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BULLETIN 186

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DEPARTMENT OF ENERGY,
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DEVONIAN STRATIGRAPHY OF NORTHEASTERN BRITISH COLUMBIA

G. C. Taylor and W. S. MacKenzie

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Canada
1970

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DEVONIAN STRATIGRAPHY OF NORTHEASTERN BRITISH COLUMBIA

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By

G. C. Taylor and W. S. MacKenzie

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PREFACE

This bulletin provides a summary of the stratigraphy of the Devonian carbonate rocks exposed in northeastern British Columbia.

The authors examined twenty-six sections along the western margin of the basin in which the strata were deposited. The study presents data of immediate interest to petroleum exploration in the area.

Taylor is responsible for establishing the local stratigraphic framework of the Devonian, whereas MacKenzie reports mainly on the petrography of the Dunedin Formation.

Y. O. FORTIER
Director, Geological Survey of Canada

OTTAWA, March 4, 1969

BULLETIN 186 — Devonische Stratigraphie des Nordostens von Britisch-Kolumbien

Von G. G. Taylor und W. S. MacKenzie

Abriss der Stratigraphie der im Nordosten Britisch-Kolumbiens freiliegenden devonischen Karbonatgesteine. Einführung von vier neuen Formationsnamen für zwischen Silurschichten und der devonischen Besa-River-Formation liegenden Einheiten.

БЮЛЛЕТЕНЬ 186 — Стратиграфия девона северо-восточной части Британской Колумбии.

Г. К. Тейлор и Уоррен С. МакКензи

Резюме стратиграфии девонских карбонатных горных пород, обнаженных в северо-восточной части Британской Колумбии. Введено 4 новых названия формаций для единиц, находящихся между силурийскими толщами и девонской формацией реки Беса.

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DEVONIAN STRATIGRAPHY OF NORTHEASTERN BRITISH COLUMBIA

Abstract

Five lithologically distinct rock units of Devonian age are recognized within the report area and new formational names are proposed for all except an uppermost previously named sequence of dark grey shales, the Besa River Formation.

Lower Devonian strata in this region rest unconformably on Silurian rocks. They are divided into two formations: a lowermost sequence of finely crystalline, argillaceous dolomites with rare fossil fish remains, the Muncho-McConnell Formation; and an overlying Wokkpash Formation of yellow-brown weathering sandstone, dolomitic sandstone, and argillaceous dolomite.

Middle Devonian beds, separated from underlying strata by a disconformity, are subdivided into three formations; a lower Stone Formation, a middle, Dunedin Formation, and overlying shales of the Besa River Formation. The Stone Formation, dated as Eifelian, consists of dolomite, argillaceous dolomite, dolomite breccia, and scattered intercalated beds of limestone. It varies appreciably in thickness within the report area. Locally the Dunedin Formation rests with disconformity on the underlying dolomites of the Stone Formation, and has a diachronous upper contact. It consists dominantly of dark grey, argillaceous limestones that range in age from late Eifelian to Givetian.

The overlying Besa River Formation is from 1,000 to 3,000 feet thick, and contains fossils of Middle and Late Devonian and of Mississippian age. Both lower and upper contacts are diachronous.

Résumé

La région étudiée comprend cinq unités de roches du Dévonien, distinctes du point de vue lithologique. L'auteur propose de nouvelles désignations pour ces formations, sauf pour la succession supérieure de schistes gris foncé déjà nommée formation de Besa River.

Les strates du Dévonien inférieur de cette région reposent en discordance sur des roches siluriennes. Elles se divisent en deux formations: une succession inférieure de dolomies argileuses à cristaux fins renfermant de rares fossiles de poissons, désignée sous le nom de formation de Muncho-McConnell, et une formation sus-jacente dite Wokkpash de grès jaune-brun altéré, de grès dolomitique et de dolomie argileuse.

Les couches du Dévonien moyen, séparées des strates sous-jacentes par une discordance, se subdivisent en trois formations: la formation inférieure de Stone, la formation intermédiaire de Dunedin et les schistes argileux sus-jacents de la

formation de Besa River. La formation de Stone, de l'Eifélien, comporte des dolomies, des dolomies argileuses et des brèches dolomitiques, ainsi que des lits de calcaire intercalés çà et là. Par endroits, la formation de Dunedin repose en discordance sur les dolomies de la formation de Stone et leur contact supérieur est diachronique; elle consiste principalement en calcaires argileux gris foncé s'échelonnant de l'Eifélien supérieur au Givétien.

La formation sus-jacente de Besa River varie en puissance de 1,000 à 3,000 pieds et renferme des fossiles du Dévonien moyen et supérieur et du Mississippien; les contacts supérieurs et inférieurs sont diachroniques.

INTRODUCTION

Previous Work

Little geologic information has been published on the Devonian strata of northeastern British Columbia. In 1944 Williams made a reconnaissance survey of the structure and stratigraphy of Devonian rocks along the Alaska Highway; later, Laudon and Chronic (1949) published results of the first detailed study of these strata. Cosburn (1962) and Hughes (1963) also wrote short notes on the Devonian sequence along the Alaska Highway. Kidd (1962, 1963) named the Besa River Formation and described its type section.

Pelzer (1966) later reported on detailed geochemical aspects of the Besa River Formation. Work of a reconnaissance nature, involving the same stratigraphic sequence, has been carried out by Gabrielse (1961, 1962) and Irish (1961, 1963, 1964) in the adjacent Rabbit River and Halfway River map-areas. Many oil company geologists have studied these strata during the past 15 years, but results of their work have not been published.

A large number of studies have been published dealing with the Devonian succession in areas to the north and east. Griffin (1965) described the Devonian rocks of the subsurface immediately to the east in British Columbia, whereas Law (1955) described those strata in Alberta. Belyea and Norris (1962) described the Devonian sequence between the subsurface of northeastern British Columbia and the surface at Great Slave Lake. Norris (1965) has thoroughly described the Devonian beds exposed in the vicinity of Great Slave Lake. Important summaries of the Devonian successions of the District of Mackenzie have been published by Bassett (1960), Warren and Stelck (1962), Douglas, *et al.* (1963), and Caldwell (1964).

Present Work

This report is based on field work carried out by Taylor during the summers of 1960 and 61 and 1963 to 65, and by MacKenzie during the 1965 season. Twenty-six Devonian sections, supplemented by numerous outcrop observations, were studied within the area between 57 and 60°N and 123 and 126°W (Fig. 1). Work carried out during 1960 and 1961 was part of a one-mile-to-one-inch mapping project (MacDonald Creek map-area 94K/10, Taylor, 1963). In 1963, 1964, and 1965 the work was in conjunction with Operation Liard, a helicopter-supported, four-miles-to-one-inch reconnaissance mapping

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Calgary, Alberta.

project (Taylor, 1966) of the Geological Survey of Canada. E.W. Bamber studied the Besa River Formation as part of his survey of Upper Paleozoic stratigraphy for Operation Liard. Some of the results of his work are included in this report.

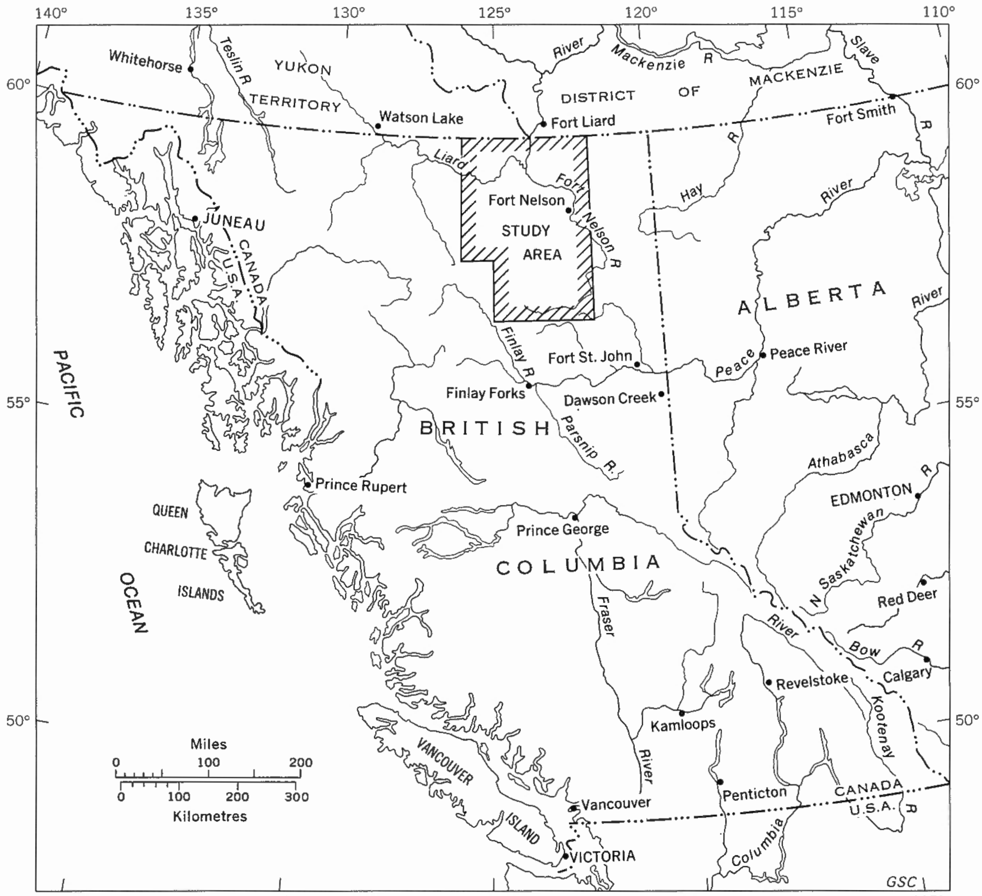

FIGURE 1. Index map.

Acknowledgments

Fossil identifications were made by A.W. Norris, D.J. McLaren, R. Thorsteinsson, T.T. Uyeno, T.P. Chamney, and M.J. Copeland of the Geological Survey of Canada.

Able assistance was given in the field by R.K. Jull, W.R. Maiklem, and E. Delinsky during the summer of 1960; by R.T. Bell, T. Frisch, and R. Young in 1961; R.T. Bell, D. Mayes, and A. Kuhme in 1963; D. Hetherington, R. Armstrong, D. MacDougal, and M. Wooding in 1964; and by B. Reive and L. Grainger in 1965. Special thanks are due to H. Lynch and M. Kaplan, S.W. McWhinnie, and I. Severson for assistance with horses and for performance of camp duties. During the summers of 1963-65 helicopters were supplied by Bullock Wings and Rotors, and the authors are greatly indebted to pilots, J. Davies and H. Tetz, and the late C. Bullock, and to maintenance engineers M.E. Brown and P. Ettinger.

STRATIGRAPHY

Potential oil- and gas-producing Middle Devonian and older carbonate rocks trend from the District of Mackenzie and British Columbia southeastward across Alberta, Saskatchewan, parts of Manitoba, and into North Dakota. They have recently yielded hydrocarbons in commercial quantities to the north of the report area, in the Beaver River region, and at Clark Lake to the east. Saka, Zama Lake, and Rainbow Lake are other nearby localities where oil discoveries have been made in Middle Devonian carbonate strata. These discoveries mark the beginning of a third major period of oil discovery in Devonian rocks, following Leduc in 1947 and Swan Hills in 1957.

Middle Devonian and older carbonate rocks are widespread over much of northeastern British Columbia. Williams (1944) was the first to describe a representative succession of these strata along the Alaska Highway and to define correctly their upper and lower age limits. Laudon and Chronic (1949) later subdivided the carbonate sequence into four formations, basing much of their nomenclature on supposed correlation with familiar formations in the Mackenzie River area.

Formational Nomenclature

Recent detailed work by the writers has shown that the original correlations made by Laudon and Chronic (1949) are incorrect, and a new system of nomenclature is proposed here, with revised formational boundaries.

The earliest Devonian sediments in this area were laid down on eroded Silurian strata (Table I). Another break in sedimentation within Devonian carbonates divides them into lower and upper parts. The lower part comprises rock units of the Muncho-McConnell and Wokkpash Formations, and the upper part of those of the overlying Stone and Dunedin Formations. In addition, a local disconformity occurs in the southern part of the Operation Liard area between the Stone and overlying Dunedin Formations (Fig. 2).

TABLE I. Formation nomenclature.

<table>
<tr><th colspan="3">Laudon and Chronic (1949)</th><th colspan="3">This Report (1969)</th></tr>
<tr><td rowspan="6">DEVONIAN</td><td colspan="2">Fort Creek Formation</td><td rowspan="6">DEVONIAN</td><td>Late</td><td>Besa River Formation</td></tr>
<tr><td rowspan="3">Ramparts Formation</td><td>Upper</td><td rowspan="2">Middle</td><td>Dunedin Formation</td></tr>
<tr><td>Middle</td><td>Stone Formation</td></tr>
<tr><td>Lower</td><td rowspan="3">Early</td><td>Wokkpash Formation</td></tr>
<tr><td colspan="2">Muncho Formation</td><td rowspan="2">Muncho-McConnell Formation</td></tr>
<tr><td colspan="2">McConnell Formation</td></tr>
<tr><td>SILURIAN</td><td colspan="2">Ronning Formation</td><td>SILURIAN</td><td colspan="2">Nonda Formation</td></tr>
</table>

GSC

Fossils are scarce throughout most of the Devonian sequence except in the uppermost part of the Dunedin Formation. On the basis of the abundant and diagnostic faunas occurring in these upper beds, the time transgressive nature of the upper contact of the formation was established. The base of the formation may also be time transgressive, but fossils do not indicate this as definitely as they do the upper boundary. The contact between the Muncho-McConnell and Wokkpash Formations is a facies boundary and probably is also diachronous.

Distinctive rock units within the report area are assigned new formation names (Table I) because correlation with similar units in other areas could not be demonstrated. The Lower Devonian Muncho-McConnell and Wokkpash Formations undergo rapid facies changes northward in the vicinity of Crow River, and cannot be positively identified in the well-exposed sequence along Beaver River only 26 miles north of the report area. Both the Dunedin and Stone Formations grade laterally northward into equivalent shales within the report area and, therefore, cannot be followed into adjacent areas to the north. It is more desirable to name new rock units and correlate them with distant areas than to assign to them existing names that may prove eventually to be incorrect.

Muncho-McConnell Formation

Laudon and Chronic (1949) named the Muncho and McConnell Formations in northeastern British Columbia and designated type sections for them in the Sentinel Range east of the Alaska Highway at Mile 472. Workers later recognized that faults cut upper parts of the interval that include the two type sections; moreover, these workers were unable to recognize a two-fold division in that interval. It then became the common practice to regard the entire interval as a single mapping unit, to which the informal name Muncho-McConnell was applied. The writers herein elevate this unit to formational rank and propose the name Muncho-McConnell Formation. It is a unit of alternating medium and dark grey, finely crystalline dolomite that rests disconformably on the Silurian Nonda Formation (Norford, *et al.*, 1966) throughout much of northeastern British Columbia.

