GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

This document was produced by scanning the original publication.

Ce document est le produit d'une numérisation par balayage de la publication originale.

BULLETIN 328

LOWER CRETACEOUS FORT ST. JOHN GROUP AND UPPER CRETACEOUS DUNVEGAN FORMATION OF THE FOOTHILLS AND PLAINS OF ALBERTA, BRITISH COLUMBIA, DISTRICT OF MACKENZIE AND YUKON TERRITORY

D.F. STOTT

Canada

1982

BULLETIN 328

LOWER CRETACEOUS FORT ST. JOHN GROUP AND UPPER CRETACEOUS DUNVEGAN FORMATION OF THE FOOTHILLS AND PLAINS OF ALBERTA, BRITISH COLUMBIA, DISTRICT OF MACKENZIE AND YUKON TERRITORY

D.F. STOTT

GEOLOGICAL INFORMATION
DIVISION

MAY
MAI 12 1982

DIVISION DE L'INFORMATION
GÉOLOGIQUE

1982

©Minister of Supply and Services Canada 1982

Available in Canada through

authorized bookstore agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Québec, Canada K1A 0S9

and from

Geological Survey of Canada
601 Booth Street
Ottawa, Canada K1A 0E8

A deposit copy of this publication is also available
for reference in public libraries across Canada

Cat. M42-328E Canada: $22.00
ISBN 0-660-11117-9 Other countries: $26.40

Price subject to change without notice

Critical Readers

J.H. Wall
C.R. Stelck

Scientific Editor

E.R.W. Neale

Technical Editor

L. Machan

Word Processing and Production

H. King
P. Greener

Artwork by CARTOGRAPHY UNIT
Institute of Sedimentary and
Petroleum Geology

Original manuscript submitted: 79-07-18

Approved for publication: 81-11-06

Preface

The Fort St. John Group, one of the oldest recognized stratigraphic intervals in western Canada, has gained recent importance because of its substantial coal and hydrocarbon resources. Regional stratigraphic studies carried out between 1957 and 1971 form the basis for this report in which the paleogeography of a major part of the Lower Cretaceous succession of western Canada is described. The results of numerous petrologic studies are presented, the application of studies in clay mineralogy to the solution of stratigraphic problems is summarized and the facies variations and depositional environments of the widespread assemblage of clastic marine rocks are outlined.

Coal-bearing deposits are delineated and data are provided which are applicable to potential hydrocarbon reservoir rocks in the Deep Basin to the southeast of the area studied.

This bulletin, together with bulletins 152 and 219 published some years ago, provide the geological information that is fundamental to further exploration of these rocks as part of the search for additional energy resources.

R.A. Price
Director General
Geological Survey of Canada

OTTAWA, February 1982

PLATE 1

Fort St. John, British Columbia, 1875. The name Fort St. John has been applied to several trading posts in the Peace River district since 1805. In 1823 the fort was burned by the Indians and the white inhabitants killed. Since the initial rebuilding in 1860 there have been a number of moves from one side to the other of the Peace River. At the time of Selwyn's visit the fort was located on the north bank of the river. (Photo by A.R.C. Selwyn, GSC 199625)

CONTENTS

CONTENTS (cont'd)

Illustrations

Illustrations (cont'd)

Tables

LOWER CRETACEOUS FORT ST. JOHN GROUP AND UPPER CRETACEOUS DUNVEGAN FORMATION OF THE FOOTHILLS AND PLAINS OF ALBERTA, BRITISH COLUMBIA, DISTRICT OF MACKENZIE AND YUKON TERRITORY

Abstract

The Lower Cretaceous Fort St. John Group and Upper Cretaceous Dunvegan Formation, exposed along the Foothills belt of the Rocky Mountains in northeastern British Columbia, occur also in the subsurface of the Plains, and extend into the Liard Plateau of the Yukon Territory and District of Mackenzie. Deposition, related to tectonism in the Columbian Orogen, was influenced by the Peace River Arch and Laramide trends. The rocks contain deposits of several major deltas and reveal a complex interrelationship of continental to marine sediments.

The succession in the Foothills ranges in thickness from about 4800 feet (1450 m) at Peace River to almost 7500 feet (2286 m) at Scatter River. It comprises four major sequences; each contains marine shale at the base which grades vertically upward into near-shore sandstone, and in the lowermost and uppermost sequences, into deltaic and alluvial deposits. The distribution of Cretaceous rocks is illustrated by a geological map at the scale of 1:500 000. In addition, a series of columnar stratigraphic cross-sections outline complex facies relationships of the numerous lithologic units, both along the outcrop belt and also across the basin, relating surface exposures to the subsurface succession as encountered in boreholes. Descriptions of outcrop sections and contained fauna are included in the Appendix.

Basal marine shales of the Fort St. John Group, included in the Moosebar, Buckinghorse, and Garbutt Formations and lying mainly within the Early Albian **Arcthoplites** Zone, are overlain by sandstones of the Gates Formation and the Bulwell Member (new) of the Scatter Formation. Gates strata, overlying Hulcross shales and Boulder Creek sandstones and conglomerates, formerly included in the Commotion Formation, are given formational status. Shales, extending upward in the Middle Albian Zone of **Pseudopulchellia pattoni** are assigned to the Hulcross Formation, lower middle Buckinghorse Formation and the Wildhorn Member (new) of the Scatter Formation. Marine sandstone included in the basal Boulder Creek Formation, the Cadotte Member, and the upper or Tussock Member (new) of the Scatter Formation lie within the **Gastroplites** Zone. Younger marine shale, included in the Hasler, middle Buckinghorse and Lepine Formations and lying within the Late Albian **Stelckiceras liardense** Zone, grades upward into epineritic Goodrich and Sikanni sandstones, deposited during the Late Albian **Neogastroplites** Zone. The Cruiser and Sully Formations, of Albian to Cenomanian age, grade transitionally upward into the Cenomanian (earliest Late Cretaceous) Dunvegan Formation.

The coarse clastic sediments of the Dunvegan Formation indicate the widespread development of alluvial deltaic conditions before the time of **Dunveganoceras** (Late Cenomanian). The formation, about 600 feet (182 m) thick at Liard River, grades laterally southeastward from conglomerate and carbonaceous sandstone into siltstone, which in turn grades into marine shale.

Substantial coal resources are known from the Gates Formation south of Pine River. Seams, as much as 30 feet (10 m) thick, occur and the coal is of coking quality. In addition, large volumes of natural gas have been recently discovered in the Cretaceous conglomerates and sandstones in the southern Peace River Plains to the east of the Foothills.

Résumé

Le groupe de Fort St. John du Crétacé inférieur et la formation de Dunvegan du Crétacé supérieur affleurent le long de la totalité des Foothills des montagnes Rocheuses dans le nord-ouest de la Colombia-Britannique. On les retrouve aussi en position de subsurface dans les plaines et se prolongent sur le plateau de la Liard du territoire du Yukon et du district de Mackenzie. La sédimentation en relation avec la tectonique de l'orogenèse du Colombien a été influencée par les orientations structurales de l'arche de Peace River et l'orogenèse du Laramide. Les roches contiennent des sédiments de plusieurs grands deltas et montrent une association complexe de sédiments marins et de sédiments continentaux.

La succession dans les Foothills accuse une épaisseur de 4800 pieds (1450 m) à rivière Peace et atteint presque 7500 pieds (2286 m) à rivière Scatter; elle comprend quatre séquences principales, chacune contient des schistes argileux marins à la base, qui passent verticalement vers le haut à des grès littoraux et dans les séquences inférieure et supérieure, à des sédiments deltaïques et alluviaux.

Une carte géologique au 1/500 000 montre la distribution des roches crétacées de la région. De plus, une série de coupes stratigraphiques columnaires montre les relations complexes entre le faciès de plusieurs unités lithologiques le long de la zone d'affleurement et la succession en subsurface rencontrée dans les forages. Les coupes faites dans les affleurements et la faune qu'ils contiennent sont décrites dans l'annexe.

Les schistes argileux marins de base du groupe de Fort St. John, faisant partie à des formations de Moosebar, Buckinghorse et Garbutt et appartenant principalement à la zone à **Arcthoplites** de l'Albien inférieur sont recouverts par les grès de la formation de Gates et du niveau (nouveau) de Bulwell de la formation de Scatter. Les couches de Gates, les schistes argileux sus-jacents de Hulcross, et les grès et les conglomérats de Boulder Creek, antérieurement placés dans la formation de Commotion, sont maintenant classés comme de nouvelles formations.

Les schistes argileux qui s'étendent vers le haut dans l'Albien moyen, zone à **Pseudopulchellia pattoni**, sont attribués à la formation de Hulcross, à la partie moyenne inférieure de la formation de Buckinghorse et au niveau (nouveau) de Wildhorn de la formation de Scatter. Les grès marins faisant partie à la base de la formation de Boulder Creek, au niveau de Cadotte et du niveau de Tussock (nouveau) qui constitue la partie supérieur de la formation de Scatter de la zone à **Gastroplites.**

Des schistes argileux marins plus jeunes des formations de Hasler, Buckinghorse moyen et de Lépine et se retrouvant dans la zone à **Stelckiceras liardense** de l'Albien supérieur passent progressivement vers le haut à des grès épineritiques de Goodrich et de Sikanni qui se sont déposés dans la zone à **Neogastroplites** de l'Albien supérieur.

Les sédiments grossiers clastiques de la formation de Dunvegan indiquent le très grand développement des conditions deltaïques, alluviales, avant le temps des **Dunveganoceras** (Cénomanien supérieur). Cette formation, de 600 pieds (182 m d'épaisseur environ à la rivière Liard, passe latéralement vers le sud-est des conglomérats et des grès charbonneux à des siltstones qui, à leur tour, passent à des schistes argileux marins.

On connaît des gisements importants de charbon dans la formation de Gates au sud de la rivière Pine. On trouve des veines de l'ordre de 30 pieds (10 m) d'épaisseur et le charbon semble être de qualité cokéfiable. De plus, on a découvert récemment de grands volumes de gaz naturel dans des conglomérats et des grès du Crétacé dans les plaines du sud de la rivière Peace à l'est des Foothills.

LOWER CRETACEOUS FORT ST. JOHN GROUP AND UPPER CRETACEOUS DUNVEGAN FORMATION OF THE FOOTHILLS AND PLAINS OF ALBERTA, BRITISH COLUMBIA, DISTRICT OF MACKENZIE AND YUKON TERRITORY

INTRODUCTION

Cretaceous clastic marine rocks included in the Fort St. John Group and Dunvegan Formation are exposed along the entire Foothills belt of the Rocky Mountain system within northeastern British Columbia (Fig. 1). They occur also in the subsurface of the Plains and are continuous with beds that underlie the Liard Plateau of the Yukon and Northwest Territories. These rocks include the deposits of several major deltas and the interrelationships of the various facies have an important bearing on the exploration for and exploitation of petroleum, natural gas, and coal resources.

This report is a synthesis of a series of regional stratigraphic studies undertaken as separate projects between 1957 and 1971 that extended along the Foothills from Smoky River (Latitude 54°N) to Mackenzie River (Latitude 62°N). The Fort St. John Group in the most northerly and southerly regions was described previously. As a result, this report gives major emphasis to the succession occurring between Sikanni Chief River (Latitude 57°N) in the south and Scatter River (Latitude 60°N) in the north. It provides information on major facies variations and distribution of continental to marine environments along the western margin of an extensive marine embayment that existed during latest Neocomian to Cenomanian time.

This discussion reviews the history of nomenclature and geological investigations in the region, outlines the variations in thickness, the relationships to regional unconformities, fossil content, age and correlation. Petrologic studies provide criteria for an interpretation of the origin and history of the sediments. A summary of a major investigation of the clay mineralogy of the shales provides a unique example of the application of clay studies to stratigraphic problems. Finally, the paleogeography, depositional environments, and tectonic influences are discussed.

This report deals mainly with rocks that were examined in outcrop sections[1] but supplementary studies were made of mechanical logs, samples, and cores of boreholes in the adjacent Plains region. Forty-two sections are described in the Appendix but altogether more than eighty sections were measured and sampled and many outcrop localities were examined. The records of approximately one hundred and fifty boreholes were examined also. The locations of outcrop sections and wells used in cross-sections are shown in Figure 2.

All measurements of outcrop sections were in feet and subsequently converted to metres. As a result, totals indicated in the section descriptions are accurate only for measurement in feet. Totals in metres may not be accurate.

Accessibility

Two major highways provide the main access to the region. The eastern and northern parts of the region are most easily reached from the Alaska Highway which extends 1500 miles (2414 km) from Mile 0 at Dawson Creek in the south to Fairbanks, Alaska. The Alaska Highway is paved to Mile 82 north of Fort St. John, and, in part, near Fort Nelson, and elsewhere is a well maintained gravel road. The John Hart Highway, which joins the Alaska Highway at Dawson Creek, is paved and crosses the foothills and mountains by way of Pine Pass, giving access to the southern part of the region.

In the south, a paved highway branches northward from the John Hart Highway at Chetwynd, crosses Peace River at Hudson Hope and joins the Alaska Highway north of Fort St. John. The road provides access to the type sections of the Fort St. John Group that lie between Peace River canyon and The Gates on Peace River.

Several poorly maintained roads and seismic trails extend westward from the Alaska Highway between Fort St. John and Fort Nelson. Of these, the roads in the vicinity of Graham and Halfway Rivers are passable by light trucks in dry weather. The type sections along Sikanni Chief and Buckinghorse Rivers may be reached on foot from the highway although travel along the river bank is difficult.

Most of the localities in the Foothills and north of the highway between Fort Nelson and Muncho Lake were reached by means of helicopter transport. Base camps were located at Pink Mountain, Trutch, Redfern and Tuchodi Lakes, Mile 375 and Muncho Lake on the Alaska Highway, and in earlier work, at Fort Liard.

Liard River between Toad and Fort Nelson Rivers is navigable by river-boat. High water at flood stage interferes with boat travel and also prevents helicopter landings along the shore.

Dawson Creek, Fort St. John, and Fort Nelson are scheduled stops for regular commercial air lines and charter services of small fixed wing planes and helicopters are available at each airport. A line of the Pacific Great Eastern Railway connects Prince George, Fort St. John and Fort Nelson. A branch line joins the Northern Alberta Railway at Dawson Creek.

