, Fig. 4).			
	Cranswick Fm.	394 ft	(120.1 m)	incomp.
	Unnamed carbonate unit	646 ft	(197.0 m)	
	Silurian(?)	37 ft	(37.0 m)	incomp.
3	Flyaway Creek (106F-6) at approximately 65°27'N, 132°01'W (This report, Fig. 4).			
	Imperial Fm.	916 ft	(279.2 m)	incomp.
	Canol Fm.	362 ft	(110.3 m)	
	Hume Fm.	757 ft	(230.7 m)	
	Cranswick Fm.	120 ft	(36.6 m)	incomp.
4	Near headwaters of Cranswick River (106F-5) at 65°07.8'N, 132°16-18'W (This report, Fig. 4).			
	Mount Baird Tg.	257 ft	(78.3 m)	
	Cranswick Fm.	1822 ft	(555.4 m)	
	Unnamed carbonate unit	520 ft	(158.5 m)	
	Silurian(?)	630 ft	(192.0 m)	incomp.
5	Canyon Ranges of Mackenzie Mountains (106F-13) at 65°28-30'N, 133°03'W (This report, Fig. 4).			
	Silurian(?)	1230 ft	(374.9 m)	
6	Immediately west of Snake River (106-11) at 65°26-29'N, 133°33-42'W (This report, figs. 4, 5 and 8).			
	Imperial Fm.	50 ft	(15.2 m)	
	Canol Fm. approx.	100 ft	(30.5 m)	incomp.
	Mount Baird Fm.	1952 ft	(595.0 m)	
	Tongue of Road River Fm.	390 ft	(118.9 m)	
	Cranswick Fm.	395 ft	(120.4 m)	
	Unnamed carbonate unit	405 ft	(123.4 m)	
	Silurian(?)	50 ft	(15.2 m)	incomp.
7	Knorr Range (106E-14) at 65°23'N, 134°15'W (This report, Fig. 5).			
	Road River Fm.	2720 ft	(829.1 m)	incomp.
	Ordovician	170 ft	(51.8 m)	incomp.
8	Royal Creek (106E-15) at 65°02-04'N, 135°08-10'W (This report, Fig. 6).			
	Road River Fm.	3420 ft	(1042.4 m)	
	Upper Ordovician	160 ft	(48.8 m)	
9	South Illtyd Range (106E-5) at 65°14'N, 135°11-14'W (This report, Fig. 6).			
	Kutchin Fm.	725 ft	(221.0 m)	
	Silurian(?)	1170 ft	(356.6 m)	incomp.
10	Lower Prongs Creek (106E-5) at 65°17-18'N, 135°39-42'W (This report, Fig. 6).			
	Road River Fm.	1915 ft	(583.7 m)	
	Upper Ordovician	60 ft	(18.3 m)	incomp.
11	Upper Prongs Creek (106E-1) at 65°18.8-20'N, 135°46.4-45.5'W (This report, Fig. 6).			
	Imperial Fm.	3726 ft	(1135.7 m)	
	Canol Fm.	502 ft	(153.0 m)	
	Road River Fm.	2240 ft	(682.8 m)	
	Upper Ordovician	480 ft	(146.3 m)	incomp.
12	North flank of dome, 6 miles (9.6 km) west of Clear Creek (116H-3) at 65°23.7-25.9'N, 136°12.8'W (This report, Fig. 6).			
	Lower Carboniferous (?)	1395 ft	(425.2 m)	incomp.
	Imperial Fm.	1185 ft	(361.2 m)	
	Canol Fm.	475 ft	(144.8 m)	
	Road River Fm.	1575 ft	(480.1 m)	
	Upper Ordovician	500 ft	(152.4 m)	incomp.
13	Lower Porcupine River (116O-7) at 67°34'N, 138°10'W (This report, Fig. 7).			
	Pennsylvanian-Permian	20 ft	(6.1 m)	incomp.
	Road River Fm.	450 ft	(137.2 m)	incomp.
14	Northern Ogilvie Mountains, one mile (1.6 km) northwest of Hart River (116H-2) at 65°38-38.5'N, 136°45.2-45.6'W (This report, Fig. 5).			