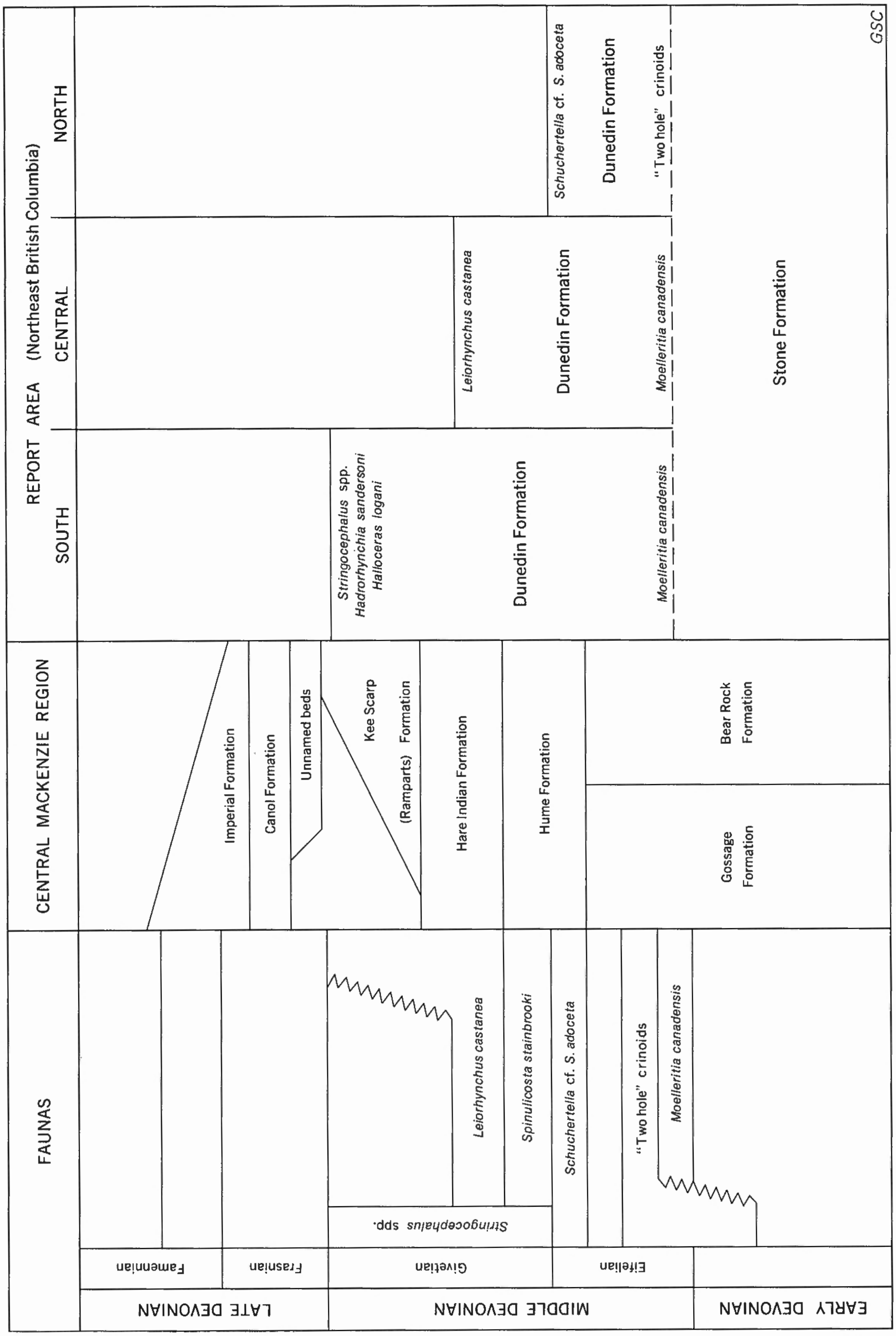

FIGURE 2. Chart showing the distribution of significant faunas, and the relationships between the Dunedin Formation of the report area and formations in central District of Mackenzie.

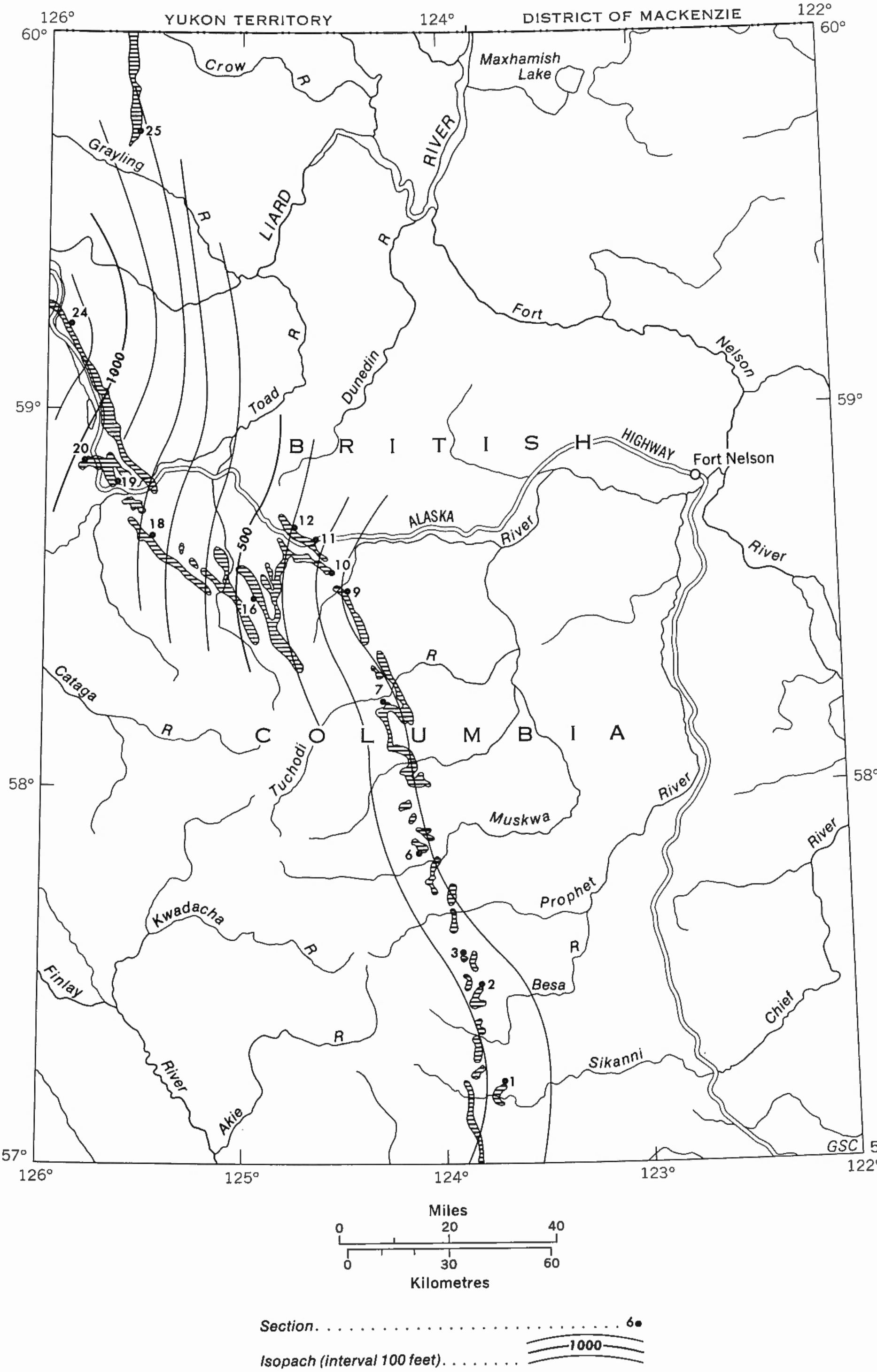

FIGURE 3. Isopach map of the Muncho-McConnell Formation.

The type section of the Muncho-McConnell Formation is about 2 1/2 miles west-northwest of Toad River bridge at Mile 438 on the Alaska Highway (Fig. 3, Sec. 19). The strata are exceptionally well exposed in this area and rest disconformably on the type Nonda Formation (Pl. I-3). Elsewhere in the report area they outcrop in a narrow belt along the front of the Rocky Mountains and in several thrust sheets in the central ranges. Figure 3 shows the present distribution and thickness of the Muncho-McConnell Formation in the area covered by Operation Liard. Gabrielse (1962) mapped equivalent strata in the Rabbit River map-area to the west, and Norford recognized the same unit in the Halfway River and Pine Pass map-areas to the south (Norford, *et al.*, 1966, pp. 510-511).

The base of the Muncho-McConnell Formation typically is a disconformable surface with little relief. In most places the rocks overlying the disconformity are recessive, light brown weathering, sandy, argillaceous dolomites. Consequently, the Silurian-Devonian contact is marked in outcrop by a conspicuous, recessive zone immediately above the more resistant beds of the Nonda Formation. An alternating succession of dolomites overlies the basal sandy strata and is developed best in the western part of the area. It consists of medium to finely crystalline beds ranging from light grey to dark grey, but with the lighter greys predominating in the lower part of the formation. Thin varicoloured shale partings are common in the basal dolomites. In the eastern part of the report area conspicuous beds of light grey dolomite containing up to 40 per cent of well-rounded, frosted, fine-grained quartz sand are common in the upper half of the formation. Desiccation breccias (Pl. I-2) and thin, fine-grained, quartz sandstones also occur in this area as well as primary sedimentary structures that are indicative of deposition in shallow water above wave base.

The Muncho-McConnell Formation grades abruptly in the upper few feet to the overlying Wokkpash Formation. The contact is defined by an abrupt increase in clastic quartz content, and is accompanied by a change of colour from the predominantly grey weathering Muncho-McConnell beds to the yellow-brown weathering Wokkpash Formation. With the increase in clastic quartz content the rocks are much less resistant to erosion, so that a conspicuous step in the weathering profile is developed at the contact.

Fossils are rare in the Muncho-McConnell Formation and most of those collected are not diagnostic. High-spired gastropods are the most common, but of little biostratigraphic value, though they are indicators of environment. The type section yielded poorly preserved specimens of *Favosites, Coenites,* and leperditid (*Briartina*? sp.) ostracods that suggest a possible Devonian age (Norris and Copeland, *pers. com.*). The most significant fauna collected consists of fish fragments that occur southeast of Long Mountain in the Terminal Range (Gabrielse, 1962), and just north of Keily Creek (Norford, *et al.*, 1966). R. Thorsteinsson (*pers. com.*) considers the age of these fish remains to be Early Devonian. Denison (1964) described some Early Devonian fish from northwest of Muncho Lake, which most likely are from the Muncho-McConnell Formation.

Wokkpash Formation

The name Wokkpash Formation is proposed for a 156-foot sequence of sandstone (Fig. 4, Sec. 15), dolomitic sandstone, and argillaceous dolomite, that is continuously exposed in the bed of a small tributary stream entering Wokkpash Creek from the east about 10 miles southeast of its junction with Racing River.

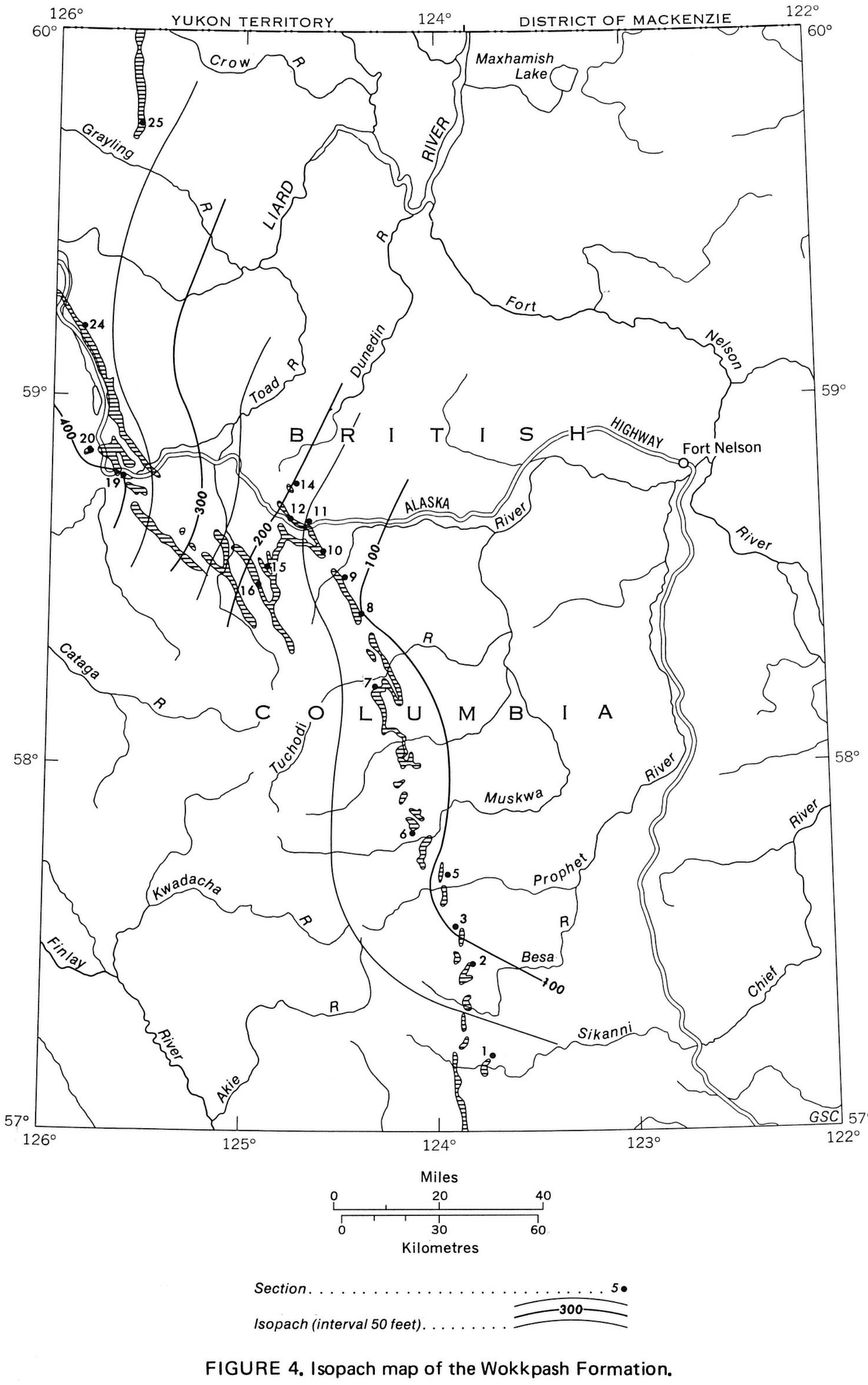

FIGURE 4. Isopach map of the Wokkpash Formation.

The formation is exposed almost continuously in a narrow belt within the Front Ranges of the Rocky Mountains (Fig. 4). It can be recognized from Sikanni Chief River northward to just within the Yukon Territory where it plunges under younger Devonian rocks. South of Sikanni Chief River the formation apparently was eroded from extensive areas during the pre-Middle Devonian hiatus and, where preserved, has lost many of the lithologic characters that distinguish it from the underlying Muncho-McConnell Formation. In the subsurface east of the mountains Van Hees (1964) has shown that the Middle Devonian beds lie directly on Middle Cambrian and older strata and, therefore, that both Wokkpash and Muncho-McConnell Formations are absent.

The base of the Wokkpash type section is marked by a medium grained, calcareous, quartzose sandstone with light yellow-brown colours in contrast to the sombre greys of the Muncho-McConnell Formation. Impure, argillaceous, finely crystalline dolomites overlie the basal sandstone and are succeeded by more massive sandstones characteristic of the formation. At the latitude of Summit Pass the concentration of sand within the formation reaches a maximum. North, south, and west from the type locality the argillaceous and dolomitic content increases. The abundant sand probably marks a zone of high energy indicative of a strand environment. Shrinkage cracks and desiccation breccias occur in several zones within the formation at most localities and indicate that the general depositional environment was one of very shallow water, shoaling eastward with, locally, temporary emergence.

The Wokkpash Formation is conformable with the underlying Muncho-McConnell Formation. The contact is subtle and gradational on close examination though conspicuous from a distance. The upper contact with the overlying Stone Formation is sharp and unconformable. At the type section slight (a few degrees) angularity exists (Pl. I-1), but elsewhere the contact is paraconformable. Although a hiatus marks the top of the formation, little erosion is believed to have occurred. Throughout the project area the thickness of the Wokkpash Formation is a relatively constant fraction of that of the underlying Muncho-McConnell Formation, and the two apparently had similar patterns of deposition.

No fossils have yet been found in the Wokkpash Formation. It has been dated as Early Devonian because it overlies conformably and is intimately related to known Early Devonian rocks, and because it is overlain unconformably by early Middle Devonian rocks.

Stone Formation

The name Stone Formation is proposed for a sequence of light grey, finely and medium crystalline dolomite, and dolomite breccia, that overlies the Wokkpash Formation and is overlain by limestones of the Dunedin Formation. Strata of the type section are continuously exposed and easily accessible in a small stream, known locally as One Ten Creek, that flows southward from Mount St. Paul and crosses the Alaska Highway a short distance west of Mile 398. The formation derives its name from Stone Mountain about 5 miles to the north, where it is also well exposed.