Regional setting

The Fort St. John Group and Dunvegan Formation are widely distributed in northeastern British Columbia, extending eastward from the Foothills across the Plains (Fig. 2). The group was examined in the foothills, mountains, and immediately adjacent plains between Smoky and Mackenzie Rivers, at Latitudes 54°N and 62°N respectively. The region of the current report extends from Peace River to Liard Plateau, more than 350 miles (563 km), and varies in width from 10 to 100 miles (16-160 km). The total area examined covers more than 30,000 square miles.

The sediments of the Fort St. John Group were deposited originally in a vast embayment that extended from the Arctic region across the present northern Plains region into the central part of the continent to join eventually with a southern embayment extending from the Gulf of Mexico.

[1] Outcrop sections are described in Appendix.

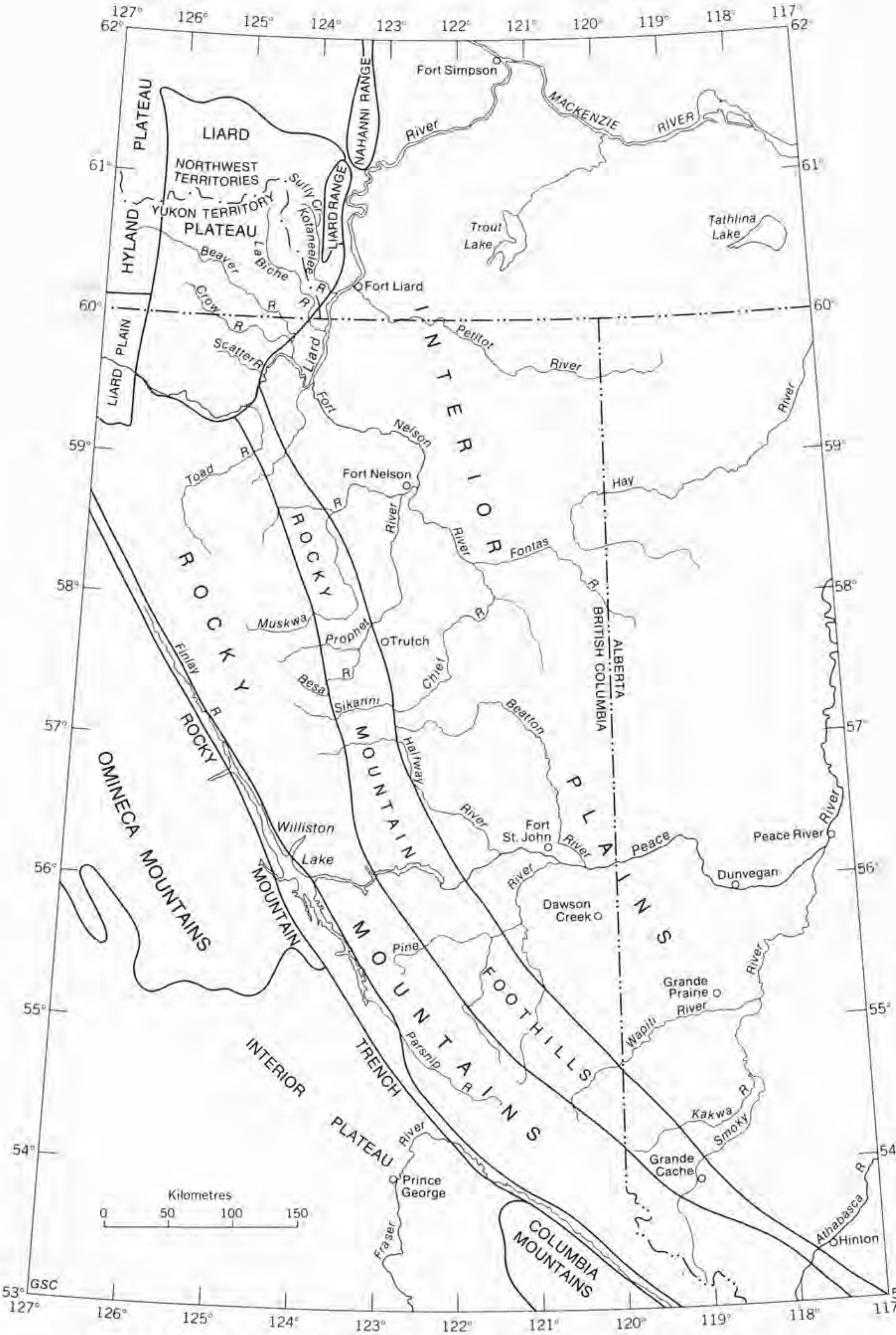


FIGURE 1. *Index map showing location of main geographic features and physiographic divisions, northeastern British Columbia.*

The area of study lies near the western margin of the embayment. The western limit of Cretaceous exposures is sharply defined by major faults of the Rocky Mountain System (Fig. 1), and the westernmost margin of the basin is not preserved. The eastern margin of Cretaceous exposures, flanking the Precambrian Shield but some distance removed from it, is erosional.

The region includes part of the Interior Plains, the Foothills of the Canadian Cordillera, and Liard Plateau (Bostock, 1946, 1970; Holland, 1964). The Plains are underlain by nearly flat-lying shales of Early Cretaceous age. The Foothills belt, as much as 50 miles (80 km) wide, is underlain by gently folded Cretaceous rocks in the east and by faulted and folded older Mesozoic and Paleozoic formations in the west. The Liard Plateau comprises several linear ridges, with Paleozoic rocks in their core, which are flanked by broad areas underlain by Cretaceous sediments.

The Plains region is relatively flat to gently undulating and drains northeastward. Much of the country is low-lying, covered by muskeg and small lakes or by dense forest. The Peace River east of the Foothills is incised to about 1600 feet (488 m) above sea level whereas the Fort Nelson River in the north is only about 1000 feet (304 m) above sea level. Prominent west-facing cuestas, including Halfway, Sikanni, Trutch, Muskwa, Dunedin, and Liard escarpments and Tsoo Tablelands mark the western boundary of the Plains. The elevations of these scarps approach 4000 feet (1219 m) but decrease eastward to about 3000 feet (914 m) or less. The country east of the escarpments has a plateau-like appearance, is essentially free of glacial deposits, and generally is heavily forested. The scarps have developed on the resistant Sikanni sandstone with the recessive slopes and low-lying region to the west being formed by Buckinghorse and equivalent shales. Well-developed mesas on the plateau areas to the east have formed as a result of erosion of the capping Dunvegan conglomerate and underlying Sully shales. The Trutch escarpment, occurring in the Fort Nelson map-area, merges with the Fort Nelson Lowland southwest of Klua Creek. Many of the streams head east of the escarpment but several large rivers, including the Sikanni Chief, Buckinghorse, Prophet, and Muskwa, have been incised and cut across the main escarpments. Major streams lie at the base of and parallel to the escarpment; the Halfway River drains southeastward into Peace River whereas the Prophet, Muskwa and Dunedin are part of the Liard drainage, which in turn is part of the Mackenzie River drainage system that flows northward into the Arctic Ocean. Much of the region is forested except for some farming land south of Fort St. John. Bedrock is exposed intermittently in the valleys of Prophet, Muskwa, and Fort Nelson Rivers but more continuous exposures occur in the escarpments and as rimrock of the cuestas and mesas.

The topography of the Foothills mainly reflects the structure of the underlying bedrock. The eastern part consists of low, rolling hills and low-lying swampy terrain underlain chiefly by Cretaceous shales. Exposures are generally confined to the eastward flowing streams that cross the structural grain. Farther west, many anticlinal hills are stripped surfaces of pre-Fort St. John rocks and softer Cretaceous shales tend to be preserved only in the synclinal valleys. The western Foothills have a relief of 3000 feet (914 m) and include Triassic, Jurassic, and Cretaceous strata. The eastern Foothills are more subdued with the exception of Pink Mountain.

The Liard Plateau, the southern part of the Mackenzie Mountains area, extends into British Columbia from the Yukon and is bordered on the west by Liard Plain and on the east by the Plains. Its southern border is Liard River. It is a region of broad hills and wide valleys; the hills are as much as 4500 feet (1372 m) above sea level and the valley floors are as low as 1500 feet (457 m) above sea level. The eastern border of the plateau is formed by north trending ranges, including Liard, Kotaneelee and La Biche Ranges that have an en échelon arrangement. These ranges have elevations of 5000 to 6000 feet (1524-1829 m). Paleozoic rocks exposed in the cores of the higher ranges are flanked by Triassic and Cretaceous shales and sandstones which are exposed in the river valleys. The higher hills and mountains are well above tree-line but much of the intervening region is heavily wooded. Exposures of bedrock are good along the canyons of Beaver, Crow, La Biche and Kotaneelee Rivers but are sporadic elsewhere.

Continental ice-sheets covered the eastern Plains area during Pleistocene time but had little effect on the underlying bedrock. Glacial deposits are thin or entirely absent in the higher plateau areas but are thick on the adjacent lowlands and in the major valleys.

Field work and acknowledgments

Cretaceous rocks in the vicinity of Mackenzie and Liard Rivers were examined during the field season of 1957 as part of Operation Mackenzie, under the general direction of R.J.W. Douglas. From 1958 to 1960, Lower Cretaceous rocks were studied in the region south of Peace River. Subsequently, detailed reports based on those studies were published (Stott, 1960a, 1960b, 1968a), outlining the Fort St. John Group at the southern and northern limits of this study.

Studies north of Peace River began in 1961 and continued in 1962 in conjuction with studies by B.R. Pelletier of Triassic stratigraphy in Halfway River (94B) and Trutch (94G) map-areas. Field investigations of the Cretaceous succession in the vicinity of Muskwa and Tetsa Rivers were initiated in 1964 and extended during 1965 into the region of Scatter and Liard Rivers. During those last two years, the study was integrated with Operation Liard, a regional mapping project directed by G.C. Taylor in the mountains, foothills and adjacent Plains between latitudes 57°N and 60°N and longitudes 122°W and 126°W. Sections near Peace River were revisited and new localities were examined for short periods during field seasons from 1968 to 1971, providing additional data for establishing relationships between the type region and more northerly areas.

Triassic fauna were identified and dated by E.T. Tozer; Jurassic macrofauna by Hans Frebold; Cretaceous microfauna by J.H. Wall; Cretaceous microflora by D.G. McGregor; Cretaceous megafauna by J.A. Jeletzky; and Cretaceous megaflora by W.A. Bell and D.C. McGregor.

Helicopter transportation was used for most of the studies except for a brief time in 1961 when packhorses were used. The writer gratefully acknowledges the services provided by Okanagan Helicopters, Foothills Aviation Limited, Bullock Wings and Rotors Limited, and Alpine Helicopters Limited. Pilots included R. Burton, F. Nobels, J. Davies, H. Tetz, G. Causs, D. Roadhouse, and C. Watanabe, and Engineers, E. Haylock, K. Harding, J. Warden, M. Brown, P. Ettinger, and S. Chivers.

Logistics of the operation in 1962 were the responsibility of B.R. Pelletier, and in 1964, 1965, 1968 and 1969 of G.C. Taylor.

Assistance in the field was given in 1961 by M.L. Larson; in 1962, by A.R. Clark and M.J. Osatenko; in 1964, by R. Armstrong, M. Wooding, D. Hetherington, and D. McDougall; in 1965, by D. Herron; in 1968, by J. Irish, E. Thorsteinsson, D. Dutton, R. Peterson; in 1969, by J. Irish,

P. Lord, J. Craig; in 1970, by J. Irish, D. Jamieson, P. Latour; and in 1971, by J. Ross. The writer is indebted to W. Boring, R. Cameron, O. Gauthier, A. Lamont, D. McDougall, R.L. Ross, I. Severson, S. McWhinnie, M. Lawrence and D. Turner, all of whom assisted in camp operations.

The writer is indebted to the following persons[1] and companies for release of information concerning coal occurrences; G.R. Wallis, Clifford McElroy and Associates Pty., Limited, and Brameda Resources Limited; A.A. Johnson, Denison Mines Limited; M.S. Cholach, Consolidation Coal Company of Canada; D.L. McKelvie, McIntyre Porcupine Mines Limited; D. Fullerton, Utah Mines Limited; C. Carew McFall; and P. Dyson.

The writer is grateful for the laboratory assistance provided by J.C. Beauvilain and Miss D. Moncrieff. R.I. Thompson and G.K. Williams who have investigated the Cretaceous succession in parts of this and adjoining areas, were particularly helpful in reviewing the regional relationships and providing constructive criticism. The writer also thanks J.A. Jeletzky and the critical readers, C.R. Stelck and J.H. Wall, for their many suggestions and comments.

HISTORICAL REVIEW

The first geological investigation of rocks now assigned to the Fort St. John Group was made during the exploration in 1875 of the Peace River region by A.R.C. Selwyn (1877) who was accompanied by John Macoun and Arthur Webster. Selwyn descended Peace River and arrived at Fort St. John (Plate 1). While there, he "examined the cliffs about a mile below the post and found numerous fossils: inoceramus, large ammonites and other Cretaceous forms". After a side trip up the Pine River, Selwyn continued to travel downstream on Peace River to the mouth of Smoky River. On his return journey, while supplies were portaged around Peace River canyon, Selwyn examined the shales in the vicinity of Hudson Hope, and gave the first comprehensive statement describing the occurrence of Cretaceous shales in that region.

In 1879, G.M. Dawson (1881) of the Geological Survey of Canada, accompanied by R.G. McConnell, travelled from the Pacific Coast to Edmonton, crossing the Rocky Mountains by way of Pine Pass. They continued eastward to Fort Dunvegan (Plate 35) on Peace River and spent some time examining the country south to Wapiti and Smoky Rivers, and also north beyond Peace River. Although Dawson provided little new information to supplement that contained in Selwyn's report, he did establish a stratigraphic succession for the region and applied names to the various subdivisions, all of which are still being used (Fig. 4).