	Ogilvie Fm.	1245 ft	(379.5 m)	
	Michelle Fm.	550 ft	(167.6 m)	
	Road River Fm.	75 ft	(22.9 m)	
15	West bank of Hart River (116H-4) at approximately 65°34'N, 136°55'W (This report, Fig. 5).			
	Ogilvie Fm.	45 ft	(13.7 m)	incomp.
	Michelle Fm.	465 ft	(141.7 m)	
	Road River Fm.	250 ft	(76.2 m)	incomp.
16	Northern Ogilvie Mountains, about 1 mile (1.6 km) east of Hart River (116H-11) at 65°27.5'N, 137°01'W (This report, Fig. 6).			
	Ogilvie Fm.	615 ft	(187.5 m)	
	Michelle Fm.	380 ft	(115.8 m)	
	Road River Fm.	840 ft	(256.0 m)	

Sec. No.	Locality			
17	Northern Ogilvie Mountains, about 1 mile (1.6 km) east of Hart River (116H-9) at 65°25.2'N, 137°06'W (This report, Fig. 6).			
	Ogilvie Fm.	1138 ft	(346.9 m)	
	Michelle Fm.	385 ft	(117.3 m)	
	Road River Fm.	5 ft	(1.5 m)	incomp.
18	Northern edge of Ogilvie Mountains about 8 miles (12.8 km) east of Blackstone River (116H-8) at 65°41-42'N, 137°10.2-11'W (This report, Fig. 5).			
	Lower Carboniferous	40 ft	(12.2 m)	incomp.
	Unnamed shale unit	560 ft	(170.7 m)	
	Ogilvie Fm.	2305 ft	(702.6 m)	
	Michelle Fm.	385 ft	(117.3 m)	
	Road River Fm.	1215 ft	(370.3 m)	
	Ordovician	585 ft	(178.3 m)	incomp.
19	Northern edge of Ogilvie Mountains immediately east of Blackstone River (116H-13) at 65°42-42.5'N, 137°26-26.5'W (This report, Fig. 5).			
	Ogilvie Fm.	4440 ft	(1353.3 m)	
	Michelle Fm.	620 ft	(189.0 m)	
	Road River Fm.	130 ft	(39.6 m)	incomp.
20	East side of Ogilvie River (116G-8) at 65°23-24'N, 138°15'W (This report, Fig. 6).			
	Ogilvie Fm.	170 ft	(51.8 m)	incomp.
	Road River Fm.	1205 ft	(367.3 m)	
	Ordovician	100 ft	(30.5 m)	incomp.
21	Southeast flank of Nahoni Range (116G-10) at 65°33'N, 138°42.5-46'W (This report, Fig. 5).			
	Unnamed shale unit	819 ft	(249.6 m)	
	Ogilvie Fm.	2380 ft	(725.4 m)	
	Michelle Fm.	185 ft	(56.4 m)	
	Road River Fm.	175 ft	(53.3 m)	incomp.
22	Northeast flank of Nahoni Range (116G-9a) at 65°47'N, 138°55'W (This report, Fig. 7).			
	Lower Carboniferous	25 ft	(7.6 m)	incomp.
	Unnamed shale unit	1057 ft	(322.2 m)	
	Ogilvie Fm.	130 ft	(39.6 m)	incomp.
23	Southern end of Nahoni Range (116G-4) at 65°28-29'N, 139°09'W (This report, Fig. 5).			
	Ogilvie Fm.	2393 ft	(729.4 m)	
	Michelle Fm	275 ft	(83.8 m)	
	Road River Fm.	380 ft	(115.8 m)	
23a	Between Ettrain and Jungle creeks near Yukon-Alaska Boundary (116F-15) at 65°22.8'N, 140°49-49.3'W (This report, Fig. 5).			
	Unnamed shale unit approx.	400 ft	(121.9 m)	incomp.
	Ogilvie Fm.	547 ft	(166.7 m)	
	Kutchin Fm.	580 ft	(176.8 m)	incomp.