The type section is 1,252 feet thick. Representative strata are exposed almost continuously in a narrow, sinuous belt (Fig. 5) extending along the Front Ranges of the

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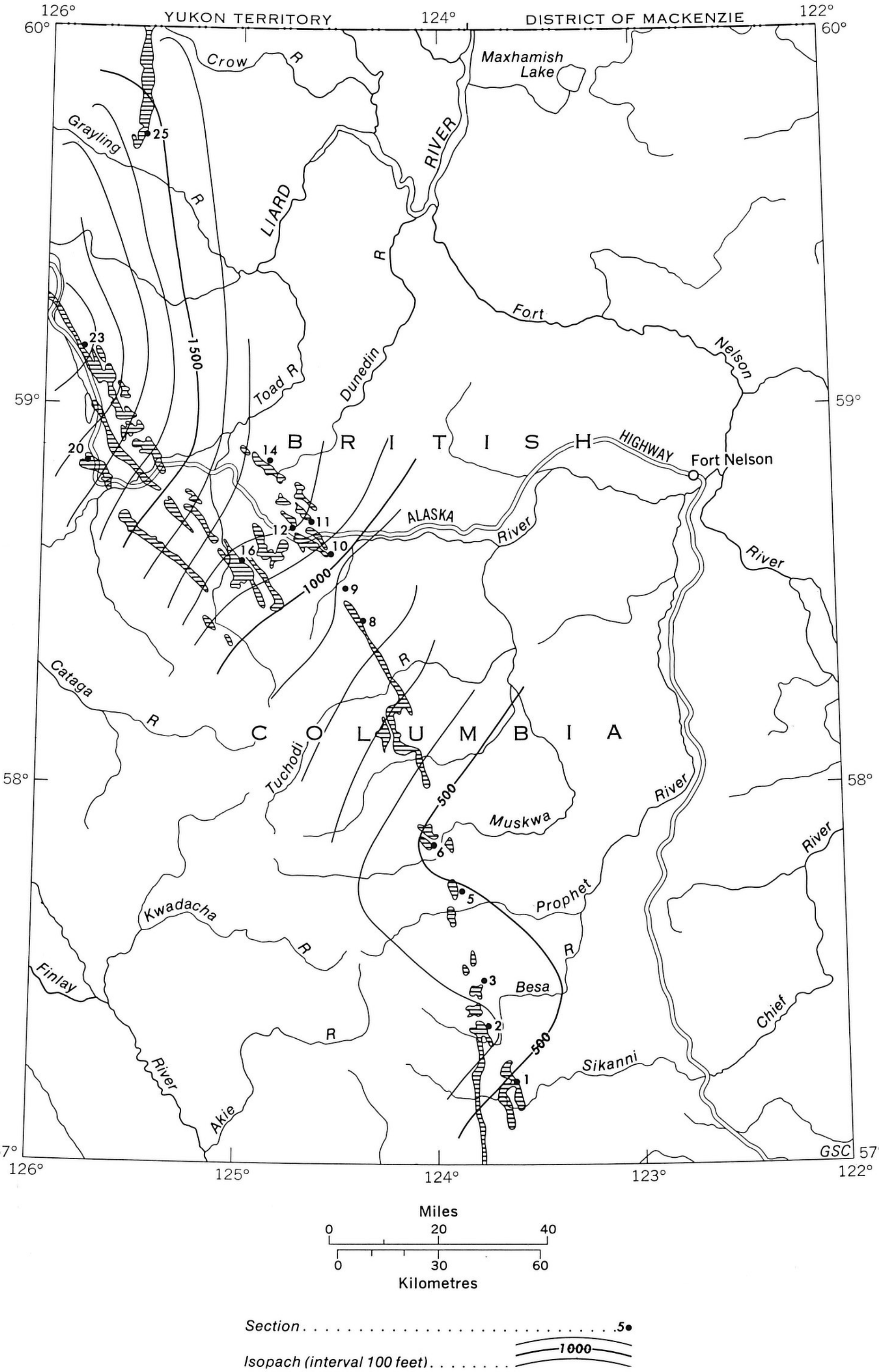


FIGURE 5. Isopach map of the Stone Formation.

Rocky Mountains from 57° to 60°N latitude. Thicknesses range from 459 feet at Mount Bertha in the south to 1,935 feet in Sentinel Range some 150 miles to the northwest.

Within the area studied three facies were recognized in the Stone Formation. South and east of Muskwa River the lower part of the formation is characterized by a significant proportion of well-rounded quartz sand. A central facies occurring between Muskwa River and Racing River is characterized by dolomite breccias. The third facies occurs north and west of Racing River, where it contains little sand or breccia but exhibits a prominent cyclical development of medium and light grey, finely crystalline dolomites.

The Stone Formation typically comprises finely and medium-crystalline, light coloured, massive, cliff-forming dolomites that weather to a lighter grey than the overlying Dunedin Formation limestone and contrast with the underlying yellow-brown weathering Wokkpash beds. Brecciated zones of large dolomite blocks in a cement of white calcite (Pl. I-4) occur sporadically within the sequence and are most conspicuous where they are freshly exposed or washed by running water. The detailed texture of the breccias in most other areas has become obscured by a grey weathering film on the white calcite although the beds are still obvious from a distance. Barite and fluorite also occur as an interfragment cement. A zone of grey-black dolomite at a height of about 600 feet in the formation persists almost everywhere in the outcrop belt north of 58°N latitude, and is useful for mapping because of its conspicuous appearance in outcrop and on air photographs. It may eventually provide a means of positive correlation with nearby subsurface beds. Where the Stone Formation is thick, as in the vicinity of Muncho Lake, it was subdivided into a lower part of slightly silty, light weathering beds, and an upper part of more argillaceous, darker weathering strata. These divisions are about 1,115 and 820 feet thick just east of Mile 470 on the Alaska Highway.

In an area south of Keily Creek the basal beds of the Stone Formation consist of deltaic sandstone made up of fine, rounded quartz grains floating in the dolomite. The beds are typically massive, and weather a light brown similar to that of the Wokkpash Formation, which outcrops to the south. From a distance these beds of the Stone Formation could be easily mistaken for the Wokkpash Formation.

Thin sections show that primary limestone textures have been unusually well preserved in many dolomites with crystal sizes in the 10- to 20-micron range. The most commonly preserved fabrics suggest an original, slightly silty calcite mud. Other more coarsely crystalline dolomites show varying degrees of replacement by calcite and of occlusion of vuggy and intercrystalline porosity by calcite infilling.

In most areas the lower boundary of the Stone Formation is drawn above a sequence of yellowish brown weathering, dolomitic siltstones and sandstones that mark the top of the underlying Wokkpash Formation. The base of the Stone Formation is sandy in most areas and, in addition, is conglomeratic locally in western exposures. Barite cobbles that appear to be a lag-deposit from the underlying weathered Wokkpash Formation have been observed in Sentinel Range north of Muncho Lake. On the eastern side of the exposure belt the basal beds of the formation most commonly consist of dolomite breccia. The lower contact of the formation is disconformable and, though difficult to detect when nearby, is sharp when viewed from a distance. South of Muskwa River the underlying Wokkpash Formation is recessive below the basal resistant dolomite beds of the Stone Formation.

Throughout most of the report area the upper contact of the Stone Formation is drawn at an abrupt change upward from dolomite to dark grey limestone of the Dunedin Formation. North and west of Racing River the contact is apparently conformable; south of Muskwa River the contact is clearly disconformable. Between these two areas the evidence is poor but suggests a disconformable relationship.

Because diagnostic fossils are scarce, the age of the Stone Formation is based largely on stratigraphic position. It overlies Early Devonian rocks unconformably in all exposures, and is known to be overlain conformably by Middle Devonian rocks. The following fossils, collected from 486 feet above the base of the formation in the Caribou Range, were identified by A.W. Norris.

GSC loc. 57339: *Paracyclas* sp.
undet. planispiral gastropods
loosely coiled cephalopod fragments
Atrypa sp.
Spinatrypa sp.
trilobite pygidium fragment

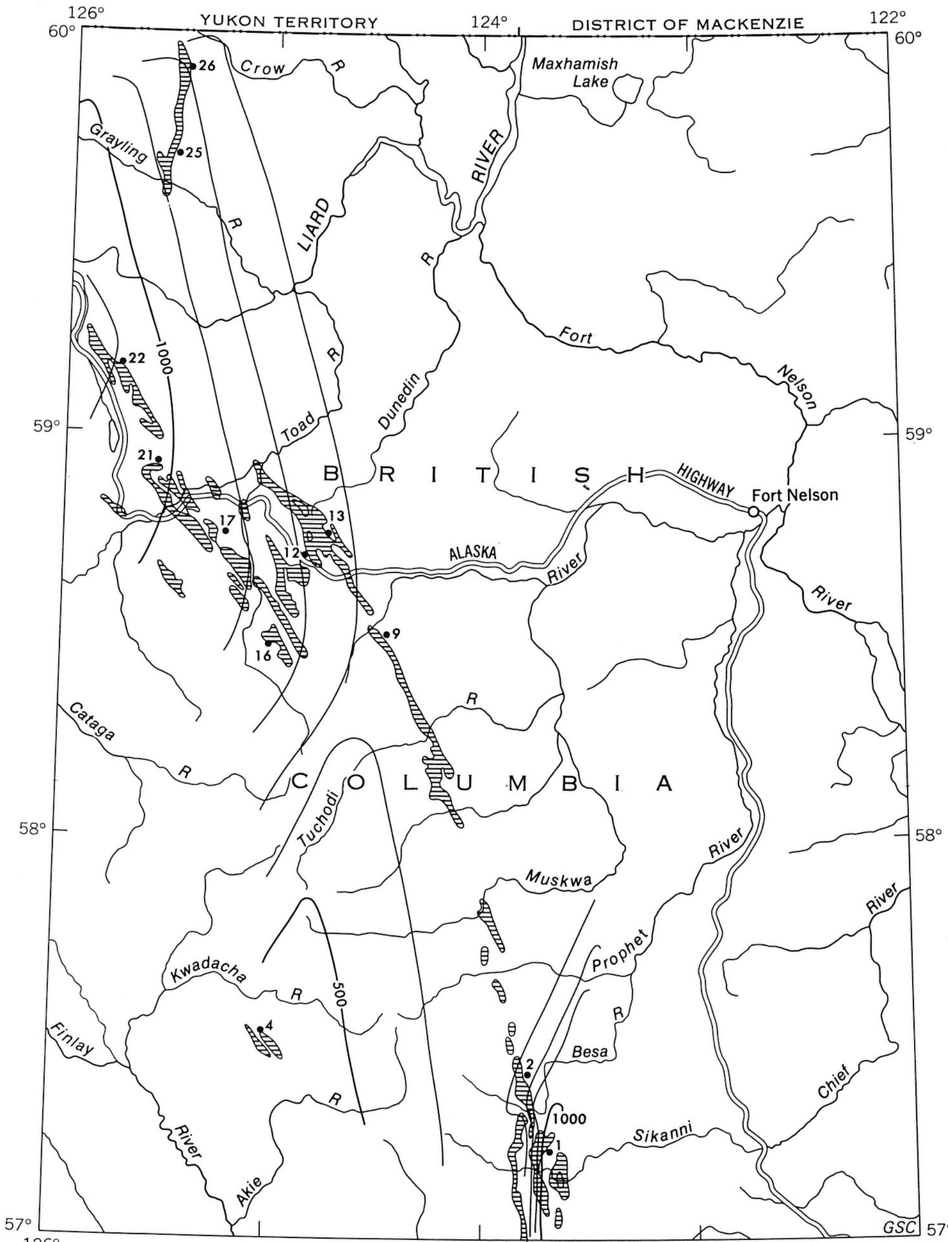
In the same region crinoid ossicles with double axial canals occur in strata some 225 feet above the top of the formation. Norris stated that such ossicles occur most abundantly in beds dated as Middle Devonian (middle Eifelian), but that they do range down into beds of a late Lower Devonian (late Emsian) age. The Stone Formation is probably of lower Middle Devonian age.

Because of their stratigraphic position, strata of the Stone Formation are most likely equivalent to the subsurface Chinchaga Formation of northeastern British Columbia, and probably to the exposed Bear Rock Formation of the District of Mackenzie. Fisher (1963) has discussed the formation in the report area, and referred it to the Bear Rock Formation. In many of his sections, however, he included in the basal part of the Bear Rock Formation strata that the present writers have assigned to the Wokkpash Formation.

Dunedin Formation

The name Dunedin Formation is proposed for a uniform sequence of argillaceous, in places siliceous and dolomitic, dark grey, bedded limestones (Pl. I-5,6) that overlies light coloured dolomites of the Stone Formation and that is overlain at the type section by Besa River Shale. The strata are exposed continuously in One Ten Creek, a small stream that flows southward from Mount St. Paul and crosses the Alaska Highway a short distance west of Mile 398. The uppermost beds of the formation and some of the overlying Besa River shales can be seen from the highway. The formation is named after Dunedin River which has its headwaters about a mile to the north of the type locality and flows along the northeast flank of Mount St. Paul eastward into Liard River.

The Dunedin Formation is exposed continuously in a narrow belt that extends for some 230 miles along the Front Ranges of the Rocky Mountains between Halfway River and the Caribou Range. The formation is 781 feet thick in the type section and reaches a maximum of 1,260 feet in the Sentinel Range to the west. It thins progressively northward from the Caribou Range and grades in a short distance to shales of the Besa River Formation.



Miles

0 20 40

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Kilometres

Section . . . . 2•

Isopach (interval 100 feet). 1000

FIGURE 6. Isopach map of the Dunedin Formation.

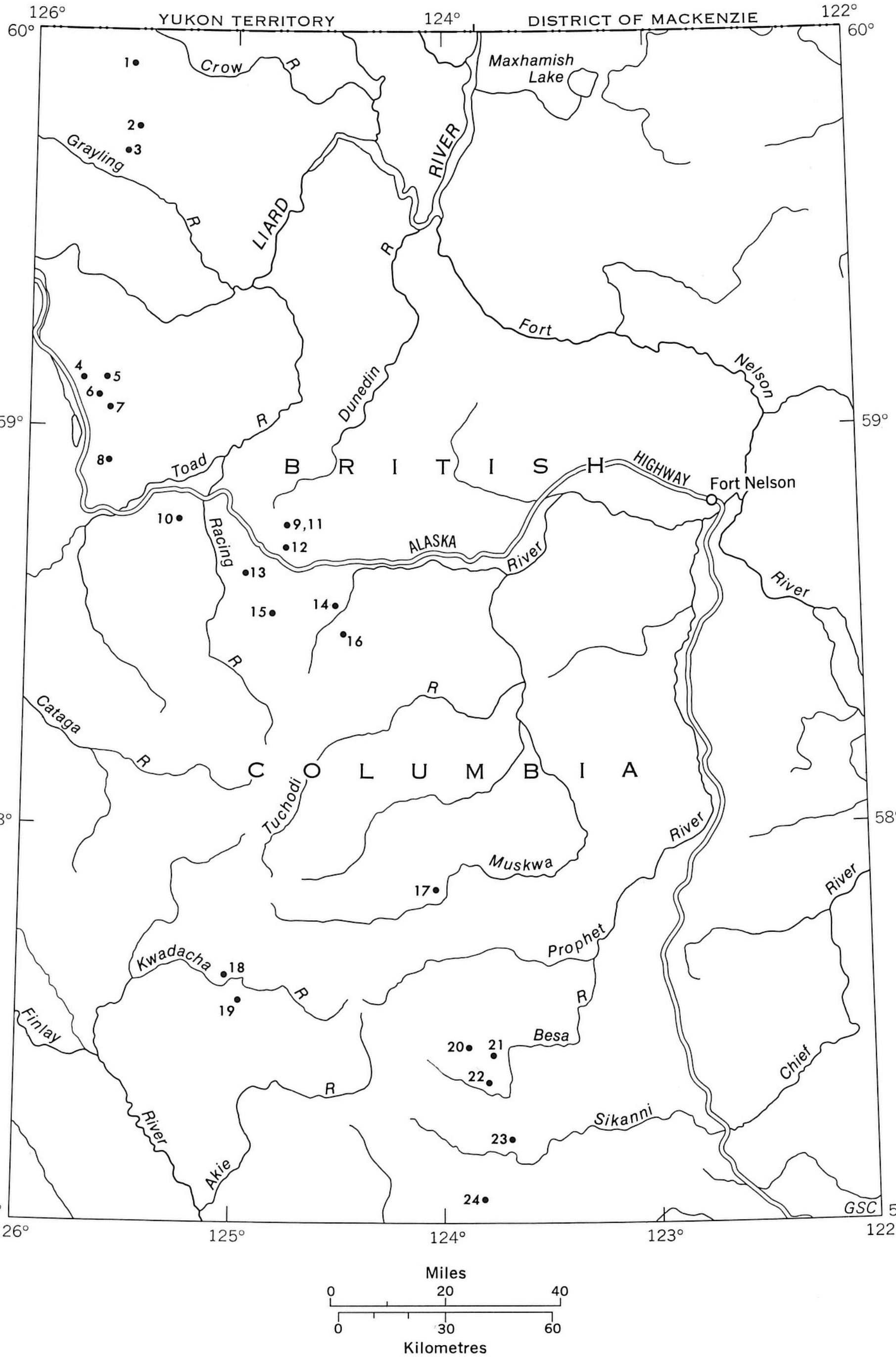

FIGURE 7. Locality map of fossil collections, Dunedin Formation.

The formation consists of a uniform sequence of bedded, dark grey, argillaceous limestone. At the type locality and in the Caribou Range the strata are conspicuously siliceous, particularly within an upper 100-foot interval, where lenses and nodules of black chert up to 3 inches thick are common. Elsewhere the formation is relatively free of silica. Dolomite, commonly in the form of small, euhedral crystals, occurs sporadically in association with rock fractures, as a partial or complete replacement of fossil remains, as a lining or infilling of small vugs, and as diffuse patches and mottlings in some of the more argillaceous beds. Dolomite is present also in the lowermost strata in the western part of the outcrop belt and in an area south of Keily Creek where there is a major facies change to porous reef-like beds. These lower dolomites are characteristically argillaceous, finely crystalline and thin bedded. They commonly contain dark shale partings, thin, laterally restricted intercalations of shale, and scattered sandstone lenses. *Amphipora* are a quantitatively important rock constituent in this part of the formation. The upper two thirds of the sequence in the report area consists of thick-bedded to massive, finely crystalline, dark grey limestone and interbedded granular limestone. Porous, dolomitized zones occur in this part of the sequence near its limit north of the Caribou Range.