The northern part of the region was explored geologically first by R.G. McConnell (1890) who entered it in 1887 via Stikine and Dease Rivers and descended Liard River to its junction with Mackenzie River. McConnell recognized the Cretaceous succession and briefly described its lithology and outlined its distribution. The Liard River had been used by the Hudson Bay Company as a trading route to the Yukon and a series of posts had been built between Fort Simpson on Mackenzie River and Fort Selkirk at the junction of Lewes and Pelly Rivers. McConnell (1890) reported that most posts had been abandoned before he entered the country. The route had been used also by prospectors and, according to McConnell, the discoverers of the Cassiar goldfield, McCullough and Thibert, followed the Liard River from Fort Simpson to the mouth of Dease River in 1871-1872. According to McConnell (1890, p. 52D):

> *In 1872-73 a party of miners crossed from Peace River to the Liard . . . They descended Peace River to Halfway River . . . and ascended the latter . . . for a hundred miles. They then made a portage of twenty-five miles, and reached the Nelson[2] . . . (They) described the river as following for a long distance above Fort Nelson, between lofty banks of sandstone and shale.*

Wm. Ogilvie (1893) provided the first description of the country between Fort Nelson and Fort St. John. In 1891, after making a micrometer survey for the Department of the Interior in the vicinity of Slave and Mackenzie Rivers, Ogilvie travelled southward from Fort Providence on Mackenzie River to Fort St. John on Peace River. He canoed up the Liard and Fort Nelson Rivers to the settlement of Fort Nelson. From there he continued southward via the Fort Nelson and Sikanni Chief Rivers. Although the usual Indian portage to Peace River started near the lower falls on Sikanni Chief River and continued by way of Lily Lake, Elbow Creek, and Halfway River, Ogilvie left the valley of Sikanni Chief River before reaching the falls. He travelled on foot through country that now lies east of the Alaska Highway, crossed the headwaters of Beatton River ("Pine River of the North") and apparently followed the valley of Aitken Creek to Blueberry River, continued southward along Stoddart Creek to Charlie Lake, and finally arrived at the post of St. John on Peace River.

In 1917, F.H. McLearn, of the Geological Survey of Canada, examined rocks along Peace River from above the canyon down to Vermilion, and reported (1918) on the discovery of oil below the town of Peace River. In 1922, he made detailed measurements of the coal succession in the main Peace River Canyon and its tributary canyons, and named and described several Cretaceous formations (1923).

Camsell and Malcolm (1921) described the Mackenzie River basin, summarizing previous geological reports. Their comments on the Peace and Liard Rivers drainage areas were largely based on work by Dawson, McConnell, Ogilvie, and McLearn. Their map showed Cretaceous beds along Sikanni Chief and Fort Nelson Rivers and Triassic and Cretaceous rocks extending up Liard River almost to Smith River.

For many years, the region between Peace and Liard Rivers remained relatively inaccessible and poorly known geologically. In 1922, G.S. Hume and M.Y. Williams travelled by packtrain from Fort St. John to Sikanni Chief River and then canoed down the Fort Nelson and Liard Rivers to Fort Simpson on the Mackenzie River. Williams (1923) described the geology between Fort St. John and the junction of Fort Nelson and Liard Rivers. Hume (1923) briefly mentioned Cretaceous outcrops in the region downstream from the junction.

Much of the later investigation of Cretaceous stratigraphy in this region dates from the time of the Second World War when additional petroleum reserves were required and the country became more accessible with the building of the Alaska Highway. A preliminary road between Fort St. John and Fort Nelson, started as part of the Northwest Staging Route in 1939, was completed as the Alaska Highway between 1942 and 1944 by the American Corps of Engineers.

---

[1]The persons listed were employed by the company indicated at the time the information was provided.

[2]Presumably the Sikanni Chief River which is one of the major tributaries of Fort Nelson River.

Geological surveys of the adjoining regions began in 1943. C.O. Hage (1944), working in the region between Fort St. John and Fort Nelson, extended his investigations into the Foothills as far west as Pink Mountain. The country bordering the highway between Fort Nelson and Watson Lake was mapped by M.Y. Williams (1944). E.D. Kindle (1944) descended Fort Nelson River by canoe from Fort Nelson and then travelled upstream on Liard River for 85 miles (136.8 km) to Hell Gate and also made a 40 mile (64.4 km) traverse along Beaver River. He outlined a new Cretaceous succession, defined several new formations and mapped their distribution (Fig. 4). In the following year, 1944, C.O. Hage (1945) extended the general investigations farther north, travelling down the Liard River from Fort Nelson to South Nahanni and examining many of the tributaries and much of the adjacent region. F.H. McLearn, who had been involved from 1917 in Cretaceous studies along Peace River, had by this time started his Triassic studies and visited localities in the vicinity of Sikanni Chief and Tetsa Rivers.

The results of all these early investigations were compiled in a comprehensive report by McLearn and Kindle (1950). McLearn, who was responsible for the chapters on stratigraphy, structure, and historical geology, provided a remarkable synthesis and interpretation of Cretaceous rocks that is essentially still valid.

J.B. Webb (1951, 1954, 1964) summarized the geological history of the Canadian Plains, very briefly outlining the distribution and facies of the Lower Cretaceous series.

W.R.S. Henderson (1954) described in some detail Cretaceous beds in the vicinity of Tetsa and Sikanni Chief Rivers.

In 1957, as a result of a reconnaissance mapping project, Operation Mackenzie under the direction of R.J.W. Douglas, a large area within the District of Mackenzie and Yukon was investigated. The writer participated in both mapping and detailed studies of Cretaceous stratigraphy, and some of the results are incorporated in this report. Maps pertaining to these Cretaceous studies include Great Slave and Trout River map-areas (Douglas, 1959, 1974), Fort Liard and La Biche map-area, (Douglas and Norris, 1959; Douglas, 1976a, b).

The geological mapping of the region north of Peace River is being completed only now. Charlie Lake map-area was mapped by E.J.W. Irish (1958) during the field seasons of 1956 and 1957, and Halfway River map-area, also by Irish (1970), from 1959 to 1962. B.R. Pelletier and D.F. Stott (1963), involved in detailed stratigraphic studies of Triassic and Cretaceous rocks respectively, published a preliminary map of Trutch map-area (see also Taylor, 1979). In 1963, G.C. Taylor initiated a major mapping project, Operation Liard, to complete the mapping of the mountains and Foothills of northeastern British Columbia. Maps published to date include Maxhamish Lake (Taylor and Stott, 1973), and Toad river (94N) (Taylor and Stott, 1980). In 1974, R.I. Thompson completed three map-sheets along the British Columbia-Alberta border. These, designated Beatton River, Fontas River and Petitot River, were published in 1977.

Paleontological studies of Early Cretaceous fossils were made in conjunction with most field investigations. Whiteaves (1885, 1893) reported on fossil collections made by Selwyn, Dawson, and McConnell. Many reports on the distribution, composition and zonation of Cretaceous fauna were given by McLearn (1919a, 1921, 1931, 1933, 1944a, 1944c, 1945). Other discussions of macrofauna include those of Warren and Stelck (1958b) and Reeside and Cobban (1960). Stelck et al. (1956) and Caldwell et al. (1978) summarized the microfossil and megafossil zonation. More recently, J.A. Jeletzky (1964, 1968, 1971a, b, 1980) has presented a series of reports, many of which are pertinent to the distribution, composition, and zonation of the Fort St. John fossils.

Subsurface studies of Lower Cretaceous rocks in northeastern British Columbia have provided a general framework for the succession. One of the earliest reports was by Allan and Stelck (1940). The report of the Alberta Study Group (1954), chaired by L. Workman, is the basis for subsurface Cretaceous stratigraphy south of Peace River. A preliminary report on Lower Cretaceous rocks in northern Alberta was given by Badgley (1952). R.A. Rudkin (1964) summarized the stratigraphy of Lower Cretaceous rocks in western Canada, presenting a synthesis of the current knowledge of the succession in northwestern British Columbia. L.L. Price (1963) presented a structural contour map of the Fish Scale marker horizon in Lower Cretaceous rocks of northeastern British Columbia and adjoining Alberta and Northwest Territories.

A more current report by G.K. Williams (1978) on Cretaceous rocks in the southern District of Mackenzie outlines facies distribution and correlations, and provides information on pre-Cretaceous geography and thickness of various units.

STRATIGRAPHY

Fort St. John Group

The Fort St. John Group was originally named by G.M. Dawson (1881) for the trading post on Peace River (Plate 1). In it, he included those marine shales occurring downstream from Hudson Hope on Peace River and lying between the Dunvegan Formation and the sandstone now included in the Gates Formation (Plate 2). Dawson was not aware that older marine shales occurred farther west, as he had not travelled as far upstream as Hudson Hope. The Cretaceous rocks along Peace River were originally described by Selwyn (1877, p. 72);

> *...They consist of dark earthy shales, in parts characterized by numerous bands and septarian nodules of clay ironstone, many of which enclose large ammonites, and they are also associated with sandy calcareous layers holding other Cretaceous fossils, among which, a species of inoceramus is tolerably abundant, while in the dark argillaceous shales the scales of fishes are frequently observed. Descending Peace River, these dark shales are first seen at about six miles below Hudson's Hope. They are nearly or quite horizontal, and are exposed at intervals between this point and Fort St. John, in cliffs which rise almost perpendicularly from the water to heights of fifty or a hundred feet. Near where they are first seen, the hills at a little distance back... rise to 500 or 600 feet, and towards their summit present cliffs in which some thick beds of brown fine-grained sandstone crop out...*

McConnell (1893, pp. 49D, 53D) who accompanied Dawson, continued exploration downstream on Peace River and placed the lower limit of the Fort St. John shales at the Peace River Sandstones, now known to be stratigraphically higher than the Gates.