24	Mount Burgess (116J-5) at 66°03'N, 139°35.2-37'W (This report, Fig. 7).			
	Lower Carboniferous	5 ft?	(1.5 m)?	
	Ogilvie Fm.	2190 ft	(667.5 m)	
	Kutchin Fm.	350 ft	(106.7 m)	
	Middle Ordovician	675 ft	(205.7 m)	incomp.
25	North of Mount Dewdney (116J-12) at 66°10'N, 139°10'W (This report, Fig. 7).			
	Ogilvie Fm.	285 ft	(86.9 m)	
	Kutchin Fm.	900 ft	(274.3 m)	incomp.
26	Ogilvie Mountains, 19 miles (30.6 km) bearing 175T from Bear Cave Mountain (116J-10) at 66°12.5-12.7'N, 139°17-18'W (This report, Fig. 7).			
	Lower Carboniferous	130 ft	(39.6 m)	incomp.
	Unnamed shale unit	1657 ft	(505.1 m)	
	Ogilvie Fm.	841 ft	(256.3 m)	
	Kutchin Fm.	750 ft	(228.6 m)	
27	Ogilvie Mountains, 7.2 miles (11.6 km) bearing 338T from Bear Cave Mountain (116J-3) at 66°36.5-37'N, 139°24-25'W (This report, Fig. 7).			
	Ogilvie Fm.	443 ft	(135.0 m)	
	Kutchin Fm.	790 ft	(240.8 m)	incomp.
28	Northern end of Ogilvie Mountains, 6 miles (9.6 km) west of Cody Creek (116J-9) at 66°42.8'N, 139°14-16'W (This report, Fig. 7).			
	Ogilvie Fm.	568 ft	(173.1 m)	
	Kutchin Fm.	1260 ft	(384.1 m)	incomp.
29	Peel Plateau Eagle Plains Y.T. No. 1 well at 66°48'54"N, 138°08'30"W (Norris, 1968b, Fig. 5).			
	Cretaceous(?)	-	-	
	Ogilvie Fm.	1194 ft	(363.9 m)	
	Kutchin Fm.	2032 ft	(619.4 m)	
	Silurian	-	-	
30	Fish Creek, White Mountains (116P-7) at 67°45'N, 136°31-33'W (This report, Fig. 8).			
	Pennsylvanian-Permian	20 ft	(6.1 m)	incomp.
	Ogilvie Fm.	766 ft	(233.5 m)	
	Kutchin Fm.	1785 ft	(544.1 m)	
	Unnamed beds	665 ft	(202.7 m)	
	Vunta Fm.	50 ft	(15.2 m)	incomp.
31	East side of south end of Campbell Lake (107B-1) at 68°10'N, 133°28'W (This report, Fig. 8).			
	Cranswick Fm.	680 ft	(207.3 m)	
	Silurian			
32	North side of Campbell Lake (107B-2) at 68°15.2-17.1'N, 133°21-26.4'W (This report, Fig. 8).			
	Cranswick Fm.	230 ft	(70.1 m)	
	Silurian	700 ft	(213.4 m)	incomp.

Sec. No.	Locality			
33	'Snafu' Mountain (116P-4) at 69°39.5-39.7'N, 136°18-20'W (This report, Fig. 8).			
	Permian	70 ft	(21.3 m)	incomp.
	Imperial Fm.	3140ft	(957.1 m)	incomp.
34	Eight miles (12.9 km) east of Rat River (116P-3) at 67°27-28'N, 136°24-25.8'W (This report, Fig. 8).			
	Jurassic	60 ft	(18.3 m)	incomp.
	Permian	415 ft	(126.5 m)	
	Imperial Fm.	2345 ft	(714.8 m)	incomp.
35	Trail River, eastern flank of Richardson Mountains (106L-5) at 66°24.5-27.5'N, 135°22-31'W (This report, Fig. 8).			
	Lower Cretaceous	-	-	
	Tuttle Fm.	1175 ft	(358.1 m)	
	Imperial Fm.	4075 ft	(1242.1 m)	
	Canol Fm.	740 ft	(225.6 m)	
	Road River Fm.	1755 ft	(534.9 m)	
	Ordovician or Silurian	165 ft	(50.3 m)	
36	Wernecke Mountains, headwaters of unnamed tributary of Wind River (106D-3) at approximately 65°53'N, 134°57'W (This report, Fig. 6).			