A study of thin sections showed that micritic limestones are the most common rock type. They commonly contain broken fragments of ostracods, brachiopods, gastropods, bryozoans, echinoderms and other fossils as well as complete tests of foraminifera and calcispheres. Granular limestones occur less frequently.

The lower boundary of the Dunedin Formation is drawn above the highest, finely crystalline, light grey dolomite or dolomite breccia of the Stone Formation. The contact is normally conformable, either sharp or gradational, but locally it is disconformable. At the type section the dolomites immediately below the base are brecciated and show local scouring suggestive of erosion. Near Mile 470 on the Alaska Highway, in the Caribou Range to the north, and in the vicinity of Mount Mary Henry and Wokkpash Creek south of the type locality, the contact between the Dunedin Formation and underlying light brown dolomite is sharp but apparently conformable. In contrast, the lower beds of the Dunedin Formation southeast of Muncho Lake are progressively more dolomitic downward and no sharp line of demarcation can be drawn here between the two formations. South of Keily Creek the contact between the Dunedin and Stone Formations is sharp and unconformable. Temporary emergence prior to deposition of the overlying Dunedin Formation is suggested by the presence of thin, basal sandstones, and limonite nodules.

In many regions, soft shales of the Besa River Formation have been eroded from gently dipping, cliff-forming strata of the Dunedin Formation leaving exposed appreciable flat areas of the limestone; elsewhere there is evidence of interfingering between the two facies.

Within the report area, the top of the Dunedin Formation is diachronous and ranges in age from Eifelian in the north to late Givetian in the south (Fig. 2; Appendix II). In the north, for example in the Caribou Range, *Schuchertella* cf. *S. adoceta* occurs at the top of the Dunedin Formation and suggests correlation with the lower part of the Hume Formation (Eifelian) of the central Mackenzie Region. In the central part of the report area *Leiorhynchus castanea* collected from the top of the Dunedin Formation indicates correlation with the lower part of the Hare Indian Formation (Givetian) of the central

Mackenzie Region. In the southern part, uppermost beds of the Dunedin yielded *Hadrorhynchia sandersoni* and *Halloceras logani* of probable late Givetian age. Thus, from north to south in the report area the top of the Dunedin Formation becomes progressively younger; the base of the formation is probably about the same age throughout the area. The presence of *Moelleritia canadensis* near the base suggests that these beds are of either Early Devonian or early Middle Devonian age.

Besa River Formation

The Besa River Formation was defined by Kidd (1962, 1963) as:

> ... the thick black shale sequence which is present in northeast British Columbia foothills and mountains, lying between Mississippian cherty limestones and Middle Devonian carbonates.

He designated as the type section the exposures 4 miles north of Muskwa River at 57° 57′30″N, 123°43′00″W.

Within the region covered by this report the Besa River Formation is exposed in a narrow belt along the length of the Rocky Mountain Front. It is exposed also in the core of the Muskwa River anticline where the type section occurs in the upper part of several thrust plates within the mountains near Wokkpash Lake, and in a broad area surrounding the Caribou Range north of Liard River. The formation is more than 2,700 feet thick at the type section. Elsewhere in the area surface sections are about 1,000 feet thick, which indicates a rapid eastward thickening. Equivalent rocks in the Pan American Beaver River A-1 well, just north of the British Columbia-Yukon boundary are 7,400 feet thick (Pelzer, 1966), which shows that the thickening continues beyond the report area.

Black shale is the predominant rock type of the Besa River Formation. Thin, impure limestone, chert, and siltstone beds are known from the upper part of the formation in eastern sections.

The Besa River Shale commonly rests with a sharp, conformable contact on limestones of the underlying Dunedin Formation. However at Water Ouzel Creek[1] there is interfingering of the two lithologies in a zone about 5 feet thick. At the north end of the Caribou Hills, carbonates of the entire Dunedin Formation and much of the underlying Stone Formation grade abruptly into equivalent Besa River Shale. A similar change takes place in the south, near Keily Creek, where limestones of the Dunedin Formation pass rapidly into equivalent shales of the Besa River Formation. Between these two areas of rapid facies change there is a broad area where the base of the formation apparently maintains a relatively constant position with respect to time.

Fossils are very rare in the Besa River shales. Little shale was deposited in Givetian or earlier time, except in the extreme northwest where Middle Devonian carbonates pass laterally into equivalent black shale. Diagnostic Middle Devonian fossils were not recovered from the shales, though they are known to occur in the intercalated limestones in the "transition zone" on Water Ouzel Creek. Hughes (1963) reported Middle Devonian fossils from beds of the Besa River Formation that are transitional with the Dunedin Formation, and that are included in this study. Fitzgerald (1965, p. 422) reported Middle

[1]Water Ouzel Creek (58°35′N; 124°31′W) is the name proposed for the small stream flowing north into an unnamed fork of North Tetsa River.

Devonian fossils in the Besa River Formation but gave no identification or location, and indicated that Kingston (1956) had established a Middle Devonian age for the lower part of the formation. Ten miles to the northwest at One Ten Creek, Uyeno identified the following conodonts collected 56 feet above the base of the shales. He considered the fauna to be of early Frasnian age.

GSC loc. No. 68742: *Ancyrodella rotundiloba* (Bryant) subsp.
Ozarkodina spp.
Polygnathus sp.
Synprioniodina sp.
Icriodus? sp.

The upper age limit of the Besa River Formation is variable. In the west the formation contains black shales equivalent to the Prophet Formation. Chesteran ammonoids (*Goniatites* sp.) were reported by Hughes (1963) from black shales near Smith River bridge. These shales have been assigned to the Besa River Formation. This locality, therefore, has the youngest dated Besa River shales.

PETROGRAPHY OF THE DUNEDIN FORMATION

The following descriptive notes, based on a study of thin sections and polished rock surfaces, constitute a brief account of the main sedimentary and diagenetic features of the Dunedin Formation limestones. The Dunedin Formation was chosen for study because it is dominantly limestone, and so has retained many of its primary sedimentary textures. Macrofossils are more abundant throughout this unit than in other rock units of the study area and, as was expected, microfossils and skeletal fragments were conspicuous constituents of the rocks.

Classification

Particle size and type of cement were chosen as the two main parameters for a simple descriptive classification. Both these features reflect depositional environments and the nature of the primary sediment. The strata are dominantly clastic, in that the constituent limestone particles have been moved about on the basin floor. Although they are of intrabasinal origin they can not be classified as biogenic because colonial organisms are scarce. The limestones were separated into two main groups: granular limestones, typically with a cement of coarsely crystalline calcite; and micritic limestones, with an inter-particle cement of fine calcareous mud. Recrystallization appears to have affected the granular rocks to a greater degree than it has the micritic ones so that the former are frequently difficult to classify within the group.

Limestone Rock Types

Granular Limestone

The granular limestones are made up dominantly of medium and fine, rounded grains of relatively pure limestone embedded in a cement of clear, coarsely crystalline calcite. Large composite grains occur sporadically, and limestone pellets made up of clusters of oval-shaped grains occur less frequently. Limestone fossil fragments are ubiquitous in the sequence, but quantitatively are not important as rock-builders. It is significant that these organic fragments commonly are undamaged even in the granular rocks. Quartz silt grains, presumably of terrestrial origin, occur sporadically.

Micritic Limestone

A micritic limestone is a rock that is made up dominantly of fine calcareous mud. The group includes also sediments composed of grains of micritic limestone embedded in a micritic matrix, to produce a rock which is sometimes clearly granular and sometimes only vaguely so. Limestones with a uniformly micritic texture are rare.

Limestone Grains

The various rock types contain limestone grains of inorganic origin such as detrital limestone grains made up of microcrystalline calcite, as well as grains of organic origin consisting of fragmented brachiopod and ostracod shells and whole and fragmented foraminifera and calcispheres. Round and oval grains lacking internal texture have been classified tentatively as pellets and included among the organic fragments. Small fragments of this type may have been destroyed by recrystallization and so may once have been more numerous.

Inorganic Grains

Microcrystalline calcite that occurs as single grains or as aggregates of grains is quantitatively the most important rock-forming constituent of the limestones. A common type of aggregate grain, in places as large as 2.5 mm in maximum dimension, consists of particles about 100 microns in diameter of fine calcite mud embedded in a cement of clear, coarsely crystalline calcite. Such composite grains occur frequently as partly disintegrated clusters of small grains, similar in size and shape to discrete particles of calcite mud in the surrounding matrix (Pl. II-1). They are comparable in shape and internal texture to grapestone lumps (Illing, 1954, Pl. 3-10) but have been considerably modified by recrystallization. Relatively weak currents probably caused partial disintegration of many of these grapestone lumps. Strong currents or prolonged rolling about would almost certainly have worn smooth more firmly cemented material. Illing (1954, p. 30) attributed the formation of grapestone lumps to early cementation of the particles by aragonite precipitated from sea water. In contrast, microcrystalline and pelleted calcite particles are bound by algal filaments to form modern algal mats which break up into lumpy composite grains (Scholl and Taft, 1964, Fig. 3). Although the composite lumpy grains of the Dunedin Formation are not clearly of organic nature, their textures are comparable to ancient and modern organically bound grains and the possibility of this origin should, therefore, not be discounted.

Other large grains with an internal texture similar to that of the grapestone lumps and with maximum dimensions up to 2.5 mm also are common (Pl. II-2). They differ, however, in that they are frequently tabular and have a sharp contact with the enclosing sparry calcite cement. Many have angular corners, which may be the result of recrystallization. Fine, detrital quartz silt is a common constituent of this type of limestone fragment. Johnson and Konishi (1958, p. 54) suggested that algal filaments can bind large amounts of foreign material in mats of fine calcareous mud. The large amount of detrital material associated with these composite grains suggests that they may have been formed by the break-up of such an organically-stabilized sediment layer. The common presence of tabular and angular fragments with sharp grain boundaries suggests that the source material may have been at least partly consolidated.

Rounded, discrete, rimmed grains of microcrystalline calcite about 200 microns in average diameter occur in small numbers throughout the formation (Pl. II-3). In this case. also, recrystallization has obliterated almost completely even some of the larger grains. A rim of material, suggestive of an oölitic coating, surrounds many of them. A similar coating exists on elongate grains that may be fossil fragments. Brown (1964, F. 4-A) described oölitic coating on pelsparite grains that were less strongly altered, and Dixon and Reeves (1965, Fig. 19) showed coated fossil fragments in some Mississippian limestone cores. The coated, rounded grains and fossil fragments from the Dunedin Formation probably can be classified best as superficial oölites as they have no visible concentric layers. Oölites are forming today in less than 10 feet of water (Pilkey, *et al.*, 1966), and the coated grains and fossil fragments also may have formed in an environment of shallow, turbulent water saturated with calcium carbonate.

By far the most common type of inorganic grain consists of subrounded and rounded fragments of dense microcrystalline calcite (Pl. II-4). They show little internal texture, and aside from being relatively dark in colour and finely crystalline have few distinguishing features. Some evidence of compaction within the limestone sequence is indicated by the flattening of some of these grains (Pl. II-5), but the phenomenon is not common.

Organic Grains

Stromatoporoids form small bun-like colonies from an inch to 2 inches in diameter and occur also as lenticular encrusting masses. In some places the colonies have been broken into fragments and constitute grains of sediment. In the Dunedin Formation stromatoporoids are most common in the Caribou Range near the northern limit of limestone deposition. They occur here in the uppermost beds of the sequence, most commonly in lenticular masses up to 2 feet long. Recrystallization has almost completely obliterated most of the microscopic structures (Pl. II-6). Some of the stromatoporoids show affinities with *Anostylostroma* sp., *Stromatopora* sp., and *Trupetostroma* sp. (C.W. Stearn, *pers. com.*), but the only genus that can be identified with confidence is *Amphipora.*

Amphipora is a common form of stromatoporoid and a good Devonian index fossil. It occurs infrequently throughout the Dunedin Formation as thin, vermicular, branching stems that lie along bedding planes, but presumably grew upright on the sea bottom. Small fragments are difficult to recognize but larger ones are identified by their common brownish tinge, large peripheral vesicles, and axial canals. Some grains contain scattered dark specks. and most retain traces of a primary fibrous texture.

Gastropods occur mainly in the dense micritic facies as whole specimens and as relatively large shell fragments. Low conispiral forms are most common, but a few smooth, unbroken, high spired shells about 3 mm long were observed. Many shell cross-sections show a flat-topped infilling of rounded, uniformly size-sorted grains of microcrystalline calcite that provide a directional element within the rock. These infilling grains, because of their association with the shells, are probably gastropod fecal pellets. The most significant aspects of the gastropod shell fragments are their association with fine-grained rocks and their relatively fresh, unworn appearance, both of which suggest a quiet-water environment.

Pelecypods are rare in the Dunedin Formation. They occur as arcuate shapes whose internal shell texture has been obliterated by diagenesis leaving only a mosaic of large calcite crystals. A dark enclosing envelope that appears to have replaced the surface of most shells has been interpreted as infilling of algal borings (Pl. III-1). Similar textures affecting gastropod shells and crinoid ossicles have been attributed to the corroding effect of algae (Bathurst, 1966; Braithwaite, 1966, Fig. 10; Wolfe, 1965, Fig. 9).

Brachiopod fragments can be distinguished by their shape and shell layering. Their most common occurrence is among other skeletal remains in the micritic rocks where they show little evidence of prolonged abrasion. They occur in the granular facies as well, but are less numerous and whole shells are scarce.

Coral fragments are typically yellowish brown but, unless large enough to show characteristic shapes, are difficult to distinguish from other organic remains.

Bryozoans observed in thin sections are of the branching type. The few examples seen consist of tangential sections that show a rather thick integrate wall structure. They are commonly associated with silty, micritic limestones and so may have a degree of environmental significance.

Echinoderm remains are easily recognized in thin section by their shape and by the total extinction of the fragments in polarized light. They occur most commonly in the micritic limestones and probably lived in quiet water. Their remains are rare in the granular rocks.

Ostracods can be identified by their overlapping valves and small size. They occur as whole specimens or fragments in almost all thin sections, but are particularly characteristic of the micritic facies. Some micritic limestones contain great numbers of thin valves and fragments of valves, many of which have been almost completely destroyed by recrystallization (Pl. III-2). Geopetal fabrics in the form of flat-topped sediment inside the shells are common in the micritic rocks. This feature probably has little value as a directional indicator in granular rocks as the ostracod remains have presumably been transported from elsewhere. Ostracods can be transported easily and are, therefore, good index fossils. Their remains persist longer in strongly recrystallized rocks than do those of other fossils.

Foraminifera in thin sections of the Dunedin Formation are of the single chambered spherical form with regularly and irregularly arranged peripheral spines (Pl. III-3). They range in size from 50 to about 300 microns, depending perhaps on their degree of maturity. In some thin sections of the micritic facies, forams are particularly abundant and make up an estimated 15 to 20 per cent of the rock. In thin sections of granular rocks they are also numerous, but are concentrated in patches of coarsely crystalline calcite cement that presumably filled voids into which the hollow spheres had drifted. They presumably floated for long distances and, therefore, do not indicate local environment. However, they do indicate marine conditions, and diagnostic species provide excellent stratigraphic markers. One poorly preserved tikhinellid "foraminifer" was noted in a sample from 60 feet below the top of the type section of the Dunedin Formation.

Algae have not been definitely identified in strata of the Dunedin Formation, although scattered, presumed algal borings (Pl. III-1) suggest their presence in the original sediments. Calcareous tubes with dark grey micritic walls and infillings of coarsely crystalline calcite, interpreted as algal remains, occur sparingly. The tubes (Pl. III-4), are similar to those illustrated by Wolfe and Conolly (1965, Pl. XVI). Other segmented tubes, some with cellular wall structure (Pl. III-5,6) also may represent a variety of calcareous algae. They are plants that require sunlight for their metabolism and therefore indicate relatively shallow water.

SUMMARY

A belt of Lower, Middle, and Upper Devonian mainly carbonate rocks with oil and gas potential extends from the District of Mackenzie through northeastern British Columbia and into northwestern Alberta. Five formations occur within the succession in the report area. They are as follows:

The Lower Devonian Muncho-McConnell Formation of dark grey dolomite, which, in most of the report area, rests disconformably on Silurian strata.

The Lower Devonian Wokkpash Formation of yellow-brown sandstone and argillaceous dolomite with an abrupt transitional lower contact.

The lower Middle Devonian Stone Formation of light coloured dolomite and dolomite breccia with a disconformable lower contact.

The upper Middle Devonian Dunedin Formation of argillaceous, dark grey limestone with a locally disconformable lower contact and a diachronous (younger in the south) upper contact.

The Middle and Upper Devonian Besa River Formation of black shale which, in most areas, rests with a sharp and conformable contact on the underlying carbonates but grades abruptly into them near their northern limit.