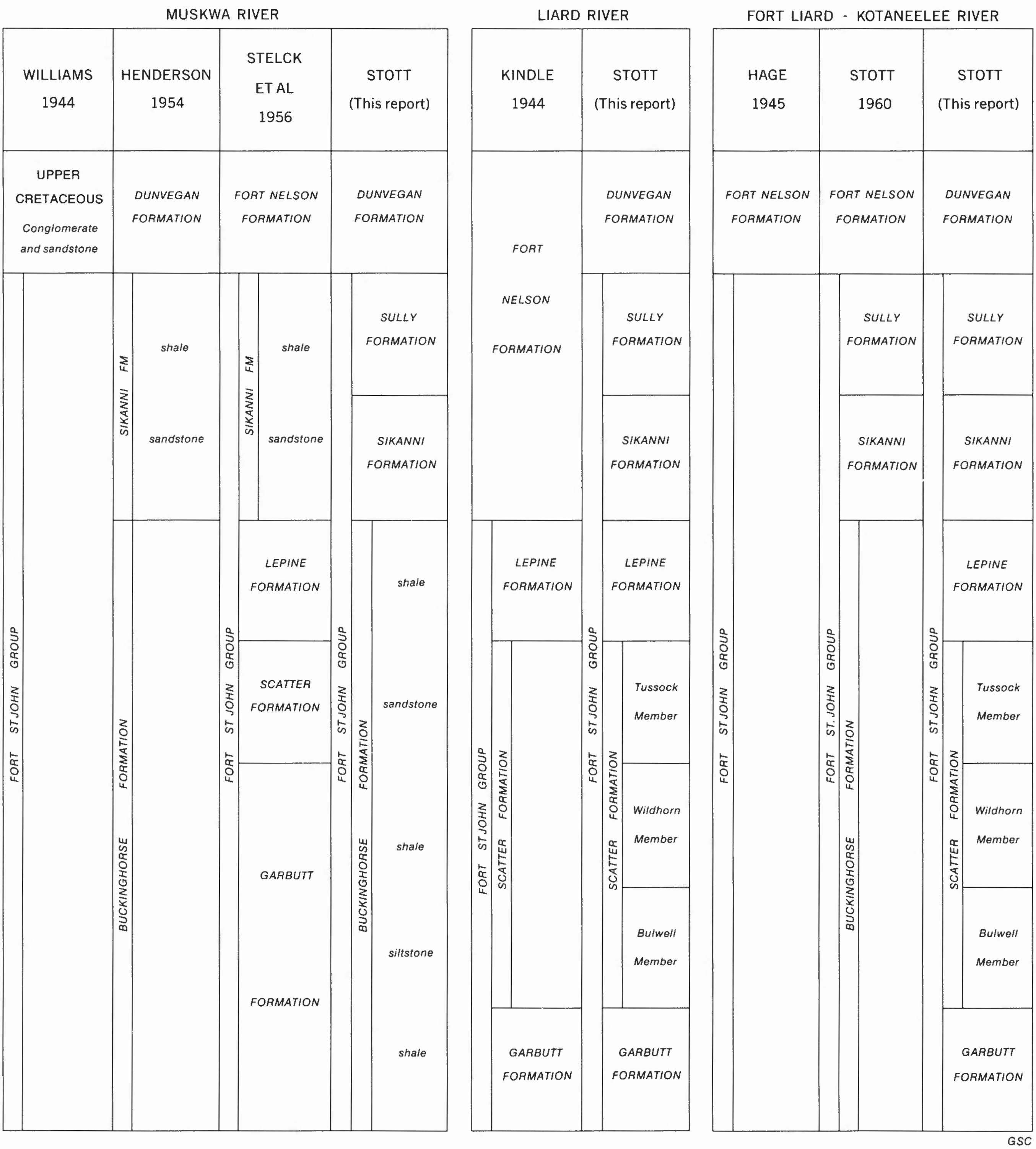


FIGURE 4. *History of terminology of Fort St. John Group.*

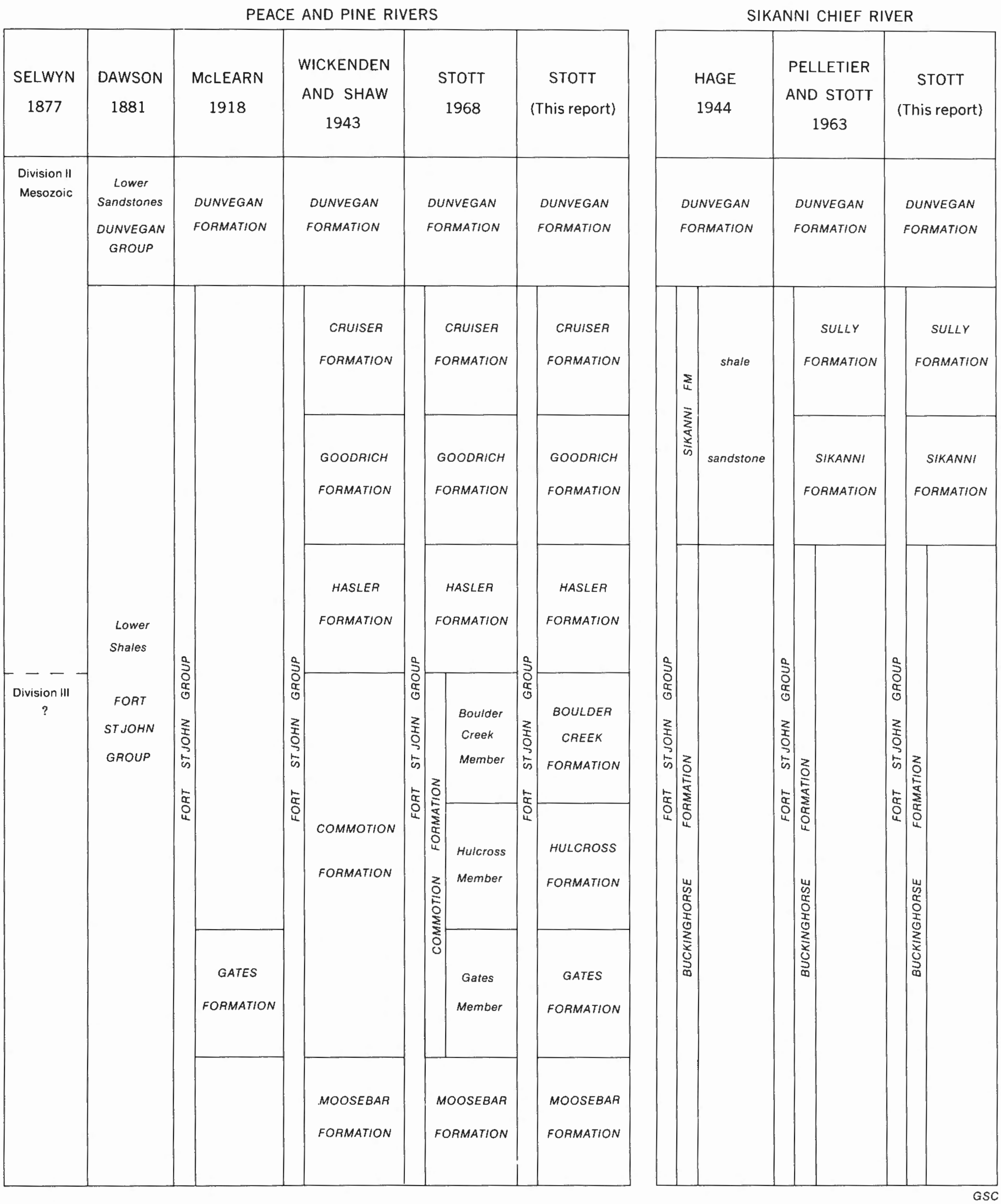
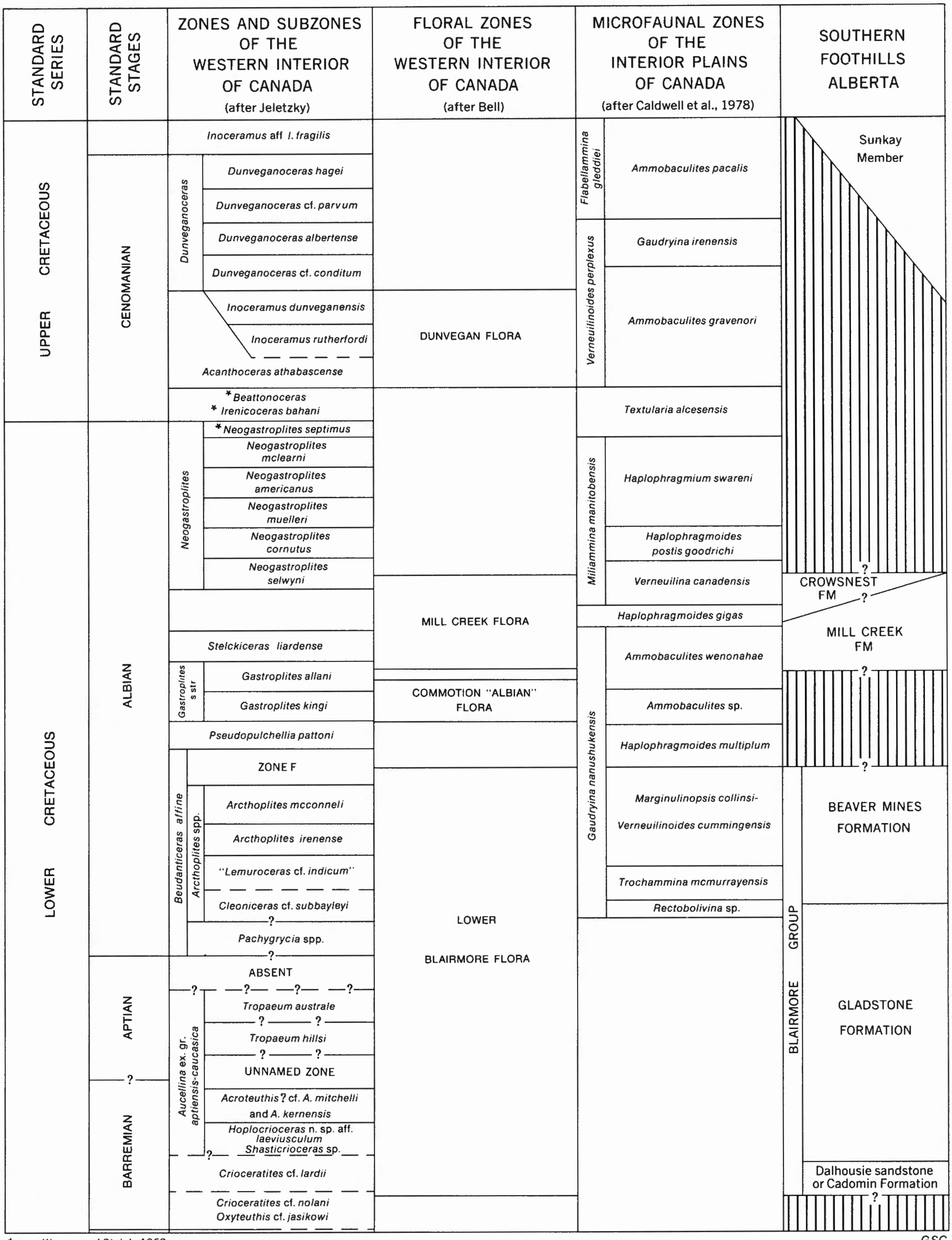


FIGURE 4. *(cont'd)*



* see Warren and Stelck, 1969

FIGURE 5. *Correlation chart.*

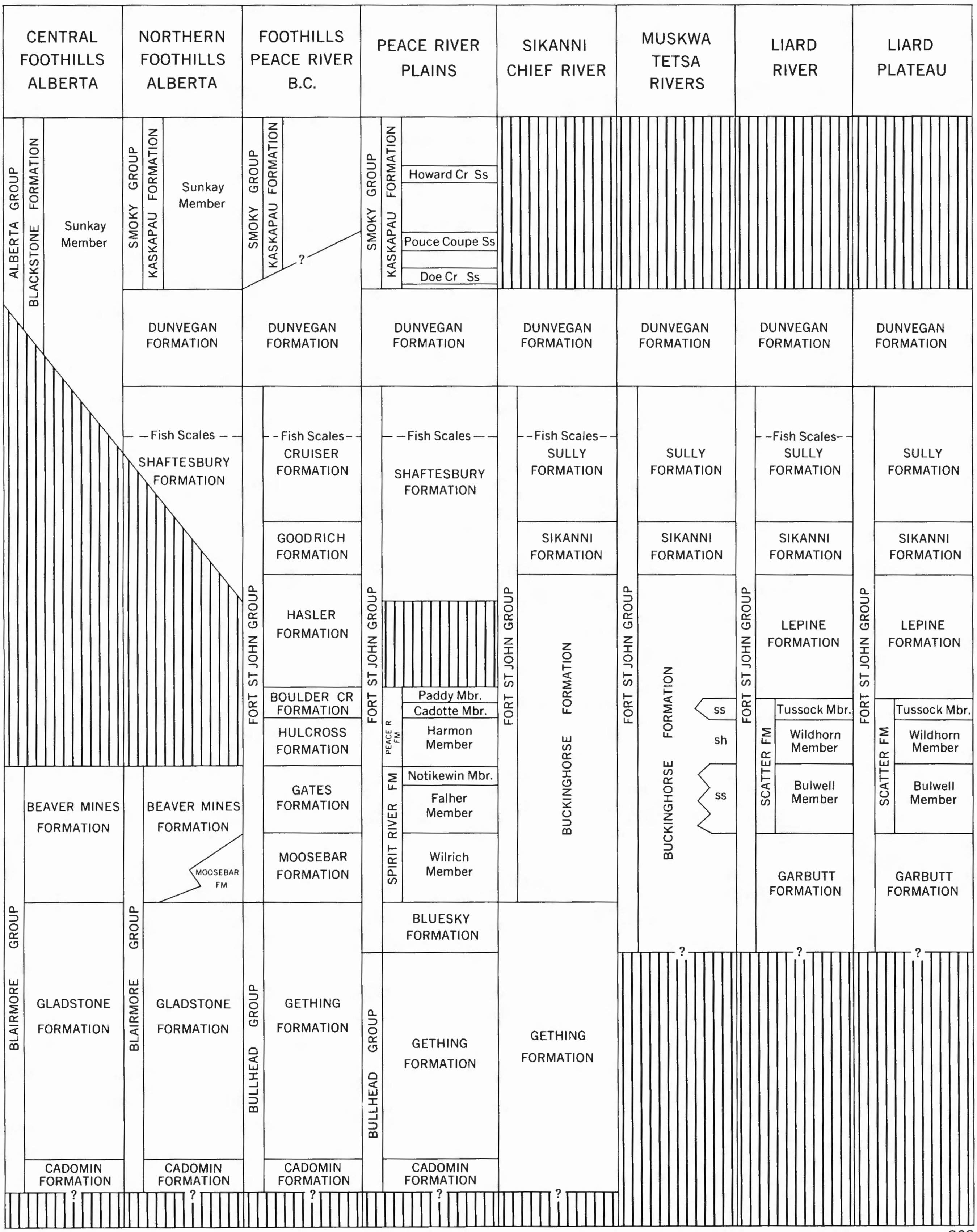


FIGURE 5. *(cont'd)*

McLearn (1918), in 1917, extended his studies westward beyond the canyon on Peace River and examined the Cretaceous succession. He assigned the sandstones at the Canyon to the "Bull Head Mountain formation", thereby correcting an error of Dawson who, never having seen them, considered from Selwyn's description that they were part of the much younger Dunvegan Formation. In addition, McLearn revised the definition of the Fort St. John Formation, stating (1918, p. 17C):

> *...The St. John Formation, as here interpreted, embraces all the strata lying between the Bull Head Mountain below and Dunvegan sandstones above. It consists of two thick shale members separated by a thin sandstone member...*

The sandstone, downstream from Hudson Hope, was designated by McLearn (1923) as the Gates Formation and the underlying shale, as the Moosebar Formation (Fig. 4). McLearn apparently was reverting to Dawson's original definition of the Fort St. John Shale, as he made passing reference (op. cit., p. 6B) to those shales overlying the Gates sandstone. McLearn was more specific in 1932 when he indicated that the Fort St. John Formation occurred above the Gates. Spieker (1921) and Williams and Bocock (1932), through errors in correlation, unintentionally restricted the name to much the same interval, approximately the same as that used by McConnell (1893).

Wickenden and Shaw (1943, p. 3) in their investigation of Cretaceous rocks of Pine valley, recognized five formations between the Bullhead and Dunvegan sandstones (Fig. 4) and stated:

> *...Rather than attempt to correlate any or all of these with the St. John Formation as previously defined, it seems advisable to redefine the term as a group name to include all those predominantly marine strata. Such a usage would equate the group with the St. John Formation as defined (by McLearn, 1918) in 1917...*

McLearn (1918) shortened the name to St. John but Wickenden and Shaw reverted to the older Fort St. John which has been used since.

Other geologists working elsewhere in northeastern British Columbia and District of Mackenzie at about the same time applied the name Fort St. John to marine shales of Lower Cretaceous age (i.e. Williams, 1944; Kindle, 1944; Hage, 1944, 1945). However, several major facies changes occur within the region and the subdivision of the group varied from one area to another (Fig. 4). McLearn and Kindle (1950, p. 73), in their synthesis of Cretaceous stratigraphy, retained the name, but stated: "It is not possible to use one, uniform classification of the strata for all of northeastern British Columbia". The name was extended into the subsurface by Badgley (1952) and the Alberta Study Group (1954) and the assignment of the thick marine Lower Cretaceous succession to the Fort St. John Group has been accepted by subsequent authors (i.e. Stelck et al., 1956; Stott, 1960a, 1960b, 1968a; Rudkin, 1964).

The Fort St. John Group has been subdivided in several formational sequences (Figs. 5, 6) not only because of the facies variation but also as a consequence of work being carried on in local areas at different times by different geologists. As each sequence is useful locally, only minor modifications are made to existing terminology. The first part of this discussion deals with each local region, outlining the definition, distribution, thickness, lithology, fossil content of the group, a synthesis of age relationships and correlation (Fig. 5). The last part of the report provides an interpretation of depositional history and paleogeography.

The Fort St. John Group ranges from approximately 2300 feet (701 m) at Deadhorse Meadows in the extreme south to a maximum of 6500 feet (1981 m) in the vicinity of Scatter River. Few complete surface sections are known; the section at Dokie Ridge, more than 5000 feet (1524 m) thick, was designated as a standard in the Peace River region.

The correlation of the surface section on Dokie Ridge (sec. 60.5, Stott, 1968a) with the subsurface section in Sun et al. Chetwynd 14-20-77-23 well is shown in Figure 7. All the typical formations can be readily recognized. The detailed relationship with other wells between Dokie Ridge and the Imperial Spirit River No. 1 well was shown by Stott (1968a, Fig. 5) and schematically in Figure 8. These figures illustrate not only the marked increase in thickness of the Fort St. John Group in the Foothills but also several pronounced facies changes. The strong development of nonmarine sediments in the Falher Member of the Spirit River Formation in the eastern region indicates the development of a south to southwesterly derived deltaic lobe. The thick Goodrich sandstone grades laterally eastward into shales assigned to the Shaftesbury Formation.

Two other columnar cross-sections (Figs. 10, 11) illustrate the relationship of the Fort St. John Group of the Pine-Peace region with other sections along lines trending northwestward along the Foothills and westernmost Plains. Columnar sections, based on outcrop measurements have been drawn with the datum at the top of the Boulder Creek and Scatter Formations. Although some minor diachronism may be associated with that datum, the sequence of **Gastroplites** in the various sections indicates the datum does approximate a time line. Along that line of section, the thickness between the base of the Fort St. John Group and the datum remains relatively uniform between Peace River and Scatter River despite major facies changes from marine shale to sandstone. The Boulder Creek and Gates sandstones disappear northward beyond Peace River and the Scatter sandstones appear near Scatter River. In contrast, the interval from the datum to the top of the Fort St. John Group shows a marked decrease southeastward from Peace River to Deadhorse Meadows and a marked increase northward into the region of Scatter River. The Goodrich and Sikanni sandstones form an extensive sand sequence, broken only by erosion in the vicinity of Peace River.