	Ogilvie Fm.	710 ft	(216.4 m)	
	Kutchin Fm.	1570 ft	(478.5 m)	incomp.
37	Wernecke Mountains, east side of headwaters of Royal Creek (106D-2) at 67°47.2'N, 135°12'W (This report, Fig. 6).			
	Devonian	1740 ft	(530.4 m)	
	Silurian	925 ft	(281.9 m)	
	Ordovician	180 ft	(54.9 m)	incomp.
38	Wernecke Mountains, west side of headwaters of Royal Creek (106D-1) at approximately 64°47'N, 135°15'W (This report, Fig. 6).			
	Road River Fm. Dev.	2805 ft	(855.0 m)	
	Sil.	1040 ft	(317.0 m)	
	Ordovician	195 ft	(59.4 m)	incomp.
39	Ogilvie Mountains, 12 miles (19.3 km) east of Ogilvie River (116H-18) at 65°30.2'N, 137°57'W (This report, Fig. 5).			
	Ogilvie Fm	3450 ft	(1051.6 m)	
	Kutchin Fm.	120 ft	(36.6 m)	incomp.
40	Ogilvie Mountains, 12.5 miles (20 km) west of Blackstone River (116G-3) at approximately 65°14'N, 138°09'W (This report, Fig. 6).			
	Road River Fm.	1800 ft	(548.6 m)	incomp.
41	Ogilvie Mountains, east side of unnamed tributary of Ogilvie River (116G-7) at 65°16.2'N, 138°11.5'W (This report, Fig. 6).			
	Ogilvie Fm.	300 ft	(91.4 m)	
	Kutchin Fm.	980 ft	(298.7 m)	incomp.
42	Southern Ogilvie Mountains (116G-12) at approximately 65°28.7'N, 138°13.5'W (This report, Fig. 5).			
	Ogilvie Fm.	2100 ft	(640.1 m)	
	Michelle Fm.	145 ft	(44.2 m)	
	Road River Fm.	440 ft	(134.1 m)	incomp.
43	Ogilvie Mountains, 12.5 miles (20 km) west of Blackstone River (116G-15) at approximately 65°03'N, 138°35'W (This report, Fig. 6).			
	Road River Fm.	1270 ft	(387.1 m)	incomp.
44	South Nahoni Range (116G-2) at approximately 65°25'N, 139°25'W (This report, figs. 5 and 7).			
	Lower Carboniferous	670 ft	(204.2 m)	incomp.
	Unnamed shale unit	590 ft	(179.8 m)	
	Ogilvie Fm.	1150 ft	(350.5 m)	
	Michelle Fm.	325 ft	(99.1 m)	
	Road River Fm.	130 ft	(39.6 m)	incomp.
45	Nahoni Range near headwaters of Whitestone River (116G-6) at approximately 65°32'N, 139°28'W (This report, Fig. 7).			
	This section is not plotted because field notes describing section were largely destroyed by fire. Although the rock sequence is known, important data such as thicknesses are missing for parts of the section.			
46	Eight miles (12.9 km) northwest of Mount Klotz (116F-8) at approximately 65°27'N, 140°18'W (This report, Fig. 5).			
	Unnamed shale unit	775 ft	(236.2 m)	
	Ogilvie Fm.	780 ft	(237.7 m)	
	Michelle Fm.	350 ft	(106.7 m)	incomp.
47	Northeastern White Mountains (116P-15) at approximately 67°59'N, 136°33'W (This report, Fig. 8).			
	Ogilvie Fm.	830 ft	(253.0 m)	
	Kutchin Fm.	3160 ft	(963.2 m)	
	Upper Silurian Vunta Fm.	100 ft 1590 ft	(30.5 m) (484.6 m)	 incomp.

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