Potential hydrocarbon traps occur in locally developed porosity in the Muncho-McConnell and Wokkpash Formations. Pre-Stone Formation erosion, however, has affected both formations so that probably only thin wedges of the carbonates remain as potential reservoirs in the subsurface of the foothills belt.

The overlying Middle Devonian rocks (Stone and Dunedin Formations) thicken from east to west and show marked changes in lithology that make them attractive prospects for gas and oil. Abrupt changes take place vertically between porous breccias and enclosing non-porous dolomites in the Stone Formation and between the breccias and overlying limestone of the Dunedin Formation. Potential stratigraphic traps exist in the Caribou Range to the north where dolomite breccias and porous dolomites of the Stone Formation, as well as locally developed dolomite porosity in the Dunedin Formation, grade laterally to shales of the Besa River Formation.

Porous crinoidal beds occur in the Dunedin Formation in the northern part of the report area near the limit of limestone deposition, and in association with a change in facies near Redfern Lake in the south. In this southern region a reef facies in the Dunedin Formation trends northeast to the Fort Nelson area where it yields gas.

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APPENDIX I – Stratigraphic Sections

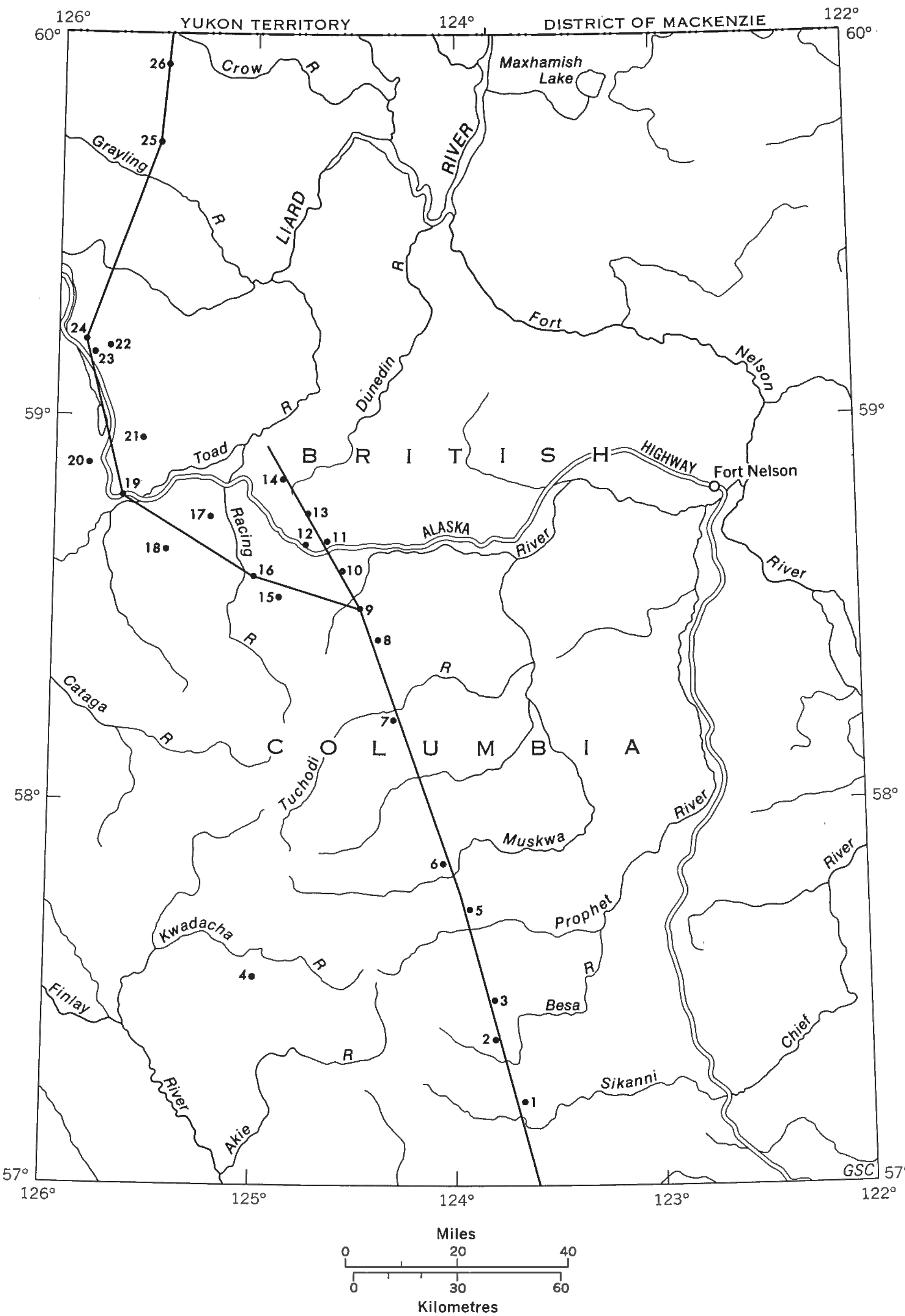
APPENDIX II – Fossil Occurrences, Dunedin Formation

TABLE II. Stratigraphic sections.

SECTION	NAME	LOCATION		THICKNESS IN FEET			
		LATITUDE	LONGITUDE	MUNCHO-MCCONNELL	WOKKPASH	STONE	DUNEDIN
1	Mt. Bertha	57°12′	123°43′	266	181	459	209 +
2	Keily Creek	57°27′	123°51′	281	110	639	712
3	Richards Creek	57°33′	123°51′	249	92	548	93 +
4	Paul River	57°30′	124°49′				410
5	Prophet River	57°43′	123°56′	178 *	90	523	
6	Muskwa River	57°49′	124°06′	225	109	495	227 +
7	Tuchodi River	58°12′	124°17′	233	138		
8	Chischa River	58°25′	124°27′		100	878	
9	Mt. Mary Henry	58°28′	124°30′	165	107	870	666
10	Water Ouzel Creek	58°34′	124°34′	272	139	1060	
11	Summit Pass	58°39′	124°43′	345	135	1185	
12	One Ten Creek	58°41′	124°48′	396	183	1242	781
13	Dunedin River	58°44′	124°44′				730
14	Stone Mountain	58°51′	124°51′		200	1270	
15	Wokkpash east	58°33′	124°54′		156		
16	Wokkpash west	58°30′	124°57′	449	173	1174	857
17	Yash Creek	58°44′	125°17′				681 *
18	Toad River	58°42′	125°33′	704			
19	Toad Canyon	58°48′	125°42′	889	401		
20	Mt. Peterson	58°52′	125°48′	938	376	1746	
21	Nonda Creek	58°52′	125°36′				1117
22	Sulphur Creek	59°08′	125°43′				873 *
23	Sentinel Range I	59°06′	125°48′			1935	
24	Sentinel Range II	59°09′	125°52′	1152	361		
25	Caribou Range south	59°45′	125°30′	808	372	1553	831
26	Caribou Range north	59°54′	125°27′			865 *	820

GSC

*Section incomplete, base missing. . . . . ** *Section incomplete, top missing. . . . . +*



Section . . . . 7•

Line of stratigraphic section (see Figure 9) . . . . . . ———

FIGURE 8. Locations of measured sections and the line of north-south stratigraphic section (Fig. 9).

Muncho-McConnell Formation
(58° 48'N, 125° 37'W)

TYPE SECTION

SECTION 1. Located about 2 1/2 miles west-northwest of the Toad River bridge, Mile 438 on the Alaska Highway. The strata, exceptionally well exposed in this area, rest disconformably on the Nonda Formation.

Unit	Lithology	Thickness (feet) Unit	From base
	Wokkpash Formation		
121	Sandstone, dolomitic, medium- to fine-grained, light grey to brownish; weathers buff	5	20
120	Covered interval	15	15
	Muncho-McConnell Formation (889 feet)		
119	Dolomite, medium to finely crystalline, contains many sand grains, medium to dark grey; occurs in beds from 3 inches to 1 foot thick; weathers dark grey to buff	16	889
118	Sandstone, dolomitic, medium- to fine-grained, light grey to brownish; weathers buff	5	873
117	Dolomite, medium to finely crystalline, contains many sand grains, medium dark grey; forms beds from 3 inches to 1 foot thick; weathers dark grey to buff	2	868
116	Sandstone, slightly calcareous, medium- to fine-grained, light grey; beds about 3 inches thick; weathers light grey to buff	3	866
115	Sandstone, dolomitic, medium- to fine-grained, light grey to brownish; weathers buff	4	863
114	Sandstone, dolomitic, medium- to fine-grained, light grey to brownish; weathers buff	8	859
113	Sandstone, dolomitic, medium- to fine-grained, light grey to brownish; weathers buff	1	851
112	Sandstone, dolomitic, medium- to fine-grained, light grey to brownish; bed 3 inches to 1 foot thick; weathers buff	5	850
111	Dolomite, medium to finely crystalline, contains many sand grains, medium to dark grey; beds 3 inches to 1 foot thick, some beds are laminated; weathers dark grey to buff	10	845
110	Dolomite, finely crystalline, dark grey; beds 3 inches to 1 foot thick; weathers light to dark grey	7	835
109	Dolomite, medium to finely crystalline, medium to light grey; beds from 6 inches to 1 foot thick; weathers light to dark grey and buff	5	828
108	Covered interval	13	823
107	Dolomite, medium to finely crystalline, medium to light grey; beds from 6 inches to 1 foot thick; weathers light to dark grey and buff	7	810
106	Dolomite, medium to finely crystalline, dark grey; beds from 3 inches to 6 inches thick; weathers dark grey	10	803
105	Covered interval	11	793
104	Dolomite, medium crystalline, medium grey; beds 6 inches to 1 foot thick; weathers light grey mottled with buff	5	782

Unit	Lithology	Thickness (feet) Unit	From base
103	Dolomite, medium crystalline, medium grey; beds 6 inches to 1 foot thick; weathers dark grey	3	777
102	Dolomite, medium crystalline, medium grey; beds approximately 6 inches to 1 foot thick; weathers light grey mottled with buff and dark grey.	10	774
101	Dolomite, finely crystalline, dark grey; weathers dark grey; beds massive	5	764
100	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	12	759
99	Dolomite, dark grey, fine crystalline; beds 3 inches to 1 foot thick; weathers light to dark grey	1	747
98	Dolomite, very finely crystalline, medium dark grey; beds 6 inches to 1 foot thick; weathers light grey mottled with buff and dark grey	25	746
97	Shale, very dark grey, fine-grained, non-calcareous; weathers brown to dark grey	6	721
96	Dolomite, finely crystalline, light grey; beds 6 inches to 3 feet thick; weathers light grey slightly mottled with dark grey	7	715
95	Dolomite, very finely crystalline, medium to dark grey; beds from 6 inches to 1 foot thick; weathers light grey slightly mottled with dark grey	21	708
94	Dolomite, finely crystalline, dark grey; beds massive; weathers dark grey	5	687
93	Dolomite, finely crystalline, dark grey; forms light to dark grey beds 3 inches to 1 foot thick	16	682
92	Dolomite, very finely crystalline, medium to dark grey; beds 6 inches to 1 foot thick; weathers light grey, mottled buff and dark grey	1	666
91	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	3	665
90	Dolomite, very finely crystalline, medium to dark grey; beds 6 inches to 1 foot thick; slightly resistant; weathers light grey and buff	9	662
89	Dolomite, finely crystalline, dark grey; beds massive and recessive; weathers dark grey	2	653
88	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; resistant; weathers light grey mottled with dark grey	10	651
87	Dolomite, very finely crystalline, medium dark grey; beds 6 inches to 1 foot thick; recessive; weathers light green, mottled buff and dark grey	2	641
86	Dolomite, finely crystalline, dark grey; weathers dark grey; beds massive	2	639
85	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	3	637
84	Dolomite, finely crystalline, dark grey; beds massive and fractured; weathers dark grey	2	634
83	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	4	632
82	Dolomite, finely crystalline, light grey; beds 6 inches to 3 feet thick; weathers light grey mottled with dark grey	9	628

Unit	Lithology	Thickness (feet) Unit	From base
81	Dolomite, finely crystalline, dark grey; beds about 3 inches thick; contains a 2-inch bed with numerous chert nodules; weathers light and dark grey	6	619
80	Dolomite, finely crystalline, dark grey; beds 3 inches to 1 foot thick; weathers light to dark grey	2	613
79	Dolomite, finely crystalline, dark grey; with a 2-inch band of chert nodules; weathers light to dark grey	6	611
78	Dolomite, finely crystalline, light medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	6	605
77	Dolomite, finely crystalline, medium dark grey; beds 6 inches to 3 feet thick; weathers light grey to buff	12	599
76	Dolomite, very finely crystalline, medium to dark grey; beds 6 inches to 1 foot thick; slightly recessive; weathers light grey mottled buff and dark grey	3	587
75	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	7	584
74	Covered interval	3	577
73	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	2	574
72	Dolomite, finely crystalline, dark grey; beds 3 inches to 1 foot thick; slightly recessive; weathers light grey to dark grey	2	572
71	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	30	570
70	Covered interval	12	540
69	Dolomite, finely crystalline, light medium grey; beds 1 inch to 1 foot thick; resistant; weathers light and dark grey	8	528
68	Covered interval	10	520
67	Dolomite, finely crystalline, light to medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	6	510
66	Dolomite, finely crystalline, dark grey; beds 3 inches to 6 inches thick; weathers dark grey	6	504
65	Dolomite, finely crystalline, light grey; beds 3 inches to 3 feet thick; weathers light grey slightly mottled with dark grey	28	498
64	Dolomite, finely crystalline, dark grey; beds 1 inch to 3 inches thick; weathers dark grey	1	470
63	Dolomite, finely crystalline, light medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	3	469
62	Dolomite, finely crystalline, dark grey; beds massive with some thin beds 1 inch to 2 inches thick; weathers dark grey	6	466
61	Dolomite, finely crystalline, light medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	2	460
60	Dolomite, finely crystalline, dark grey; beds massive; weathers dark grey	4	458
59	Dolomite, finely crystalline, light to medium grey; beds 2 inches to 2 feet thick; weathers light grey mottled with dark grey	9	454
58	Dolomite, finely crystalline, dark grey; beds massive; weathers dark grey; resistant	3	445
57	Dolomite, finely crystalline, light to medium grey; weathers light grey mottled with dark grey; recessive	6	442

Unit	Lithology	Thickness (feet) Unit	From base
56	Dolomite, finely crystalline, light to medium grey; weathers light grey to buff	4	436
55	Dolomite, finely crystalline, light to medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	4	432
54	Dolomite, finely crystalline, dark grey; beds massive; weathers dark grey	5	428
53	Dolomite, finely crystalline, light to medium grey; beds 3 inches to 1 foot thick; weathers light grey mottled to dark grey	4	423
52	Dolomite, medium to finely crystalline, medium dark grey; beds 3 inches to 1 foot thick; with calcite veining; weathers medium dark grey	2	419
51	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	25	417
50	Dolomite, finely crystalline, dark grey; beds 3 inches to 1 foot thick; weathers light grey mottled with dark grey	10	392
49	Dolomite, finely crystalline, light to medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	39	382
48	Dolomite, finely crystalline, medium grey; beds 6 inches to 2 feet thick; weathers light grey mottled with dark grey	64	343
47	Dolomite, finely crystalline; beds 3 inches to 1 foot thick; weathers light grey mottled with dark grey	16	279
46	Dolomite, medium to finely crystalline, medium dark grey; beds 3 inches to 1 foot thick; weathers medium to dark grey	15	263
45	Dolomite, finely crystalline, medium to dark grey; weathers light grey to buff	1	248
44	Dolomite, medium to finely crystalline, medium dark grey; beds 3 inches to 1 foot thick; weathers dark grey	5	247
43	Dolomite, medium to finely crystalline, medium dark grey; beds 3 inches to 1 foot thick; weathers medium to dark grey.	10	242
42	Dolomite, finely crystalline, medium grey streaked with light brown; beds 6 inches to 1 foot thick; weathers mottled grey-buff.	5	232
41	Dolomite, finely crystalline, light grey; beds from 1 foot to 2 feet thick; weathers light grey mottled with dark grey	4	227
40	Shale, black; weathers dark grey to purple; non-calcareous, laminated	2	223
39	Dolomite, medium to finely crystalline, medium dark grey; beds 3 inches to 1 foot thick with calcite veining; weathers medium dark grey	3	221
38	Dolomite, finely crystalline; medium grey; beds 3 inches to 1 foot thick; weathers light grey mottled with dark grey	5	218
37	Shale, black; weathers dark grey to purple; non-calcareous, laminated	2	213
36	Dolomite, finely crystalline, medium grey; beds 3 inches to 1 foot thick; weathers light grey mottled to dark grey	4	211
35	Shale, black; weathers dark grey to purple; non-calcareous, laminated	6	207
34	Dolomite, finely crystalline, medium to dark grey; beds 3 inches to 1 foot thick; weathers light brown to light grey.	7	201
33	Shale, black; weathers dark grey to purple; non-calcareous, laminated with mud-cracks	3	194
32	Dolomite, finely crystalline, medium grey, mottled dark grey in spots; beds 6 inches to 1 foot thick; weathers medium grey to buff	5	191