Similar relationships are observed in subsurface (Fig. 10) although the line of section is drawn farther basinward and the main sandstone units are less well developed. The total thickness of the interval between the base of the Fort St. John Group and the datum remains about the same at Sun et al. Chetwynd 14-20-77-23 well and IOE Dunedin d-75-E/94-N-8, but decreases in the intervening wells. Much of that decrease can be attributed to less deposition in the region of the more easterly wells. Within that interval, the Boulder Creek and Gates Formations can be traced only slightly north of Peace River and the Scatter Formation is well defined only in the Dunedin well. A general increase in thickness of the interval between the datum and the top of the Fort St. John Group is noted from south to north. Sandstone equivalent to the Goodrich and Sikanni Formations is not developed in the Monsanto Dome Bear Flat 6-30-84-20 well, located to the east of the last vestiges of the Goodrich outcrops. The Sikanni sandstone is continuous northward from about latitude 57° (see Fig. 3) although it begins to grade laterally into shale in the Dunedin well.

PLATE 2

Type region of the Fort St. John Group. Aerial view of Peace River looking eastward from the junction of Halfway River, with Moberly and Pine Rivers joining the Peace at right in the distance. Most of the area is underlain by the Shaftesbury Formation of the Fort St. John Group, with the overlying Dunvegan Formation occurring beyond Pine River. B.C. Photo 1951:45.

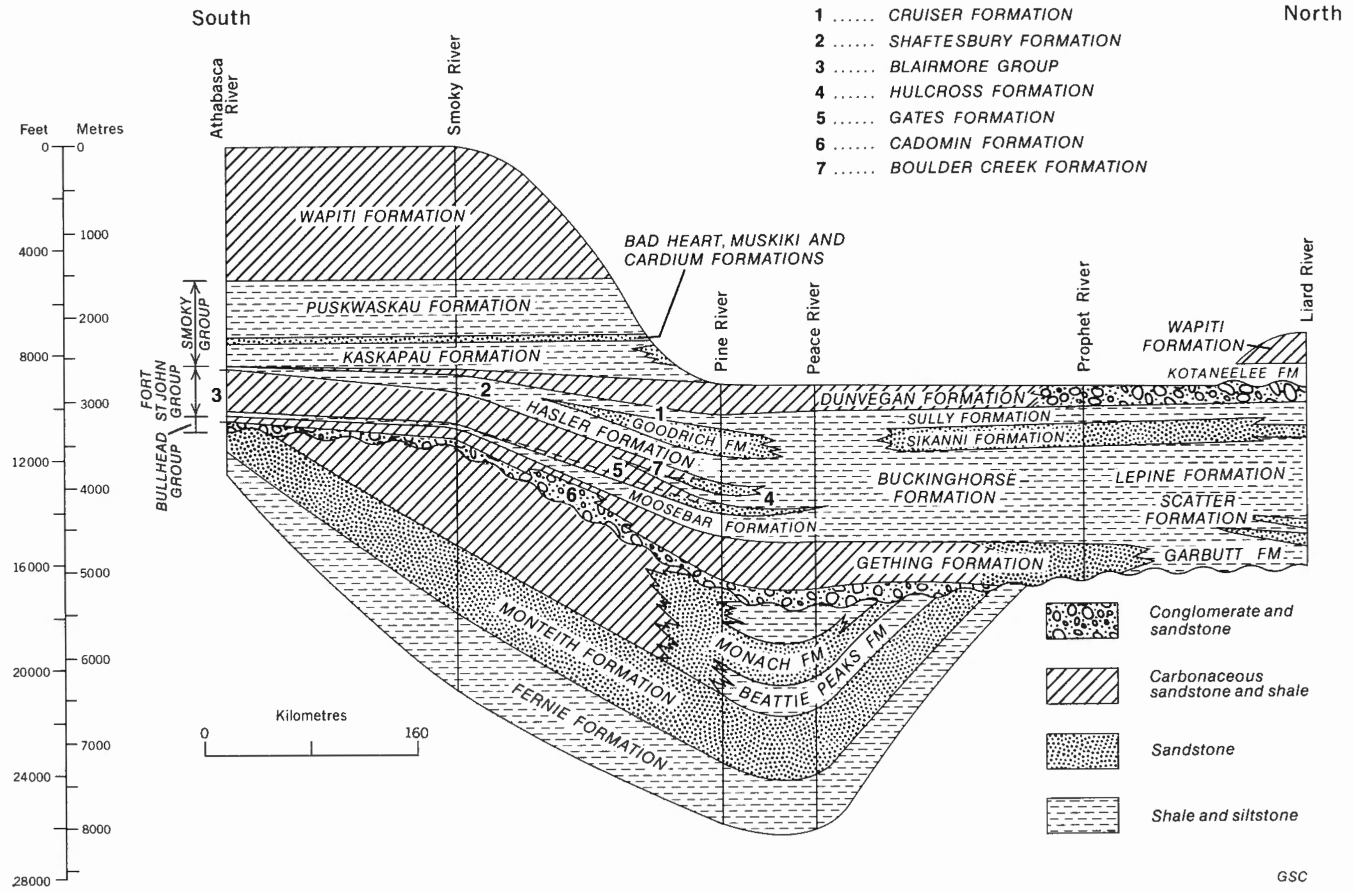


FIGURE 6. *Schematic diagram of major sequences in Jurassic and Cretaceous rocks of northeastern British Columbia.*

Pine and Peace Rivers regions

The Fort St. John Group in the region south of Peace River was outlined previously (Stott, 1968a) but its occurrence between Pine and Peace Rivers is summarized here to facilitate the comparison of equivalent successions north of there with that found in the type region as originally defined by Dawson (1881). Some major revisions of formations are made and new data are included (Figs. 4, 5).

The distribution of the group in the vicinity of Pine and Peace Rivers was shown originally by Wickenden and Shaw (1943) and Beach and Spivak (1944), and more recently by maps of the Pine Pass map-area (Muller, 1961), the Charlie Lake map-area (Irish, 1958), Dawson Creek map-area (Stott, 1961a), and Halfway River map-area (Irish, 1970), and in a composite map by Stott (1969; see also Fig. 3).

The Fort St. John Group comprises a succession of dominantly marine rocks lying between the Bullhead Group (Stott, 1973) and the Dunvegan Formation. It is divided, from the base upward, into Moosebar, Gates, Hulcross, Boulder Creek, Hasler, Goodrich and Cruiser Formations. In the Peace River Plains, shales equivalent to the last three formations are included in the Shaftesbury Formation (Plate 2; Fig. 5). Previously (Stott, 1968a), the Gates, Hulcross, and Boulder Creek (Plate 3) were treated as members of the Commotion Formation, but herein are given the status of formations.

A maximum thickness of 4812 feet (1466 m) was measured on Dokie Ridge (Stott, 1968a, sec. 60-5). The group is 4670 feet (1423 m) thick in the Sun et al. Chetwynd 14-20-77-23 well (lsd. 14, sec. 20, tp. 77, rge. 23, W6; Fig. 7). The thickness decreases southward along the Foothills, being in the order of 2300 feet (701 m) near Kakwa River (Stott, 1968a, sec. 58-9), and also eastward into the Plains, being about the same in Imperial Spirit River No. 1 well (lsd. 12, sec. 20, tp. 78, rge. 6, W6; Fig. 8). In the Imperial Spirit River No. 1 well, the Bluesky Formation is present and is included in the Fort St. John Group. That formation is equivalent to upper beds of the Gething Formation in the Foothills, so the succession in the well equivalent to the Fort St. John Group of the Foothills is about 2200 feet (670 m).

The Fort St. John Group lies on strata of the Gething Formation of the Bullhead Group throughout the Pine and Peace River region. The distinct and abrupt change from carbonaceous sediments to marine mudstone is suggestive of disconformable relationships. According to Chamney (in Stott, 1973), the basal Fort St. John shales that overlie the Gething Formation in the Prophet River region to the north are older than the Moosebar shales that overlie Gething strata at Peace River and in the area to the south. Chamney's studies were not sufficiently detailed to determine if the relationship was one of intertonguing, that is, whether or not shoreline sands of the early phase of the initial Fort St. John transgression developed in the south. It is possible that no equivalents of the basal shales on Prophet River exist at Peace River, and the Gething contact may represent a hiatus of short duration.

TABLE I

TABLE OF FORMATIONS

Pine River Region

Series	Group	Formation thickness	Description
Upper Cretaceous		Dunvegan 350-1200' (107-300 m)	Fine-to coarse-grained sandstone; conglomerate; carbonaceous shale and coal.
	Fort St. John 2000-5000' (610-1529 m)	Cruiser 350-800' (107-244 m)	Dark grey marine shale with sideritic concretions; some sandstone
Lower Cretaceous		Goodrich 50-1350' (15-411 m)	Fine-grained, crossbedded sandstone; shale and mudstone.
		Hasler 500?-1500' (152-459 m)	Silty, dark grey marine shale with sideritic concretions; siltstone in lower part.
		Boulder Creek 240-560' (73-171 m)	Fine-grained, well sorted sandstone; massive conglomerate; nonmarine sandstone and mudstone.
		Hulcross 0-450' (0-131 m)	Dark grey marine shale with sideritic concretions.
		Gates 220-900' (67-274 m)	Fine-grained, marine and nonmarine sandstones; conglomerate; coal; shale and mudstone.
		Moosebar 100-1000' (30-304 m)	Dark grey marine shale with sideritic concretions; glauconitic sandstone and pebbles at base.
	Bullhead 300-2500' (91-762 m)	Gething 75-1800' (22-549 m)	Fine-to coarse-grained, brown, calcareous, carbonaceous sandstone; coal, carbonaceous shale and conglomerate.
		Cadomin 45-700' (14-213 m)	Massive conglomerate containing chert and quartzite pebbles.
	Regional erosional unconformity; bevels rock of succeedingly older age northward and eastward.		
	Minnes 0-6500' (0-1840 m)	Bickford 0-1400?' (0-427? m)	Sandstone, fine-grained and silty shale; carbonaceous in part.
		Monach 0-1000' (0-304 m)	Sandstone, fine-grained, argillaceous; massive, fine- to coarse-grained quartzose sandstone.
		Beattie Peaks 0-1300' (0-396 m)	Interbedded fine-grained sandstone and silty shales.
		Monteith 0-2000' (0-610 m)	Sandstone, fine-grained; white, quartzose fine- to coarse-grained sandstone.
Jurassic		Fernie 0-1900' (0-579 m)	Calcareous and phosphatic shales; rusty weathering shales; glauconitic siltstone; sideritic shales, thinly interbedded sandstone, shale, and siltstone.

Moosebar Formation

Definition. The Moosebar Formation, defined by McLearn (1923), consists of marine shale and siltstone. The type locality is located at the southeastern end of Peace River canyon where the shale lies on the Gething Formation and is overlain by Gates sandstone (McLearn, 1923; see also Stott, 1968a, p. 47 for detailed description).

Distribution. The Moosebar extends southward from Peace River and can be readily recognized in the vicinity of Grande Cache on Smoky River, although it has not been mapped there. Owing to major facies changes, the overlying sandstones are not recognized north of Peace River and shale equivalent to the Moosebar is included in the Buckinghorse Formation. Equivalent shale beds in the subsurface are assigned to the Wilrich Member of the Spirit River Formation (Alberta Study Group, 1954).

Thickness. The Moosebar Formation is about 950 feet (289 m) thick at its type section, (Stott, 1968a), and probably is thicker farther west at Dokie Ridge but its base is not exposed there. The Moosebar thins southward grading laterally into sandstone and carbonaceous sediments that are included in the Gates Formation. It is only 675 feet (205 m) thick at Bullhead Mountain (Stott, 1968a, sec. 60-10) and 140 feet (43 m) at Mount Torrens (Stott, 1968a, sec. 61-14).

Lithology. The basal shale is dark grey, rubbly to blocky and commonly contains reddish brown-weathering sideritic concretions. A thin bed of pebbles commonly marks the contact with the Gething Formation. The silt content increases in the upper beds, and silty mudstones and thin platy siltstone occur toward the top of the formation.

The mineralogy of the Moosebar shale, as reported by Foscolos and Stott (1975, p. 7) is as follows: 29.3 per cent quartz, 0.52 per cent K feldspar, 2.84 per cent Na feldspar, with dolomite, siderite, pyrite, illite and chlorite, and amorphous silica. No kaolinite is present. The illite and 2:1 expandable clays in the mixed layers are combined at a ratio of 80:20. Discrete illite is composed of 30 per cent 2M illite polymorphs.

Contact relationships. The Moosebar shale lies abruptly on carbonaceous sandstone of the Gething Formation and the relationship is probably that of a disconformity. Highly glauconitic argillaceous siltstone occurs near the base in many places and a thin bed of pebbles marks the contact with the Gething Formation. The upper boundary is drawn at the base of thick, continuous sandstone assigned to the Gates Formation.

Fossil content and age. **Arcthoplites irenensis** (McLearn), obtained from upper Moosebar shales south of Peace River (GSC Loc. 42284) and **Arcthoplites** cf. **indicum** Spath or **A. belli** McLearn from Moosebar shale on Peace River (GSC loc. 32341) represent the lower part of the generalized **Arcthoplites** or **Beudanticeras affine** zone according to Jeletzky (pers. comm.) who interpreted them as late Early Albian (Fig. 5). **Arcthoplites** (previously named **Lemuroceras) irenensis** was reported by McLearn and Kindle (1950, p. 76) from near the top of the formation in the Peace River canyon.

Pelecypod forms, obtained from talus probably from the Gething Formation at Mount Belcourt (GSC No. 36639), are comparable with **Aucellina aptiensis** (d'Orbigny) Pompeckj and suggest an Aptian age (Jeletzky, pers. comm.):

> *. . .**Aucellina** of that particular type are, indeed, largely restricted to the Aptian stage, although they occur in the late Barremian and older rocks in the western interior of Canada. . .*

An early to middle Albian microfaunal assemblage, including **Marginulinopsis collinsi** Mellon and Wall and **Quadrimorphina albertensis** Mellon and Wall were obtained from Moosebar shales south of Pine River; from Deadhorse Meadows and Mount Torrens (Chamney, 1964, also in Stott, 1968a, p. 55, 56); from Belcourt Ridge, (Mellon et al., 1963, p. 67), and from Five Cabin Creek Syncline near Quintette Mountain (Wall, pers. comm., 1976), and a similar fauna from the lower Moosebar shale of the Pine River region (Stelck et al., 1956, p. 11).