Unit	Lithology	Thickness (feet) Unit	From base
31	Dolomite, finely crystalline, medium dark grey; beds 1 foot to 2 feet thick; light grey to buff, mottled, with some calcite veining, resistant	4	186
30	Dolomite, finely crystalline, medium dark grey; beds 3 inches to 1 foot thick; weathers light brown to light grey	5	182
29	Dolomite, finely crystalline, medium grey; beds 6 inches to 1 foot thick; recessive; weathers light brown to light grey	3	177
28	Dolomite, finely crystalline, medium to dark grey; beds 3 inches to 1 foot thick; resistant; weathers light brown to light grey	6	174
27	Shale, laminar, black; weathers dark grey; non-calcareous	6	168
26	Dolomite, medium grey; streaked with light brown, finely crystalline; beds 6 inches to 1 foot thick, fetid; weathers mottled grey-buff . .	6	162
25	Covered interval, with scattered outcrops of slumped, purple-weathering, mud-cracked shale	10	156
24	Dolomite, finely crystalline, medium to dark grey; beds 1 foot to 2 feet thick; more massive and resistant; weathers light brown to light grey	42	146
23	Dolomite, finely crystalline, medium grey streaked with light brown; beds 6 inches to 1 foot thick; resistant; weathers mottled grey-buff	5	104
22	Dolomite, finely crystalline, medium grey streaked with light brown; bed 6 inches to 1 foot thick; resistant; weathers mottled grey-buff	5	99
21	Dolomite, finely crystalline, medium to dark grey; beds 3 inches to 1 foot thick; recessive; weathers light brown to light grey	2	94
20	Dolomite, finely crystalline, medium to dark grey; beds 3 inches to 1 foot thick; resistant; weathers light brown to light grey	3	92
19	Dolomite, finely crystalline, light grey; beds 3 inches to 1 foot thick; fetid; recessive; weathers light grey mottled with dark grey-brown	2	89
18	Dolomite, finely crystalline, light grey; beds 3 inches to 1 foot thick; fetid; resistant; weathers light grey mottled with dark grey-brown	4	87
17	Dolomite, finely crystalline, medium to dark grey; beds 1 foot to 2 feet thick, recessive; weathers light brown to light grey	4	83
16	Dolomite, finely crystalline, medium to dark grey; beds 1 foot to 2 feet thick; resistant; weathers light brown to light grey	6	79
15	Dolomite, finely crystalline, light grey; beds 1 foot to 2 feet thick; weathers light grey mottled with dark grey	5	73
14	Dolomite, finely crystalline, light grey; beds 3 to 6 inches thick; weathers dark grey	1	68
13	Dolomite, finely crystalline, light grey; beds 1 foot to 2 feet thick; resistant; weathers light grey mottled with dark grey	3	67
12	Dolomite, finely crystalline, medium to dark grey; beds 3 inches to 1 foot thick; weathers light brown to light grey	12	64
11	Dolomite, finely crystalline, medium grey; beds 6 inches to 1 foot thick, with calcite veins; weathers light grey to buff	14	52
10	Dolomite, finely crystalline, medium grey, streaked with light brown; beds 6 inches to 1 foot thick; weathers mottled grey-buff.	4	38
9	Dolomite, finely crystalline, light grey, streaked light brown; beds 3 inches to 1 foot thick; weathers mottled grey-buff.	10	34
8	Dolomite, finely crystalline, medium to dark grey; beds 3 inches to 1 foot thick; resistant; weathers light brown to light grey, mottled dark grey in spots	6	24

Unit	Lithology	Thickness (feet) Unit	From base
7	Dolomite, finely crystalline, medium grey streaked with light brown; beds 6 inches to 1 foot thick; slightly recessive; weathers mottled grey-buff.	1	18
6	Shale, fine-grained, fissile, black; weathers light grey	3	17
5	Dolomite, finely crystalline, medium grey, streaked with light brown; beds 6 inches to 1 foot thick; weathers mottled grey-buff.	1	14
4	Dolomite, very finely crystalline, light grey-brown; beds fractured and slightly recessive; weathers buff with rust staining.	5	13
3	Covered interval	2	8
2	Dolomite, finely crystalline, medium grey, streaked with light brown; beds 6 inches to 1 foot thick; fetid; weathers mottled grey-buff . .	3	6
1	Dolomite, medium to finely crystalline, medium grey; beds 6 inches to 1 foot thick; contains calcite veins; weathers light grey to buff	3	3

Base of formation; contact with underlying Nonda Formation disconformable.

Wokkpash Formation
(58° 33′N, 124° 54′W)

TYPE SECTION

SECTION 2. Located in a small stream tributary to Wokkpash Creek about 10 miles upstream from its junction with Racing River. Strata are continuously exposed in the bed of the small stream which enters Wokkpash Creek from the east.

Unit		Thickness (feet)	Height above base (feet)
	The Wokkpash Formation is unconformably overlain by dolomites of the Stone Formation		
	Wokkpash Formation (156 feet)		
12	Dolomite, sandy, medium brown, crystalline; occurs in thick beds with laminated shale; weathers medium brown; recessive	6	156
11	Covered interval	13	150
10	Sandstone, dolomitic, light to medium grey, fine-grained with coarse, white clastic calcite; massive, some laminations; weathers dark brown; resistant	16	137
9	Dolomite, argillaceous, light grey, very finely crystalline; occurs in thin beds from 6 inches to 1 foot thick; weathers medium grey; slightly recessive	7	121
8	Sandstone, dolomitic, medium grey, fine-grained; thick-bedded, laminated; weathers medium grey; resistant.	7	114
7	Partly covered; brown silty shale	8	107
6	Sandstone, dolomitic, light to medium grey, dense, fine-grained; thick-bedded, crossbedded, laminated; weathers dark brown; resistant	47	99
5	Sandstone, light grey to white, fine-grained, well rounded; interbedded dolomitic sandstone and shale partings; thick-bedded; weathers light brown, slightly recessive	29	52
4	Shale, brown, silty and sandy	4	23
3	Dolomite and sandstone interbedded, light grey-brown, with yellow banding, fine-grained; massive; resistant	9	19
2	Sandstone, calcareous, light grey, medium-grained, well-rounded quartz grains, grades upwards to silty dolomite and mud chip conglomerate; thick-bedded; sand-channelled 1 inch into underlying dolomite; weathers light yellow-brown; resistant; contact with underlying Muncho-McConnell Formation is conformable . .	10	10
	Muncho-McConnell Formation		
1	Dolomite, argillaceous, light grey, finely crystalline; occurs in beds from 1 foot to 2 feet thick, yellow, silty shale interbeds occur about every 6 feet; weathers brown; resistant, ribbed	48	48

Stone Formation
(58° 41′N, 124° 48′W)

TYPE SECTION

SECTION 3. Measured in and along the stream bed of One Ten Creek which flows southwestward from Mount St. Paul and crosses the Alaska Highway at Mile 398. The strata are easily accessible and outcrop continuously upstream below the base of the Dunedin Formation.

Unit		Thickness (feet)	Height above base (feet)
	Dunedin Formation (incomplete)		
38	Limestone, microcrystalline, medium grey-brown; occurs in uniform, resistant, light grey weathering beds from 2 to 4 feet thick		
	Thin section: a fine-grained calcarenite of merged and rounded grains about 100 microns in diameter in a cement of coarsely crystalline calcite, a few whole ostracod remains and brachiopod shell fragments	43	43
	The contact with the underlying Stone Formation is obscure but suggests an unconformable surface with up to 6 feet of topographic relief		
	Stone Formation (1,252 feet)		
37	Dolomite, slightly argillaceous, finely crystalline, medium and light grey; dolomite breccia in upper part of unit with barite and fluorite filling interfragment areas; also brecciated in interval 10 to 20 feet below top of unit	75	1,252
36	Dolomite breccia, medium crystalline, dark grey; thick, ill-defined bedding; weathers medium grey	45	1,177
35	Dolomite breccia, finely crystalline, medium and dark grey; breccia fragments laminated; weathers medium grey; recessive	35	1.132
34	Dolomite, calcareous, medium crystalline, medium grey-brown; occurs in thick beds, locally brecciated, some barite and fluorite breccia infilling; weathers dark grey	138	1,097
33	Dolomite, calcareous, silty, finely crystalline, medium grey; occurs in beds from 8 inches to 2 feet thick, locally brecciated; weathers medium brown	55	959
32	Dolomite, very finely crystalline, very light grey; occurs in beds from 3 inches to 2 feet thick, some brecciation; weathers light brown . .	37	904
31	Dolomite breccia, very finely crystalline, light grey; massive; weathers light grey	24	867
30	Dolomite, silty, medium crystalline, medium grey; massive; weathers medium grey; resistant.	44	843
29	Dolomite, finely crystalline, dark grey; occurs in thin beds about 2 inches thick; weathers medium grey	8	799
28	Dolomite, silty, medium crystalline, medium grey; massive; weathers medium grey; resistant.	20	791
27	Dolomite, calcareous, medium crystalline, very dark grey; thick, irregular bedding; weathers dark grey; recessive.	5	771

Unit		Thickness (feet)	Height above base (feet)
26	Dolomite, silty, medium crystalline, light grey; massive; weathers medium grey; resistant	31	766
25	Dolomite, finely crystalline, medium grey; occurs in beds about 2 feet thick; weathers medium grey; recessive	35	735
24	Dolomite, silty, medium crystalline, medium grey; occurs in beds from 2 to 5 feet thick; weathers medium grey; resistant	22	700
23	Dolomite breccia, finely crystalline, medium grey; bedding well developed about 1 foot thick; weathers medium grey; resistant	15	678
22	Poorly exposed, dolomite, calcareous, medium crystalline, very dark grey; poorly bedded; weathers dark grey; recessive	19	663
21	Dolomite, finely crystalline, medium grey; vaguely bedded in units from 2 inches to 1 foot thick; weathers medium grey; resistant	10	644
20	Covered interval	65	634
19	Dolomite, medium to finely crystalline, light grey; thin 2-inch beds rhythmically interbedded with beds from 8 inches to 2 feet thick; weathers medium grey; recessive	80	569
18	Dolomite, finely crystalline, light grey; occurs in thin beds from 2 to 4 inches thick, locally brecciated; weathers medium grey	58	489
17	Dolomite, very finely crystalline, light grey; thick, ill-defined bedding; weathers medium grey, resistant	30	431
16	Dolomite, argillaceous, medium crystalline, dark grey; thick-bedded, laminated; weathers medium grey; recessive	4	401
15	Dolomite, finely crystalline, light grey; occurs in thin beds from 1 to 2 inches thick; weathers light grey; recessive	4	397
14	Dolomite, very finely crystalline, medium grey; forms beds from 1 to 2 feet thick; weathers medium grey; resistant	13	393
13	Dolomite breccia, finely crystalline, light grey; massive; weathers medium grey; recessive	3	380
12	Dolomite, very finely crystalline, light grey; occurs in beds from 1 to 3 feet thick; weathers medium grey; resistant	20	377
11	Dolomite, calcareous, finely crystalline, grey-brown; forms beds from 1 foot to 4 feet thick; recessive	2	357
10	Dolomite, silty, finely crystalline, light grey; occurs in beds about 2 feet thick; weathers medium grey; resistant	68	355
9	Dolomite, calcareous, finely crystalline, medium to dark grey; occurs in beds from 2 to 4 inches thick; weathers medium grey; recessive	2	287
8	Dolomite, finely crystalline, medium grey; beds from 6 inches to 2 feet thick, laminated locally brecciated; weathers medium grey; resistant	53	285
7	Dolomite, medium to finely crystalline, medium grey; forms beds from 1 foot to 3 feet thick, locally brecciated; weathers light grey-brown; recessive	45	232
6	Dolomite, silty, very finely crystalline, light grey; beds from 6 to 18 inches thick, laminated; weathers light grey; resistant	50	187
5	Dolomite, finely crystalline, medium grey; occurs in beds from 8 inches to 2 feet thick, partly brecciated; weathers medium grey; resistant	45	137
4	Covered interval	45	92

Unit		Thickness (feet)	Height above base (feet)
3	Dolomite breccia, finely crystalline, medium and light grey; poorly bedded, contains angular fragments from 4 to 6 inches maximum dimension; weathers light grey-brown; resistant.	12	47
2	Covered interval	35	35
	Wokkpash Formation		
1	Dolomite, sandy, light grey, finely crystalline; occurs in beds from 8 inches to 2 feet thick; weathers light grey-brown; moderately resistant		

Dunedin Formation
(58° 41′N, 124° 48′W)

TYPE SECTION

SECTION 4. Measured in and along the stream bed of One Ten Creek, which flows southwestward from Mount St. Paul and crosses the Alaska Highway at Mile 398. The strata are easily accessible. Black shales from the lower part of the Besa River Formation, visible from the highway, overlie the Dunedin Formation a short distance upstream.

Unit		Thickness (feet)	Height above base (feet)
	Besa River Formation (incomplete)		
35	Shale, soft and fissile, black; consists of alternating hard beds from 3 to 4 inches thick and soft recessive intervals from 1/2 to 1 inch thick; weathers orange and black	10	42
34	Shale, as above	10	32
33	Shale, soft and fissile, black; contains a few *Tentaculites* sp.	10	22
32	Shale, as above, a few *Tentaculites* sp.	12	12
	The Besa River Formation rests with a sharp and apparently conformable contact on the underlying Dunedin Formation		
	Dunedin Formation (781 feet)		
31	Limestone, siliceous and argillaceous, microcrystalline, dark grey-black; fossiliferous particularly on upper surface where many coral colonies were present, many remains of brachiopods, gastropods, and crinoids, *Spongophyllum* sp. A, *Favosites* sp. (GSC loc. 72887), scattered chert nodules occur at base of unit; beds weather light grey		
	Thin section: microcrystalline calcite with abundant broken remains of crinoids, ostracods, brachiopods, and algal stems, appreciable authigenic quartz and feldspar	6	781
30	Limestone, finely crystalline, medium brown-grey; contains scattered black chert nodules throughout; occurs in resistant beds from 1 foot to 2 feet thick; weathers light grey		
	Thin section: a fine-grained calcarenite with average grain size about 80 microns; extensive recrystallization appears to have reduced the apparent grain size and created an appearance of loose packing; many skeletal remains of ostracods and foraminifera *Parathurammina*? sp.	10	775
29	Limestone, argillaceous, in part siliceous, microcrystalline, dark grey to almost black; contains scattered black chert nodules, traces of broken shell fragments; occurs in resistant beds from 2 to 3 feet thick; weathers light grey		
	Thin section: original limestone texture almost completely obliterated by recrystallization; shell fragments and rock grains can be identified, abundant euhedral dolomite crystals	11	765

Unit		Thickness (feet)	Height above base (feet)
28	Limestone, argillaceous and siliceous, finely crystalline, dark grey, with small irregularly shaped black chert nodules; many poorly preserved remains of gastropods and brachiopods; cliff-forming beds 1 foot to 3 feet thick; weathers light grey Thin section: a medium-grained calcarenite of merged grains from 175 to 200 microns in diameter extensively silicified; many skeletal remains, mostly of ostracods and foraminifera *Parathurammina*? sp.	23	754
27	Limestone, argillaceous, in part dolomitic, microcrystalline, dark grey-black; with scattered gastropod and brachiopod remains. Thin section: extensive recrystallization has almost completely obliterated original textures; appears to have been a medium-grained calcarenite, skeletal remains of gastropods, brachiopods, ostracods, and foraminifera, *Parathurammina*? sp.	8	731
26	Limestone, argillaceous, dolomitic and slightly silty, finely crystalline, dark grey, with a few scattered skeletal remains; forms resistant beds from 1 foot to 2 feet thick; weathers light grey Thin section: a fine-grained calcarenite, average size of rounded grains about 100 microns; extensive recrystallization has left only ghosts of former grains; a few skeletal fragments of ostracods, brachiopods, and calcispheres.	14	723
25	Limestone, argillaceous and dolomitic, microcrystalline, dark grey, with some scattered chert nodules towards base of unit; interval partly covered Thin section: extensive recrystallization has almost completely obliterated original textures; appears to have been a medium calcarenite; contains many indeterminate fossil remains.	60	709
24	Limestone, argillaceous and dolomitic, microcrystalline, dark grey; traces of poorly preserved fossil remains; occurs in cliff-forming beds from 1 foot to 2 feet thick; weathers light grey	25	649
23	Limestone, argillaceous, dolomitic, and siliceous, microcrystalline, dark grey; traces of brachiopod remains; occurs in thin beds from 4 to 8 inches thick; recessive; weathers light grey Thin section: a medium-grained calcarenite of rounded grains of microcrystalline calcite, extensively recrystallized, scattered areas of microcrystalline calcite, a few thin shell fragments	37	624
22	Limestone, slightly dolomitic, a fine-grained calcarenite with many tabular fragments, medium grey; occurs in massive, resistant, grey weathering beds from 1 foot to 3 feet thick Thin section: a fine-grained calcarenite, average grain size about 150 microns; extensive recrystallization gives appearance of loose packing; a few fossil remains of ostracods, brachiopods, and *Amphipora*, many small spherical bodies, calcispheres?	22	587
21	Limestone, argillaceous and in part dolomitic, finely and microcrystalline, dark brown-grey; occurs in distinct resistant beds from 1 foot to 2 feet thick; weathers light grey Thin section: a medium-grained calcarenite with average grain diameters of about 200 microns; recrystallization has almost obliterated original textures; scattered patches of euhedral dolomite crystals, coral fragments and large shell fragments of brachiopods	10	565