Gates Formation

Definition. Wickenden and Shaw (1943, p. 5) defined a sequence of sandstone, shale, and conglomerate that overlies the Moosebar shale in Pine River valley as the Commotion Formation. In previous reports and maps, the writer accepted the Commotion as a valid formation and described two reference sections, one on Bullmoose Mountain and one on Dokie Ridge (Stott, 1968a, secs. 60-9, 60-5). Three members were recognized within the formation. Alluvial, deltaic, and epineritic sediments were included in the lower and upper members, Gates and Boulder Creek respectively, and the middle marine shale was designated as the Hulcross Member. In recent years, intensive exploration for coal within the Foothills of west-central Alberta and British Columbia has resulted in detailed correlations within these members, particularly within the Gates. Coal seams, thick sandstones, and other lithologic units have been mapped over large areas and the coal companies wish, for identification and correlation purposes, to recognize formally these various rock units. The Gates, Hulcross, and Boulder Creek beds meet all the requirements of formational status, being relatively thick (Plate 3), widely distributed and readily mapped over great distances (Stott, 1968a). The writer therefore proposes to elevate the Gates, Hulcross, and Boulder Creek to formational status and to abandon the term Commotion.

The prominent sandstone forming The Gates on Peace River east of Hudson Hope was defined as the Gates sandstone by McLean (1923, p. 6B) and was treated generally as a formation until the recent investigations by the writer (Stott, 1961a, 1961b, 1963, 1968a), when it was included as a member of the Commotion Formation. The Gates Formation at its type locality consists of massive to thick bedded fine-grained, well-sorted sandstone that overlies the Moosebar Formation. The two reference sections, previously designated (Stott, 1968a) at Dokie Ridge and Bullmoose Mountain (secs. 60-9, 60-5) are more typical of the sequence in the Foothills.

Contact relationships. At the type locality, the basal contact of the Gates sandstone with underlying beds is not exposed. Farther west beyond Hudson Hope, and near the Highway Bridge, Moosebar shales grade upward through interbedded silty shale and thin siltstone into the thick-bedded sandstone. Similar relationships occur elsewhere and the boundary is drawn at the base of the first thick and relatively continuous succession of fine-grained sandstone. That boundary forms no persistent datum but is drawn at the base of different sandstones from one locality to another. The upper boundary is drawn at the distinct change from sandstone or carbonaceous siltstone to dark marine shale (Plate 4). That contact appears to be one of the most persistent datums within the Fort St. John Group.

Distribution and thickness. The Gates Formation extends westward from The Gates to Steamboat Island at the lower end of Peace River Canyon. It can be traced southward from there to Pine River and as far south as Deadhorse Meadows near Kakwa River (Fig. 9).

About 60 feet (18 m) of beds are exposed at The Gates but over 200 feet (61 m) are present at Steamboat Island. The formation increases to a maximum of 863 feet (263 m) at Mount Belcourt (Stott, 1968a, sec. 58-13). Most of the increase is related to the lateral gradation from Moosebar shales to carbonaceous and sandy sediments included in the Gates.

Lithology. The Gates Formation at its type locality consists of massive- to thin-bedded fine-grained, well-sorted sandstone. Southward beyond there, the lithology is more varied. The basal part is characterized by fine-grained, fairly well-sorted sandstone but the upper part consists of a cyclic succession of carbonaceous sandstone, mudstone, siltstone, coal, and some conglomerate.

The fine-grained sandstones are brownish grey, weathering brown to slightly rusty. Most are laminated. The basal sandstones are generally fairly well-sorted whereas the upper sandstones contain much carbonaceous material and show festoon crossbedding. On Peace River, west of Hudson Hope, large flow rolls are extensively developed in the Gates Formation (Plate 5). Shales and mudstones vary from almost pure to silty mudstone and their colours range from shades of brown to grey and black. Coal is abundant from Quintette Mountain southward and several thick seams occur between Mount Belcourt and Smoky River.

The Gates sandstones consist dominantly of quartz and chert. Quartz ranges from less than 10 to more than 50 per cent and chert ranges from less than 5 to 65 per cent. Rock fragments, 15 per cent, consist of schists, slates, and quartzites. Carbonate detritus averages 15 per cent but may increase to as much as 50 per cent. Feldspar, not abundant in older Cretaceous sandstone, occurs in amounts as high as 12 per cent in the region between Pine and Peace River.

PLATE 3

Gates, Hulcross and Boulder Creek Formations, on anticline south of Murray River. Gates sandstone outcrops, in small cliff at centre of photo, are overlain by typical recessive exposures of Hulcross shale. The upper cliffs are formed by sandstone and massive conglomerate of the Boulder Creek. D.F.S. 1-12-70.

Sandstones of the Gates Formation are fine-grained, generally brownish grey and weather light brown to slightly rusty. Most are finely laminated and uniformly bedded in the Peace River region. Farther south, in the coal-bearing sequence, the sandstones are less well-sorted, show festoon crossbedding and contain abundant carbonaceous debris.

Fauna and age. Fauna of the early Albian **Arcthoplites** (previously **Lemuroceras**) zone occur in the Gates Formation at Peace River (McLearn and Kindle, 1950; see also Stott, 1968a). Irish collected (GSC Loc. 32342) **Arcthoplites irenensis** McLearn from siltstone in the upper part of the Gates west of Hudson Hope.

A large flora, previously reported by Stott (1968a) and identified by Bell, Hueber, and McGregor as the Lower Blairmore-Luscar-Gething "Aptian" flora, occurs also in the Gates Member. As early to middle Albian marine fauna occur below the Gates Formation and in laterally equivalent beds, the flora must range into Middle Albian.

Hulcross Formation

Definition. Marine shales occurring above the Gates strata were defined as the Hulcross Member by Stott (1968a, p. 68) who designated a type section north of Wolverine River (sec. 59-11, units 93-11). The Hulcross is now raised to formation rank. Only parts of the formation are exposed on Hasler Creek where it was first noted by Wickenden and Shaw (1943).

Contact relationships. The contact between the Gates and Hulcross Formations is generally abrupt, with a distinct change from sandy Gates sediments to the dark grey to black Hulcross shales (Plate 4). Commonly, chert pebbles occur at or near the base of the shales. Some evidence of scouring of the underlying Gates sandstone is found at the type section.

PLATE 4

Upper sandstone at the Gates Formation is overlain by basal shales of the Hulcross Formation; Maurice Creek on south side of Peace River below Hudson Hope, British Columbia. D.F.S. 4-2-71.

The upper beds are transitional into the overlying fine-grained basal sandstone of the Boulder Creek Formation (Plate 6). In most sections, a succession of interbedded siltstone and shale occurs at the top of the Hulcross Formation. The contact is drawn at the base of thick-bedded sandstone of the Boulder Creek.

Distribution and thickness. The Hulcross Formation, well developed between Peace and Wapiti Rivers (Plate 3), decreases in thickness southward owing to a lateral facies change to sandstone and in the westernmost exposures between Mount Belcourt and Smoky River is not easily recognized (Fig. 9). It is present along the eastern foothills ridges north of Belcourt Creek and extends south toward Kakwa River.

The formation is 180 feet (55 m) thick at Wapiti River, 385 feet (117 m) thick north of Wolverine River, and 315 feet (96 m) on Bullmoose Mountain (Stott, 1968a, secs. 59-11, type section 60-12 respectively). Owing to a lateral facies change of sandstone to shale northward, the formation increases to a maximum of 445 feet (136 m) at Dokie Ridge and 437 feet (133 m) at Starfish Creek (Stott, 1968a, secs. 60-5, 61-15). The formation is well exposed along Peace River between Starfish Creek at the lower end of the canyon and the highway bridge west of Hudson Hope. It outcrops along the upper reaches and also in the canyon of Maurice Creek, south of Hudson Hope (Plate 6). Equivalent beds occur in the gully above The Gates on the north side of the river.

E.J.W. Irish[1], while mapping the Charlie Lake map-area in 1955, described the succession occurring above the Gates sandstone in a road cut and gulch about 1 mile (1.6 km) east of The Gates. Although Irish referred to the shales as part of the Hasler Formation, they represent the Hulcross Formation of this report. The upper unit, tentatively assigned to the "Cadotte Member" by Irish, is part of the Boulder Creek Formation.

PLATE 5

Large flow rolls, Gates sandstone at Alwyth Holland Park on Peace River west of Hudson Hope. D.F.S. 2-3-69.

Irish's measured section is described as follows; with formational assignments by the writer:

	Thickness feet (m)	Height Above Base feet (m)
Overlying beds. Drift	50 (15)	50 (15)
Boulder Creek Formation		
Shale, silty; interbedded with beds of grey, medium grained sandstone up to 2 feet (0.6 m) thick and continuous and discontinuous ironstone concretions ("Cadotte Member perhaps")	75 (23)	510 (155)
Hulcross Formation		
Shale, silty, dark grey with ironstone concretionary bands about every 10 to 15 feet (3.0-4.5 m); some pelecypods remains in shale GSC Loc. 25720, in talus at level of middle of unit, the overlying unit being a vertical cliff: (Note: This fauna is probably derived from the overlying sandstone, now included in Boulder Creek-DFS) **Gastroplites spiekeri** (McLearn) and varieties **Gastroplites** ex aff. **canadensis** (Whiteaves) **Gastroplites canadensis** McLearn sensu lato **Gastroplites stantoni** McLearn **Gastroplites** aff. **G. stantoni** McLearn (= **G. flexicostatus** Jeletzky, 1964 non Imlay 1961) **Arctica**? sp. indet. **Ostrea** sp. indet. **Pecten** cf. **irenense** McLearn pelecypod, genus and species indet. gastropod, genus and species indet.	119 (36)	435 (132)
Shale, silty as (above) but no ironstone	56 (17)	316 (96)
Shale, silty, dark grey; lower half of this unit contains several 4 inch (1 cm) thick ironstone bands (discontinuous concretions)	36 (11)	260 (79)
Shale, silty, with minor siltstone beds and several thin 4 inch (1 cm) concretionary horizons. Several soft partings as in unit below. Some rusty shale and white efflorescence. GSC Loc. 25631, from shale 65 to 75 feet (20-23 cm) above base of formation; cf. **Arcthoplites** sp. indet. (? ex gr. **belli** McLearn) cf. **Arcthoplites** sp. indet. (? ex gr. **mcconnelli** Whiteaves) cf. **Beudanticeras** or **Cleoniceras** sp. indet. **Pleuromya** sp. indet. pelecypod, genus and species indet.	150 (46)	225 (68)
Shale, silty, grey to dark grey; some thin siltstone zones, some rusty zones. Occasional hard concretionary lenses. Zone contains several ½ to 2 inches (13-50 mm) thick partings of white to yellow weathering, grey, soft material	31 (9)	75 (22)
Covered	44 (13)	44 (13)
Underlying beds - Gates Formation		

Irish also traversed Dry Creek located approximately one mile (1.6 km) east of the Gully section above the type Gates sandstone. He reported that 425 feet (129 m) of the formation is exposed at the lower end of the canyon and is overlain by 75 to 100 feet (23-30 m) of glacial till. He considered that the strata exposed correspond to the upper 450 feet (137 m) of the measured section above "The Gates".

[1]E.J.W. Irish, Field Note Book 1, 1955.

C.O. Hage, in the employ of Shell Oil Limited[1], mapped in the vicinity of Maurice Creek during the summer of 1947. He mapped the top of the Gates sandstone and also the overlying shale and sandstone (combined). He interpreted these upper shales and sandstones as the upper two members of the Commotion Formation - the Hulcross and Boulder Creek Formations of this report. Hage outlined a composite section, briefly summarized as follows:

> *Upper member - 225 feet (69 m) - sandstone and shale. In lower 120 feet (37 m) "sandstone contains numerous marcasite nodules and* ***Gastroplites*** *fauna". Middle member - 360 feet (110 m) - shale with concretions. Lower member - (Gates) - 288 feet (88 m) - sandstone and interbedded shale.*

Hage indicated that the "medial shale member" was 370 feet (113 m) thick about one mile (1.6 km) below "The Gates", approximately the same thickness as he indicated on Maurice Creek but 65 feet (19 m) less than that reported by Irish. Hage's upper member is the Boulder Creek Formation and the middle member, the Hulcross Formation of this report.

Lithology. The Hulcross Formation consists of rubbly, silty dark grey to black shale or mudstone (Plate 4). The silt content increases upward through the member and thin beds of argillaceous siltstone and platy sandstone occur in the uppermost part. Reddish-brown weathering sideritic concretions are common to abundant.

The Hulcross shale, based on samples from the type section has the following composition (Foscolos and Stott, 1975, p. 7): 23.7 per cent quartz, 0.52 per cent K feldspar, 2.84 per cent Na feldspar, with illite, chlorite and kaolinite. The percentage of 2M illite polymorphs is 25 per cent of the dicrete illite.

Fossil content. Irish collected fossils from the Hulcross shales above "The Gates" (GSC loc. 25631) which include cf. **Arcthoplites** sp. indet.(? ex gr. **belli** McLearn), cf. **Arcthoplites** sp. indet. (ex gr. **mcconnelli** Whiteaves), cf. **Beudanticeras** or **Cleoniceras** sp. indet. Irish also obtained similar fossils (GSC loc. 25724) in a road cut on the west side of Dry Creek from strata 61 feet (19 m) above the base of the formation.

Pseudopulchellia pattoni, as identified by J.A. Jetetzky (GSC locs. 42272, 84117, 84118) was collected from the uppermost 100 feet (31 m) of the Hulcross Formation. However, other fossil collections occurring near the top of the Hulcross Formation (GSC locs. 42269 and 46515) and Starfish Creek at Moberly River contain a **Gastroplites kingi** fauna either devoid of **Ps. pattoni** or containing very rare fragments apparently referable to this form. Jeletzky (1980) states that:

> ***Pseudopulchellia pattoni*** *Imlay characterizes the uppermost 30.5 m (100 feet) of the Hulcross Member and its argillaceous equivalents in the Peace River Foothills. So far as is known, this zone is mostly characterized by the presence of* ***Ps. pattoni*** *alone. However, it seems to contain occasionally the oldest known representatives of* ***Gastroplites*** *s. str., such as* ***G.*** *aff.* ***kingi*** *McLearn and* ***G.*** *cf. aff.* ***stantoni*** *McLearn either alone or in association with* ***Ps. pattoni.*** *The* ***Pseudopulchellia pattoni*** *and* ***Gastroplites kingi*** *faunas appear to overlap also in the basal part of the Boulder Creek Member where* ***Gastroplites kingi*** *fauna is prevalent and* ***Ps. pattoni*** *is rare.*

According to Stelck et al. (1956, p. 15) the **Haplophragmoides multiplum** Zone extends for 370 feet (113 m) above the top of the type Gates sandstone. That interval is largely equivalent to the Hulcross Formation of the Foothills.

Boulder Creek Formation

Definition. A succession of conglomeratic beds along Commotion Creek was assigned to the Boulder Creek conglomerate member of Spieker (1921) who interpreted them as part of the "Bull Head Mountain formation". Wickenden and Shaw (1943, p. 5) indicated that they were not part of the Bullhead Group but occurred stratigraphically higher and included the beds in their newly defined Commotion Formation although the name Boulder Creek was not formally used. The name Boulder Creek was retained by Stott (1968a, p. 80) and standard sections (60-5, 60-9) were designated on Bullmoose Mountain and Dokie Ridge. Although these beds were assigned member status by the writer previously, they are herein designated as a formation (Plate 3).

Contact relationships. The Boulder Creek Formation lies gradationally on the marine shales and siltstones of the Hulcross Formation (Plate 3). The contact is drawn at the base of continuous, thick bedded sandstone and above a succession of interbedded platy sandstone, siltstone and shale. The upper boundary is drawn at a distinct and abrupt change from carbonaceous, sandy sediment to marine shale and it is commonly marked by a thin layer of pebbles or pebbly mudstone.

Distribution and thickness. The Boulder Creek Formation is typically developed in the region between Moberly and Wapiti Rivers (Plate 3). It is 556 feet (168 m) thick on Dokie Ridge, 501 feet (152 m) on the western flank of Bullmoose Mountain, and 419 feet (127 m) thick near Wolverine River (Stott, 1968a, secs. 60-5, 60-11, 59-11). It thins eastward across the Foothills, being 300 feet (91 m) on the eastern slope of Bullmoose Mountain and 204 feet (62 m) on Wapiti River (Stott, 1968a, secs. 60-9, 59-6) and is in the order of 250 feet (76 m) between Mount Belcourt and Deadhorse Meadows near Kakwa River (Fig. 9).

Northward and eastward from Moberly River, the Boulder Creek Formation grades laterally from conglomerate, sandstone and carbonaceous sediments into silty marine sandstone (Plate 6), and finally into marine mudstone (Figs. 8, 9). A relatively thick unit [200-250 feet (60-75 m)] of sandstone extends from Starfish Creek at the lower end of Peace River canyon to Maurice Creek south of Hudson Hope (Plate 6). As shown previously (Stott, 1968a, Fig. 5), that sandstone extends into the subsurface of the Peace River Plains and is recognized there as part of the Peace River Formation.

As previously noted in the description of the Hulcross Formation, Hage reported 225 feet (68 m) of sandstone and shale at the top of the Commotion Formation on Maurice Creek. The author examined the outcrops on the headwaters of the western tributary but did not measure the strata. Irish reported, from the exposures at the gully above the Gates sandstone at The Gates on Peace River, that 75 feet (22 m) of silty shale interbedded with grey medium grained sandstone occurred above a thick succession of shale. Hage reported that only 40 feet (12 m) of the upper sandstone member was exposed. Both these exposures, above the type Gates and on Maurice Creek, are considered to be eastern facies of the Boulder Creek Formation.

Equivalent sandstone has not been observed or reported north of Peace River. Presumably the sandstone grades into shale and is included in the Shaftesbury Formation (upper Fort St. John shale of Irish, 1970).

---

[1]Shell Oil Limited very kindly made available the field notes and maps prepared by Hage.

Lithology. In the Pine Pass region, the Boulder Creek Formation is readily divided into three parts: a lower unit of thick-bedded to massive, fine-grained, well-sorted sandstone; a middle massive conglomerate; and an upper coal-bearing succession of interbedded carbonaceous shales and argillaceous sandstone (Stott, 1968a). To the south of Pine River, the tripartite division is not so evident and conglomerate may occur throughout the upper part and coal-bearing beds range into the lower part of the member. To the north of Moberly River, the conglomerate and carbonaceous sediments disappear and the member consists dominantly of fine-grained sandstone with some interbedded shale (Plate 4).

On Maurice Creek, the uppermost beds of the Boulder Creek Formation are well exposed, consisting of flaggy, fine-grained sandstone with interbedded mudstone (Plate 7). Abundant ripples are present on bedding surfaces. The sandstone is laminated, grey on a fresh surface but weathering brownish grey. These beds are similar to the exposures in gullies on the south side of Peace River east of Starfish Creek. Hage indicated that the lower part of the "upper member" consisted of 120 feet (37 m) of sandstone and shale interbedded in about equal amounts. The overlying 105 feet (32 m) were reported to be fine grained sandstone in beds 1 to 2 feet (0.1-0.6 m) thick, interbedded with half the amount of dark grey shale. Irish described equivalent beds near "The Gates" as silty shale interbedded with grey, medium grained sandstone up to 2 feet (0.6 m) thick, with continuous and discontinuous ironstone concretions.

The Boulder Creek sandstone contains about 40 per cent quartz, 35 per cent chert, 15 per cent rock fragments and 10 per cent matrix. Well-sorted, fine grained arenites are typical of the basal marine sandstone. The coarser sandstones and conglomerate of the middle Boulder Creek contain a larger percentage of chert and fine grained quartzitic sandstone clasts. Carbonate detritus is not so abundant in the Boulder Creek as in the Gates Formation.

PLATE 6

Boulder Creek sandstone and siltstone overlying shales of the Hulcross Formation; Maurice Creek on south side of Peace River below Hudson Hope, British Columbia. D.F.S. 4-1-71.

Fossil content and age. C.O. Hage, in 1947, collected fossils from the upper sandstone of the Commotion Formation on Maurice Creek, which is herein considered to be the Boulder Creek Formation, and reported:

> *The upper member of the formation is characterized by the* ***Gastroplites*** *fauna of Albian, upper Lower Cretaceous age. The following fossils as identified by F.H. McLearn, Geological Survey, were collected from Maurice Creek:* ***Gastroplites*** *cf.* ***stantoni***, ***Gastroplites*** *cf.* ***canadensis*** *Whiteaves;* ***Arctica****? sp. The fossils collected from the talus below equivalent beds, located about 1 mile downstream from "The Gates" included* ***Gastroplites canadensis*** *Whiteaves var. and* ***Inoceramus cadottensis.***

Jeletzky (1980) summarized the fauna which occurs in the Boulder Creek Formation in the vicinity of Peace River. Fauna collected on Maurice Creek (GSC locs. 13799, 28117, 88031, 88033, 88035) and Starfish (=Deep) Creek (GSC locs. 9526, 9527, 46515) are assigned to the **Gastroplites kingi** Subzone. Jeletzky reports that this fauna includes such forms as typical representatives of **Gastroplites kingi** McLearn, **G.** ex aff. **canadensis** McLearn, **G. spiekeri** McLearn, **G. kingi** McLearn aff. **stantoni** McLearn (**G. flexicostatus** Jeletzky, 1964, non Imlay, 1961), gastroplitids resembling **Pseudopulchellia flexicostatus** (Imlay) and **Pseudogastroplites** sp. indet. and locally **Pseudopulchellia pattoni** Imlay or forms closely resembling it. Other fossils, more common in the **Gastroplites allani** Subzone, are found in the Boulder Creek strata. On Starfish (Deep) Creek (GSC loc. 37683), **Gastroplites allani** McLearn occurs with **G. kingi.** Above "The Gates" and on Dry Creek on the northside of Peace River below Hudson Hope (GSC locs. 25720, 25733 (=32340 and 83442), **G. allani** McLearn et var. is associated with **G. spiekeri** McLearn, and **G.** ex aff. **canadensis** McLearn. Jeletzky (1980) suggests that:

> *The more typical* ***G. kingi*** *fauna represent the main part of the* ***G. kingi*** *Subzone whilst the* ***Gastroplites allani****-bearing fauna would represent its upper part transitional to* ***Gastroplites allani*** *Subzone. Alternatively (the collections containing the* ***G. allani*** *fauna) can be interpreted as a peculiar, geologically contemporary faunal phase of the more typical* ***Gastroplites kingi*** *fauna.*

The Boulder Creek flora is characterized by several species of angiosperms which mark the major change from older flora. Wickenden and Shaw (1943) obtained angiosperms from the Boulder Creek beds in the Pine Valley (see Bell, 1956) and Mellon et al. (1963) reported angiosperms from upper Commotion beds at Mount Belcourt. Additional collections were obtained from the formation at Quintette Mountain, Bullmoose Mountain and Commotion Creek by the writer (Stott, 1968a; GSC locs. 5650, 5654, 5658). A Late Albian date was assigned by Bell (1956) but the occurrence of **Gastroplites** in equivalent beds indicates a Middle Albian age.

A microfauna assemblage, known as the Cadotte microfauna, was reported by Stelck et al. (1956) to occur well above the Gates sandstone of the upper Peace River. They indicated that the related megafauna lies within the **Gastroplites** zone.

Hasler Formation

Definition. Marine shales lying between beds now assigned to the Boulder Creek and the Goodrich Formations were defined as the Hasler Formation by Wickenden and Shaw (1943, p. 6). No complete section is exposed in the type region so a section on the west slope of Dokie Ridge was designated as type (Stott, 1968a, p. 89-90).

The Hasler Formation is mappable in the Foothills south of Peace River and as far east as Moberly Lake. Eastward, both the Boulder Creek and Goodrich sandstone disappear and the entire interval between the Gates and Dunvegan sandstone comprises shale that is largely equivalent to and continuous with the type Shaftesbury (Fig. 8). In a previous report, the writer (Stott, 1968a) included in the Hasler Formation those predominantly shale units equivalent to the Hulcross and Boulder Creek Formations that occur on Peace River between Starfish Creek and The Gates. However, the recognition of Boulder Creek sandstone between Starfish and Maurice Creeks indicates that it is neither desirable nor necessary to expand the definition of the Hasler so that it includes the succession from the top of the Gates Formation to the base of the Goodrich Formation. As a result, the Hasler Formation has approximately the same stratigraphic limits throughout the area of its distribution.

Contact relationships. The formation lies on the Boulder Creek Formation and the well-defined boundary is commonly marked by a layer of pebbles. The upper boundary is drawn at the base of the thick bedded sandstone of the Goodrich Formation and occurs at the top of a gradational sequence of interbedded sandstone and shale.

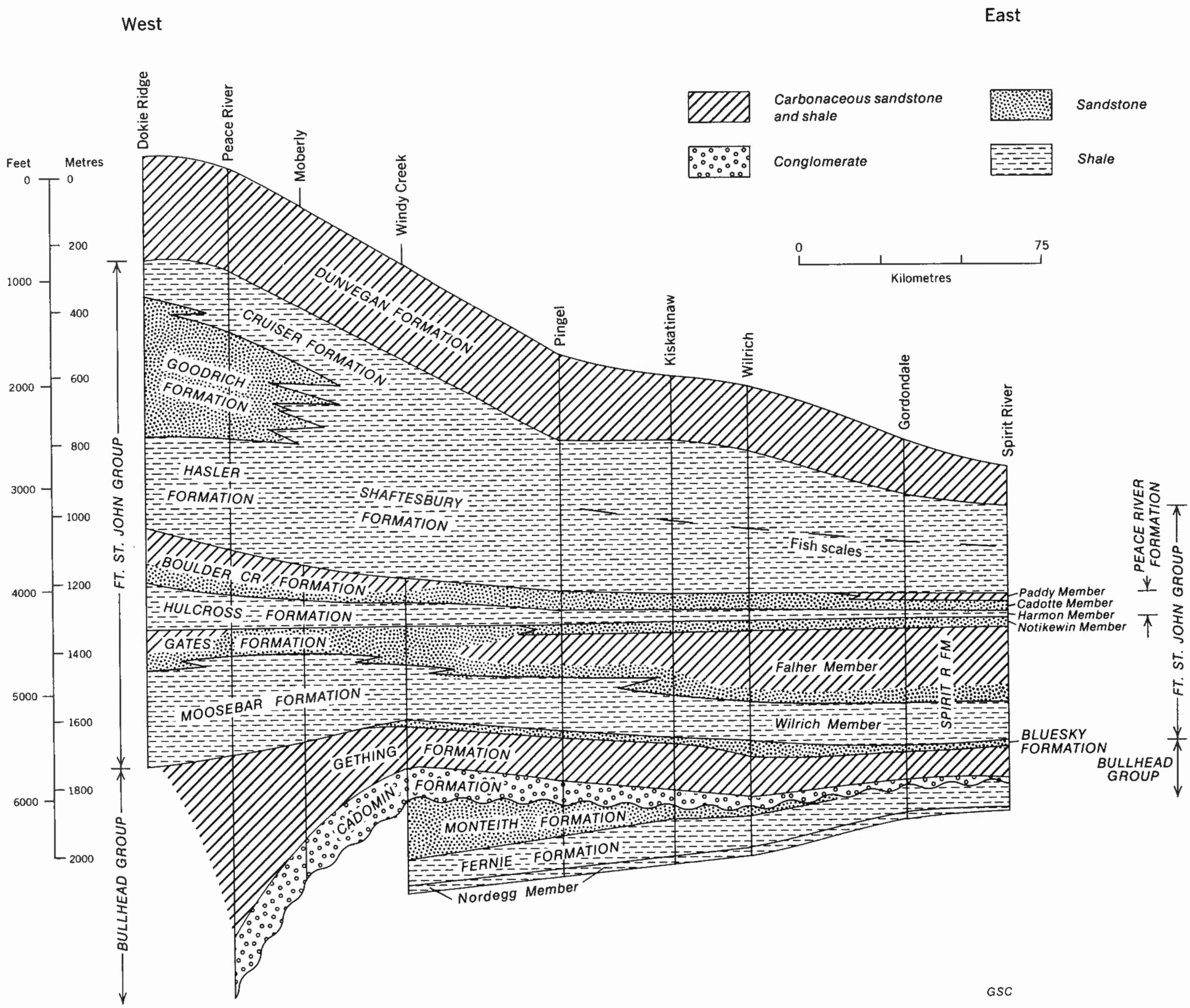


FIGURE 8. Schematic diagram of Fort St. John Group and Dunvegan Formation at latitude of Peace River.