Unit		Thickness (feet)	Height above base (feet)
20	Limestone, dolomitic and argillaceous, microcrystalline; dark grey; traces of brachiopod shells show on weathered surfaces; occurs in thin nodular beds; weathers light grey Thin section: fine- and medium-grained calcarenite with original textures obscured by recrystallization, traces of authigenic feldspar, patches of euhedral dolomite crystals, large gastropod shell fragments	11	555
19	Limestone, slightly argillaceous, a fine- to medium-grained calcarenite; traces of skeletal remains; forms a single resistant light grey weathering bed Thin section: a medium-grained calcarenite, average grain size about 200 microns, many indeterminate skeletal remains, fragments of ostracods, gastropods, and corals	2	544
18	Limestone, dolomitic and argillaceous, microcrystalline, medium brown-grey; traces of fossil remains on weathered surfaces; occurs in beds 2 to 3 feet thick; weathers light grey Thin sections: microcrystalline calcite, recrystallized to a relatively uniform mosaic with average crystal size about 200 microns; contains about 30 per cent shell fragments, mostly gastropods and brachiopods, a little authigenic feldspar	24	542
17	Limestone, argillaceous, microcrystalline, dark grey; weathers medium grey	26	518
16	Limestone, argillaceous, microcrystalline with irregularly shaped "eyes" and patches of sparry calcite; well-bedded; weathers medium grey Thin section: a medium-grained calcarenite, average grain size about 200 microns, numerous spherical and indeterminate 100- to 150-micron bodies with outlines masked by recrystallization	13	492
15	Limestone, slightly dolomitic and argillaceous, microcrystalline, dark grey-black; well-bedded; weathers light grey Thin section: microcrystalline calcite with many areas of 100-micron calcite grains; some finely comminuted skeletal debris; occasional areas of finely disseminated euhedral dolomite crystals, many calcispheres	6	479
14	Limestone, slightly dolomitic, microcrystalline, brown-grey, contains a few poorly preserved fossil fragments; occurs in resistant beds from 2 to 3 feet thick and in argillaceous, moderately recessive beds from 6 inches to 1 foot thick Thin section: microcrystalline calcite with granular and pelletted area, and many irregularly shaped "eyes" and patches of sparry calcite, high amplitude stylolitic structures, limonite cubes, vague traces of fossil remains.	30	473
13	Limestone, slightly argillaceous, microcrystalline, medium grey; massive beds; weathers light grey Thin section: a medium-grained calcarenite with average grain size about 250 microns, a few composite grains, extensively recrystallized, abundant skeletal remains, mostly whole ostracods and brachiopod shell fragments	25	443

Unit		Thickness (feet)	Height above base (feet)
12	Limestone, microcrystalline, in part calcarenitic, brown-grey; occurs in resistant beds from 2 to 3 feet thick; a few argillaceous and recessive limestone interbeds; a bed of conglomerate 2 feet thick occurs 25 feet below the top of the unit Thin section: a fine-grained calcarenite with average grain size about 140 microns, grains well sorted and little affected by recrystallization; calcispheres and foraminifera, *Parathurammina* sp.	45	418
11	Limestone, argillaceous, microcrystalline, dark grey; grades through progressively more argillaceous limestone to calcareous shale at base of unit; appears to rest with slight angular unconformity on unit 10 Thin section: microcrystalline calcite with abundant finely comminuted skeletal remains, mostly of ostracods and gastropods; scattered patches of euhedral dolomite crystals with relatively sharp dolomite-calcite boundary	30	373
10	Limestone, very dolomitic, finely crystalline, medium grey; forms massive beds from 1 foot to 3 feet thick, upper surface of unit slightly irregular Thin section: dolomite, composed of approximately 70 per cent dolomite and 30 per cent limestone both in form of 10- to 15-micron crystals, many irregularly shaped vugs with lining of euhedral dolomite crystals and infilling of sparry calcite	20	343
9	Limestone, slightly argillaceous, microcrystalline, in part calcarenitic, medium to dark grey; occurs in massive beds from 2 to 4 feet thick; weathers light grey Thin section: a fine-grained calcarenite of tightly packed merged grains from 150 to 200 microns in diameter.	35	323
8	Limestone, microcrystalline, medium brown-grey; dense massive beds; weather light grey Thin section: microcrystalline calcite with vaguely pelletted and granular areas, appreciable authigenic quartz and feldspar in small crystals, numerous "eyes" of sparry calcite, a few fossil remains of ostracods and calcispheres	30	288
7	Limestone, dolomitic and argillaceous, finely crystalline, brown-grey, contains large calcite- and barite-infilled vugs; becomes more argillaceous and recessive towards base; upper part of unit consists of light grey weathering beds from 1 foot to 3 feet thick Thin section: microcrystalline calcite with a little finely comminuted skeletal debris, about 50 per cent replaced by dolomite	34	258
6	Limestone, argillaceous, microcrystalline, dark grey, with thin zones of intraformational conglomerate Thin section: microcrystalline calcite with finely comminuted shell debris and whole ostracods; consists of about 45 per cent disseminated dolomite crystals, some large authigenic quartz crystals show replacement by dolomite and calcite.	70	224

Unit		Thickness (feet)	Height above base (feet)
5	Limestone, argillaceous and dolomitic, predominately medium-grained calcarenite, some microcrystalline areas; weathers light grey Thin section: a calcarenite composed of commonly silty composite grains up to 2 mm maximum apparent diameter; many large grains in stylolitic contact, scattered euhedral dolomite crystals occur along stylolite seams	35	154
4	Limestone, slightly silty and argillaceous; argillaceous and silty laminations conspicuous on weathered surfaces; occurs in thin beds from 2 to 4 inches thick with occasional interbeds of yellow-brown dolomitic and silty limestone	40	119
3	Limestone, microcrystalline, medium brown, with small irregular "eyes" and patches of sparry calcite; occurs in distinct beds, from 1 foot to 2 feet thick; weathers light grey Thin section: a fine-grained calcarenite with average grain size about 160 microns; many whole ostracods and coralline algae	36	79
2	Limestone, microcrystalline, medium grey-brown; occurs in uniform, resistant light grey weathering beds from 2 to 4 feet thick Thin section: a fine-grained calcarenite of merged and rounded grains about 100 microns in diameter in a cement of coarsely crystalline calcite, a few whole ostracod remains and brachiopod shell fragments	43	43
	The contact with the underlying Stone Formation is obscure but suggests an unconformable surface with approximately 6 feet of relief.		
	Stone Formation		
1	Dolomite, slightly argillaceous, finely crystalline, medium and light grey; dolomite breccia in upper part of unit with barite and fluorite filling interfragment areas; also brecciated in interval 10 to 20 feet below top of unit	75	75

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
1 within upper 15 feet	59°55'N 127°27'W *Coenites* sp. *Utaratuia* sp. *Schuchertella* sp. *Emanuella*? sp. *Warrénella* sp. *Spinatrypa*? sp. *Cyrtina*? sp. gastropod	70796
feet below top 57	59°55'N 127°27'W *Amphipora* sp. *Alveolites* sp. auloporid coral	70797
127	59°55'N 127°27'W *Amphipora* sp. *Coenites* sp. *Emanuella* sp. colonial coral	70798
177	59°55'N 127°27'W *Coenites*? sp. ambocoeliid	70799
265	59°55'N 127°27'W *Coenites* sp. *Favosites* sp. *Emanuella* sp. *Spinatrypa* sp. ostracod	70800
297	59°55'N 127°27'W stromatoporoid fragments	70804
2 in upper 12 feet	59°45'N 125°30'W *Amphipora* sp. *Utaratuia*? sp. cf. *Loxonema* sp. cf. *Philoxene* sp. cf. *Paracyclas* sp. *Schuchertella* cf. *S. adoceta* Crickmay *Emanuella* sp. stromatoporoid algae	70790

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia (*cont.*)

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
	59°45′N	
feet below top	125°30′W	
27	*Alveolites* sp.	
	Coenites sp.	
	Spinatrypa sp.	
	Emanuella? sp.	
	Warrenella sp.	
	auloporid	
	trilobite tail and head	70791
32	59°45′N	
	125°30′W	
	Utaratuia? sp.	
	stromatoporoid	70792
155	59°45′N	
	125°30′W	
	Emanuella sp.	
	trilobite tail	70793
200	59°45′N	
	125°30′W	
	Schuchertella cf. *S. adoceta* Crickmay	
	Emanuella meristoides (Meek)	
	Dechenella (*Dechenella*) sp.	72883
225	59°45′N	
	125°30′W	
	Emanuella? sp.	
	Warrenella sp.	
	Dechenella sp.	72884
240	59°45′N	
	125°30′W	
	Coenites sp.	
	Warrenella sp.	72885
290	59°45′N	
	125°30′W	
	Coenites? sp.	
	Carinatina? sp.	
	Spinatrypa sp.	
	Emanuella meristoides (Meek)	
	Warrenella? sp.	72886
580	59°45′N	
	125°30′W	
	Sieberella sp.	
	costate pentamerid	
	Schuchertella? sp.	
	Spinulicosta sp.	
	Warrenella n. sp.	
	leiorhynchid? impression	
	trilobite tail	

99394—5

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia (*cont.*)

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
	small echin. oss., single canal large echin. oss., single canal	70794
580	59°45′N 125°30′W echin. oss., double canal	70795
10	59°45′N 125°30′W *Coenites* cf. *C. rectilineatus* (Simpson) stromatoporoid	57323
140 to 155	59°45′N 125°30′W *Coenites* sp. *Alveolites* sp. stromatoporoid	57328
170	59°45′N 125°30′W *Coenites* cf. *C. rectilineatus* (Simpson)	57342
530	59°45′N 125°30′W *Spinatrypa* cf. *S. andersonensis* (Warren) *Warrenella* sp.	57353
540	59°45′N 125°30′W *Atrypa* sp. fragment *Spinatrypa borealis lata* (Warren) *Warrenella*? sp. echin. oss., double canal	57294
3 within upper 36 feet	59°43′N 125°31′W *Aulopora* sp. *Coenites* sp. *Syringopora* sp. *Spinatrypa* sp.	57335
4 feet below top 295	59°08′N 125°43′W *Emanuella*? sp. stromatoporoids	70788
315	59°08′N 125°43′W *Amphipora* sp.	70787
506	59°08′N 125°43′W auloporid gastropod traces	70785
540	59°08′N 125°43′W	

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia (*cont.*)

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
	cf. *Loxonema* sp. brachiopod fragments	70784
546	59°08′N 125°43′W *Coenites* sp. cup coral fragment	70786
620	59°08′N 125°43′W *Coenites* sp. algal? structures small smooth brachiopod	70783
5 45 feet above base	59°07′N 125°48′W *Coenites*? cf. *C.*? *rectilineatus* (Simpson) pentamerid? trace digitate stromatoporoids	70779
6 from isolated outcrop	59°07′N 125°44′W *Coenites* sp. *Syringopora* sp. *Warrenella* sp.	70789
7 in upper part of formation	59°05′N 125°38′W *Dendrostella*? sp.	70788
8 in upper 2 feet	58°53′N 125°35′W *Leiorhynchus castanea* (Meek) *Warrenella* sp. echin. oss., single canal	70777
top of formation	58°53′N 125°35′W spirally coiled gastropod	57346
feet below top 46	58°53′N 125°35′W *Coenites* cf. *C. rectilineatus* (Simpson) *Archimedes*? sp. *Ambocoelia* sp. colonial coral fragments loosely coiled gastropod	57341
96	58°53′N 125°35′W *Coenites* sp. *Coenites* cf. *C. rectilineatus* (Simpson) stromatoporoid	57340
147	58°53′N 125°35′W	

99394—5½

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia (*cont.*)

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
	Coenites sp. gastropods	57330
9 in upper part of formation	58°44′N 124°44′W *Emanuella* sp. stromatoporoid echin. oss., single canal	70482
10 feet below top 130	58°46′N 125°17′W *Warrenella* sp.	70802
435	58°46′N 125°17′W *Coenites* sp. brachiopod traces	70803
610	58°46′N 125°17′W *Coenites* sp.	71296
11 feet below top 90	58°44′N 124°44′W auloporid	70775
143	58°44′N 124°44′W *Coenites*? cf. *C.*? *rectilineatus* (Simpson)	70776
12 in upper 6 feet	58°41′N 124°48′W *Spongophyllum* sp. *Favosites* sp. cf. *Loxonema* sp. auloporid? echin. oss., single canal	72887
feet above base 736	58°41′N 124°48′W stromatoporoids	44285
706	58°41′N 124°48′W stromatoporoid coral fragments	44281
638	58°41′N 124°48′W *Lazutkinia*? sp. digitate stromatoporoid	44284
461	58°41′N 124°48′W *Thamnopora*? sp.	44283

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia (*cont.*)

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
208	58°41′N 124°48′W *Amphipora*-like markings	44280
13 near top of formation	58°38′N 124°58′W *Lazutkinia*? sp.	44282
near top of formation	58°38′N 124°58′W *Thamnopora* sp. *Favosites* sp. *Mastigospira* sp. *Hexagonaria* sp. A. *Favosites* sp. D. crinoid ossicles	44286
14 in upper 2 feet	58°33′N 124°32′W *Favosites* sp. cf. *Loxonema* sp. cf. *Philoxene* sp. *Paracyclas* sp. *Schuchertella* sp. digitate stromatoporoid cup coral trilobite tail small echin. oss., single canal large echin. oss., single canal	70481
15 from talus approximately 250 feet above base	58°32′N 124°56′W *Cyroptychius*? n. sp.	
16 in upper 5 feet	58°28′N 124°30′W *Alveolites* sp. *Coenites* sp. *Favosites* sp. cf. *Hexagonaria* sp. cf. *Syringopora* sp. *Paracyclas* sp. rugose productellid echin. oss., single canal	66024
17 196 feet above base	57°49′N 124°05′W *Moelleritia canadensis* Copeland coral harpid? fragments	65942
18 top 35 feet	57°33′N 125°04′W *Amphipora* sp.	

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia (*cont.*)

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
	Coenites sp. stromatoporoid	65943
feet below top 400	57°33′N 125°04′W stromatoporoid *Alveolites* sp. *Emanuella*? sp.	65944
405	57°33′N 125°04′W *Coenites* sp. cup coral colonial coral	65937
	57°33′N 125°04′W gastropod? traces	70782
19 250	57°30′N 124°57′W *Coenites* sp. small form *Coenites* sp. large form cf. *Briartina* sp.	65987
20 200 feet above base	57°28′N 123°55′W *Alveolites* sp. *Coenites* sp. cf. *Digonophyllum* sp. *Favosites* sp. *Utaratuia* sp. *Gypidula* sp. *Atrypa* sp. *Spinatrypa* sp. *Warrenella* sp. *Michelinoceras* sp. *Leptodesma* sp. auloporid proetid ostracods echin. oss., cross-like axial canal large echin. oss., irreg. axial canal large echin. oss., single axial canal	65991
21 feet above base 205	57°28′N 123°52′W *Coenites* sp. *Favosites* sp. *Syringopora*? sp. stromatoporoid cup coral fragment echin. oss., single axial canal	66018

Fossil occurrences in the Dunedin Formation, Northeastern British Columbia (*conc.*)

Field No. and Stratigraphy	Locality, Fauna, and Age	GSC Loc. No.
388	57°28'N 123°52'W *Favosites* sp. *Warrenella* sp. cf. *Hexagonaria* sp. colonial coral large echin. oss., single canal small echin. oss., single canal	66021
680	57°28'N 123°52'W *Amphipora* sp. *Coenites* sp. – small form coral fragment *Stringocephalus*? sp. -fragments	66020
22 at top of formation	57°24'N 123°50'W *Amphipora* sp. *Coenites* sp. *Stringocephalus* sp.	66019
23 at top of formation	57°12'N 123°43'W *Emanuella meristoides* (Meek)	66002
108 feet above base	57°12'N 123°43'W *Coenites*? sp. cf. *C.*? *rectilineatus* (Simpson)	66025
134 feet below top	57°12'N 123°43'W *Spinatrypa*? sp. *Emanuella meristoides* (Meek) echin. oss., single canal	66022
24 feet below top 30	57°03'N 123°49'W *Schizophoria* sp. *Warrenella* sp. cf. *W. kirki* (Merriam) *Hadrorhynchia sandersoni* (Warren) *Leiorhynchus castenea* (Meek) *Halloceras logani* (Meek) auloporid trilobite tail fragment echin. oss., single canal	66023

PLATE I. ILLUSTRATIONS OF STRATA IN DEVONIAN FORMATIONS

1. Unconformity between basal Stone dolomites and upper Wokkpash sandy dolomites; type section Wokkpash Formation.

2. Desiccation breccia in Munchŏ-McConnell Formation. The breccia consists of fine laminated dolomite in a matrix of structureless dolomite.

3. Type section of Muncho-McConnell Formation. The Formation is the lighter coloured dolomites overlying the type Nonda Formation. Contact between the two is placed at the low point on the skyline; about 2 miles northwest of Toad River bridge, Mile 438, Alaska Highway.

4. A solution breccia in the Stone Formation. The breccia consists of angular blocks of dolomite from a foot to 3 feet maximum dimension in a cement of white sparry calcite; part of a 39-foot thick breccia zone; about 4 miles east of Muncho Lake opposite Mile 461 on the Alaska Highway.

5. Cherty beds in the Dunedin Formation. The chert occurs as black nodules and lenses from 2 to 3 inches thick distributed parallel to the bedding; 120 feet below the top of the formation at the type section (Appendix I).

6. Typical bedded limestone of the Dunedin Formation at Wokkpash Creek about 15 miles southwest of Summit Lake, Mile 392 on the Alaska Highway; about 100 feet of strata can be seen in the photo.

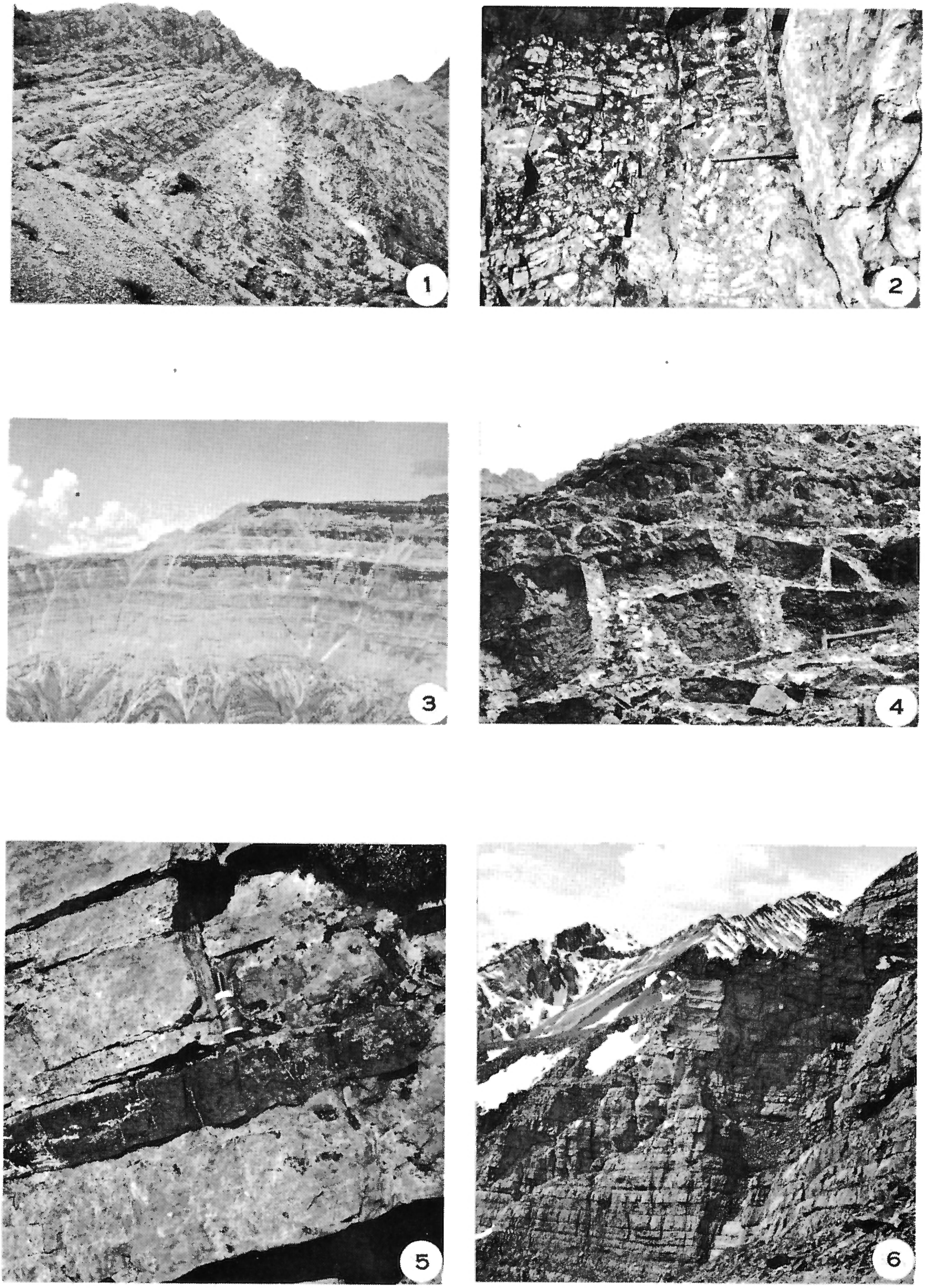

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PLATE II. TYPES OF GRAINS IN DEVONIAN FORMATIONS

1. Grapestone lumps in a medium-grained limestone. The lumps consist of small grains of microcrystalline calcite which form aggregates with characteristic lumpy and irregular shapes; from 545 feet below the top of the Dunedin Formation at Mount St. Paul.

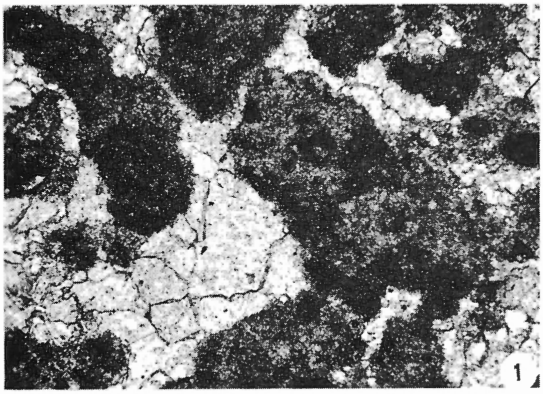
2. Coarsely granular limestone made up of composite grains, frequently tabular, up to 2.5 mm maximum dimension in a cement of coarsely crystalline calcite; from 12 feet below the top of the Dunedin Formation about 15 miles southwest of Summit Lake, Mile 392 on the Alaska Highway.

3. Rounded rimmed grains of microcrystalline calcite, probably pseudoliths, about 200 microns average diameter. Recrystallization has blurred the grain boundaries in many areas; from 194 feet below the top of the Dunedin Formation at Mount St. Paul.

4. A medium-grained limestone consisting of rounded and subrounded fragments of dense microcrystalline calcite in a cement of coarsely crystalline calcite; from 240 feet below the top of the Dunedin Formation about 15 miles southwest of Summit Lake, Mile 392 on the Alaska Highway.

5. Flattened grains in a medium-grained limestone; from 363 feet below the top of the Dunedin Formation at One Ten Creek.

6. Longitudinal section of a stromatoporoid from near the northern limit of the Dunedin Formation; recrystallization has obliterated much of the internal texture; from 320 feet below the top of the Formation in the Caribou Range.



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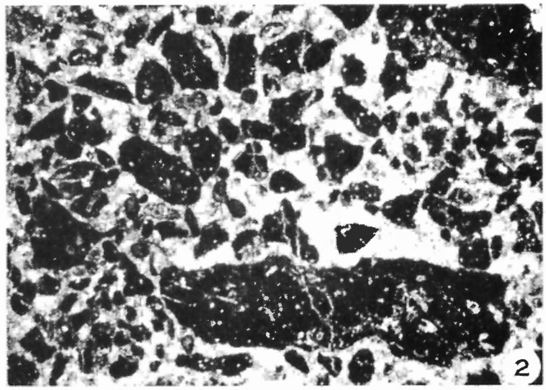

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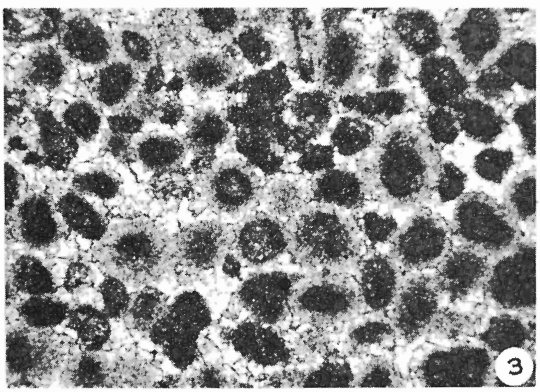

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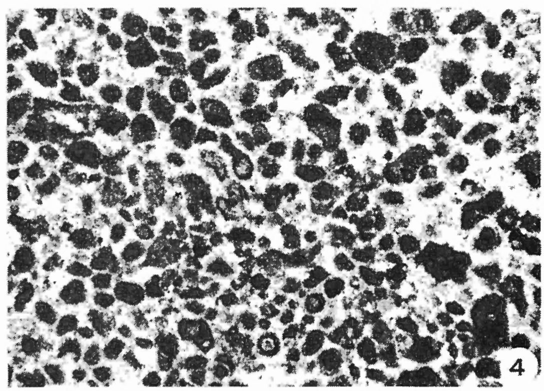

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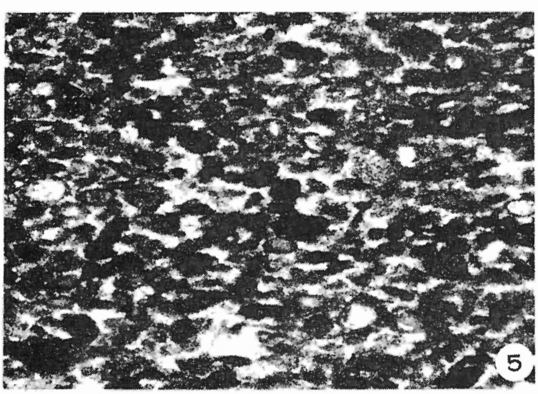

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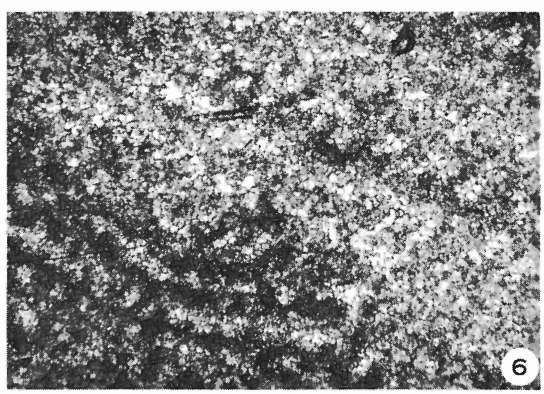

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PLATE III. FOSSILS AND FOSSIL FRAGMENTS OCCURRING IN THE DEVONIAN FORMATIONS

1. A pelecypod shell fragment showing presumed algal borings; the bored areas are represented by dark patches of microcrystalline calcite most conspicuous along the convex surface of the shell; from 30 feet below the top of the Dunedin Formation in the Caribou Range.

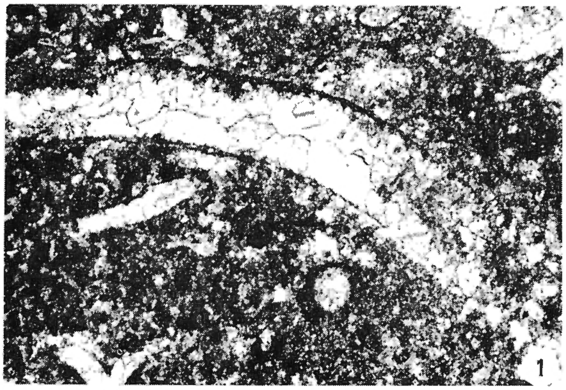
2. A vaguely granular biomicritic limestone with abundant ostracod shell fragments; from 95 feet below the top of the Dunedin Formation of Yash Creek about 8 miles south of Mile 422 on the Alaska Highway.

3. Parathuramminid foraminifers with conspicuous peripheral spines in medium-grained limestone; from 12 feet below the top of the Dunedin Formation about 15 miles southwest of Summit Lake, Mile 392 on the Alaska Highway.

4. Calcareous tubes with dark envelope of microcrystalline calcite and interior occupied by coarsely crystalline calcite; from 107 feet below the top of the Dunedin Formation about 15 miles southwest of Summit Lake, Mile 392 on the Alaska Highway.

5. Segmented tube, presumably of algal origin, in medium granular limestone; from 700 feet below the top of the Dunedin Formation at Mount St. Paul.

6. Detail of segmented algal tube showing cellular wall structure, bottom centre; from 310 feet below the top of the Dunedin Formation at Mount St. Paul.



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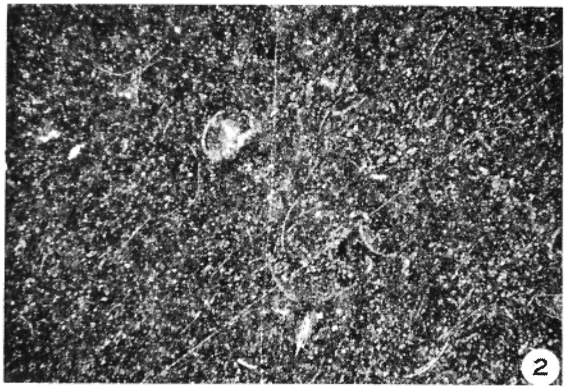

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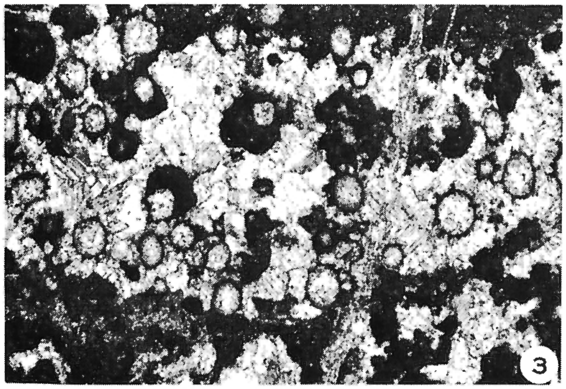

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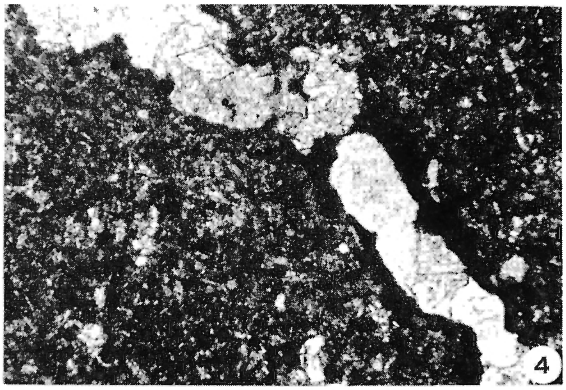

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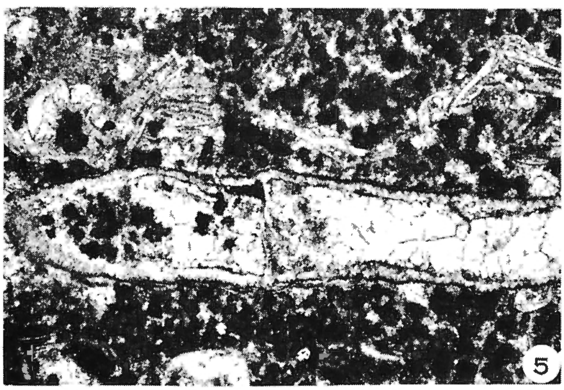

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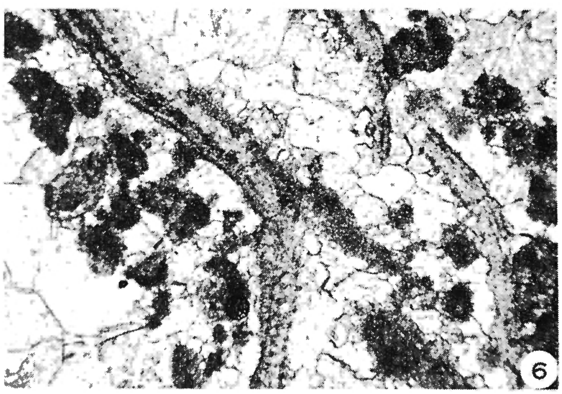

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