Distribution and thickness. The Hasler Formation generally occurs as a grass-covered, recessive interval between the prominent ridge-forming sandstones of the Boulder Creek and Goodrich Formations. It is easily mapped in the vicinity of Pine River and beyond Bullmoose Mountain to Murray Ridge. In the eastern Foothills south of Murray Ridge and in the western Foothills south beyond Mount Belcourt, beds equivalent to the Goodrich Formation grade laterally into shale and the continuous shale succession between the Boulder Creek and Dunvegan Formations is included in the Shaftesbury Formation.

Only two complete sections of the Hasler Formation are known; the type section on Dokie Ridge is 868 feet (265 m) thick and a section west of Mount Belcourt (Stott, 1968a, sec. 61-13) is 818 feet (249 m) thick. Hasler shales are well exposed in road-cuts along John Hart Highway west of Commotion Creek.

Lithology. The Hasler Formation comprises marine shale, siltstone, minor sandstone, and a few thin beds of pebble conglomerate. Two main facies occur: a basal, predominantly argillaceous siltstone with interbedded shale, and an upper rubbly shale. Several tens of feet of beds of both facies are exposed in the road-cuts along John Hart Highway west of Commotion Creek. Thin beds of conglomerate or pebbly mudstone occur in the upper facies of Hasler Creek.

As reported by Foscolos and Stott (1975, p. 9), the Hasler Formation on Dokie Ridge contains 36.88 per cent quartz, 0.46 per cent K Feldspar, 0.62 per cent Na feldspar, with illite, chlorite and kaolinite. Illite and 2:1 expandable layer silicates are combined at a proportion of 81:19 and the 2M illite polymorph content in discrete illite is 30 per cent.

PLATE 7

Flaggy fine-grained sandstone with interbedded mudstone in upper part of Boulder Creek Formation on Maurice Creek, south side of Peace River below Hudson Hope, British Columbia. D.F.S. 3-9-71.

Age. The Hasler Formation is dated as late Middle to Late Albian by its stratigraphic position between the Boulder Creek Formation containing Middle Albian **Gastroplites** and the Goodrich Formation containing the Late Albian **Neogastroplites** fauna.

Neogastroplites haasi was obtained by Sutherland and Stelck (1972, p. 553) from the upper Hasler Formation, "120 feet (37 m) below the base of the lower sandstone of the Goodrich pinchout" in a road-cut between Moberly Lake and Hudson Hope.

In a recent thesis, Koke[1] reports fifty-three species and subspecies of Foraminifera from the Hasler Formation. These species are representative of the lower part of the **Miliammina manitobensis** Zone, the upper part of the **Haplophragmoides gigas** Zone, and the **Ammobaculites wenonahae** Subzone.

Goodrich Formation

Definition. The Goodrich Formation, as defined by Wickenden and Shaw (1943), includes fine-grained sandstone and interbedded shale that occur between the thick successions of Hasler and Cruiser shales in the vicinity of Pine River. Wickenden and Shaw designated a type section on Boulder Creek where over 460 feet (140 m) of beds are exposed. A standard section was designated by Stott (1968a, p. 94) on Dokie Ridge.

Contact relationships. The Goodrich sandstone is gradational with the underlying Hasler shale and the contact is drawn at the base of the lowest thick bedded sandstone. The upper contact is drawn at the top of the highest sandstone and is generally distinct. However, the contact is probably drawn at the top of different sandstone units from one locality to another.

Distribution and thickness. The Goodrich Formation extends southward from Pine River along the western flank of a broad syncline east of Bullmoose Mountain. The sandstones grade southeastward into shale and, in the exposures south of Wolverine River, the Goodrich consists of only a few thin units of sandstone. Similarly, the Goodrich sandstone grades eastward from the type region into shale and loses its identity as a mappable unit between Moberly Lake and Hudson Hope (Fig. 3). The Goodrich Formation extends northward from Boulder Creek, forming prominent ridges near Pete Lake and Tworidge Mountain south of Peace River. It is best developed in the western Foothills between Dokie Ridge and Mount McAllister. Approximately 1320 feet (402 m) were measured on Dokie Ridge (Stott, 1968a, p. 94, sec. 60-5) and 1013 feet (308 m) on the eastern slopes of Mount McAllister.

Lithology. The Goodrich sandstones, characterized by uniform lithology, are fine-grained, platy to thick-bedded, laminated, and fairly well-sorted. Sandstone units are separated by recessive dark grey to black, concretionary mudstone. At one locality near Hasler Creek, 30 feet (9 m) of coarse grained massive sandstone lies about 60 feet (18 m) below a massive conglomerate, 25 feet (7 m) thick.

The average Goodrich sandstone consists of 44 per cent quartz, 35 per cent lithic fragments including chert, 7 per cent carbonate detritus, and about 13 per cent matrix. Feldspar is rare to absent and glauconite occurs sporadically in some of the sandstones.

[1]Koke, K.R.: Arenaceous Foraminifera from Hasler Formation, northeastern British Columbia; unpublished M.S. Thesis, The University of Alberta, 1979.

The Goodrich sandstones are predominantly fine to very fine grained, and brown weathering. They are generally platy to flaggy, and are crossbedded in many places.

Fossil content and age. **Neogastroplites haasi** Reeside and Cobban is reported by Warren and Stelck (1969) to occur 350 feet (107 m) above the base of the Goodrich and **N. cornutus** (Whiteaves) from the top of the Goodrich equivalent on lower Pine River. Wickenden and Shaw (1943) and Stott (1968a) reported a fauna including **Posidonia**? **nahwisi** (McLearn) var. **goodrichensis** from the Goodrich Formation. The **Neogastroplites** fauna, including **Posidonia**? **nahwisi** (McLearn) var. **goodrichensis** (McLearn), occurring in Goodrich sandstone, is stated by Jeletzky (1968) to be representative of the generalized **Neogastroplites** Zone of Late Albian age.

Sutherland and Stelck (1972, p. 553) reported **Posidonia nahwisi nahwisi, P. nahwisi moberliensis, Neogastroplites cornutus** var. E., **N. cornutus** var. B. and starfish trails in the Goodrich Formation in a road-cut between Moberly Lake and Hudson Hope, south of Peace River. They also obtained thirty-seven species of arenaceous foraminifera of **Haplophragmoides postis goodrichi** Subzone (Caldwell et al., 1978).

Cruiser Formation

Definition. The Cruiser Formation, as defined by Wickenden and Shaw (1943, p. 8) contains silty shales and siltstones of marine origin. Although they designated Cruiser Mountain as the type locality, no continuous section is exposed there[1] and the most complete section occurs in a small creek east of Young Creek, a tributary of Pine River (Stott, 1968a, p. 100).

Contact relationships. The Cruiser Formation lies between Goodrich and Dunvegan Formations. The basal contact is gradational, lying above different sandstones at different localities. The upper contact is drawn at the base of thick bedded to massive sandstone.

Distribution and thickness. The Cruiser Formation is mapped along the eastern Foothills from Pine River as far south as Murray River. It is also recognized in a small area west of Mount Belcourt (Fig. 3).

The Cruiser Formation is 419 feet (128 m) thick west of Mount Belcourt, 361 feet (110 m) on Dokie Ridge, and 611 feet (183 m) at Mount McAllister. It is exposed in road-cuts west of Chetwynd and the largest outcrop is on a small tributary south of Pine River where 742 feet (226 m) are exposed. The variation in thickness is largely the result of lateral facies changes. Eastward, some of the upper Goodrich sandstones and some of the lower Dunvegan sandstones grade laterally into shale of the Cruiser Formation (Figs. 8, 12). Accordingly, the stratigraphic interval of the Cruiser Formation varies from one locality to another.

Lithology. The Cruiser Formation comprises dark grey to black silty shales that weather into blocky to rubbly fragments. Sideritic concretions are common. It is less silty in eastern exposures but siltstone and sandstone appear in the westernmost outcrops, producing a banded or striped appearance.

The Cruiser Formation east of Young Creek contains 41.66 per cent quartz, 0.91 per cent K feldspars, 1.65 per cent Na feldspars, with illite, chlorite, and kaolinite. Illite and 2:1 expandable clay minerals are in a proportion of 79:21 and the percentage of 2M illite polymorphs in the discrete illite is 35 (Foscolos and Stott, 1975, p. 9).

Fossil content and age. The Cruiser Formation is dated by its stratigraphic position between the Late Albian Goodrich sandstone and the early Late Cenomanian Dunvegan Formation, and is of latest Albian to Early Cenomanian age.

Shaftesbury Formation

Definition. The Shaftesbury Formation, defined by McLearn and Henderson (1944, p. 3), comprises those beds lying between the Peace River and Dunvegan Formation along Peace River valley between Dunvegan and the town of Peace River. Equivalent beds of shales extend westward in the Peace River valley from near Dunvegan to The Gates near Hudson Hope. Farther west, the Goodrich sandstone appears near the middle of the shale succession; the lower shales are assigned to the Hasler Formation and the upper shales to the Cruiser Formation (Fig. 8).

Contact relationships. The contact of the Shaftesbury Formation and the Boulder Creek Formation on Maurice Creek appears to be abrupt, although the shales immediately over the Boulder Creek sandstone are not well exposed. On Kakwa River a thin bed of conglomerate occurs at the base of the Shaftesbury shales. Although the basal beds of the Shaftesbury and equivalent shales south of Kakwa River are known to be diachronous (Stott, 1963, 1967b), such a relationship is not well documented in the Pine River region and may not exist.

Distribution and thickness. No detailed description of the type section is available and no precise thickness of the outcrop sequence is available. In wells, westward, the Shaftesbury increases from about 850 feet (259 m) in Imperial Spirit River No. 1 well (lsd. 12, sec. 20, tp. 78, rge. 6, W6) to over 2700 feet (823 m) in Sun et al. Chetwynd 14-20-77-23 well (lsd. 14, sec. 20, tp. 77, rge. 23, W6) (Fig. 8).

The Shaftesbury Formation is recognized in the area north and east of Moberly Lake, although it is best exposed on Peace River east of The Gates and also along the lower Pine River. It is mapped also in the Monkman Pass map-area, and is recognized along the Foothills between Murray and Athabasca Rivers (Stott, 1968a; Fig. 3).

Lithology. The Shaftesbury Formation is characterized by dark grey, flaky to fissile, rusty weathering shale to mudstone. A widespread marker, the Fish Scale marker horizon (Stelck et al., 1958; Williams and Burk, 1964), occurs in the middle to lower part of the formation and contains sandy shale with abundant fish scales and thin bentonitic layers. The upper part of the formation is transitional into the overlying Dunvegan Formation and sandy siltstone and fine grained sandstone are interbedded with silty shale.

Fossil content and age. **Stelckiceras liardense** (Whiteaves), occurring on Peace River west of Halfway River (GSC loc. 84123), is considered by Jeletzky to be latest Mid-Albian. **Neogastroplites cornutus** (Whiteaves), **Posidonia**? **nahwisi** McLearn var. **goodrichensis** occur on Peace River between Bear Flat and Tea Creek (GSC locs. 84083, 84084, 84085, 84092, 84095). Stelck (1962) and Warren and Stelck (1969) report the occurrence of **Neogastroplites muelleri** and **N. americanus** from beds below the fish-scale sandstone of the Shaftesbury Formation farther east along Peace River.

---

[1] According to R.T.D. Wickenden (pers. comm.) the formation was reasonably well exposed during his mapping of the area. Since then, the shales have been covered by low vegetation.

In the Plains northeast of Pine River, Warren and Stelck (1958b; see also Stelck, 1962) reported the occurrence in upper Fort St. John beds of **Pleurobema cruiserensis** Warren and Stelck, **Beattonoceras beattonense** Warren and Stelck, and **Irenicoceras bahani** Warren and Stelck, which they dated as early Cenomanian. The Shaftesbury Formation, therefore, ranges from late Middle Albian to earliest Cenomanian.

Stelck (pers. comm., 1979) reports:

> *The fauna of the* ***Haplophragmoides gigas*** *Zone has been collected from the lower Shaftesbury beds above the beds carrying the* ***wenonahae*** *fauna and below the beds carrying* ***Neogastroplites*** *from outcrops a mile below the mouth of Halfway River.*

Caldwell et al. (1978, p. 511) reported that the **Ammobaculites wenonahae** Subzone is known to occur only in shales, assigned herein to the Shaftesbury Formation, a short stratigraphic interval above the equivalent of the Cadotte (or Boulder Creek) sandstone. As noted in the discussion of the Hasler Formation, Koke reports microfauna of the **H. gigas** Zone and **A. wenonahae** Subzone from the stratigraphic interval equivalent of the lower Shaftesbury.

Sikanni Chief region

Rocks between Fort St. John and Fort Nelson were mentioned first by Ogilvie (1893) who noted the presence, some 20 miles (33 km) upstream from Fort Nelson on Fort Nelson River, of black clay shale with small nodular masses and thin beds of clay ironstone. He reported, in addition, that sandstones overlying the shale occurred at the water's edge about 60 miles (98 km) upstream from Fort Nelson. Ogilvie left the Sikanni Chief River near its sharp westward deflection south of Buckinghorse River but observed the precipitous cliffs of grey and yellow (Dunvegan) sandstone extending along the canyon rim above steep slopes of black and grey shale.

TABLE II

TABLE OF FORMATIONS

Sikanni Chief River Region

Series	Group	Formation thickness	Lithology
Upper Cretaceous		Dunvegan 350-600' (107-183 m)	Massive conglomerate; fine to coarse-grained sandstone; some carbonaceous shale.
		Sully 270-700' (83-213 m)	Dark grey, marine shale with sideritic concretions; prominent marker bed of fish remains.
	Fort St. John 5000-6000' (1524-1828 m)	Sikanni 350-900' (107-274 m)	Fine grained, crossbedded, marine sandstone; rusty weathering, silty mudstone.
		Buckinghorse 3000-3500' (914-1067 m)	Dark grey, marine shale with sideritic concretions; fine grained, thin to thick bedded sandstone.
Lower Cretaceous		Gething 0-1300' (0-396 m)	Fine grained, cherty, marine sandstone; rusty weathering, rubbly to blocky shale; minor conglomerate and carbonaceous shale; rare coal seams.
	Regional erosional unconformity; bevels succeedingly older rocks northward and eastward.		
	Minnes 0-2500' (0-762 m)	Beattie Peaks and younger beds 0-1580' (0-482 m)	Interbedded mudstone, siltstone, and fine grained sandstone; thick-bedded sandstone in middle; minor carbonaceous sediments and coquinas.
		Monteith 0-975' (0-296 m)	Massive, quartzose sandstone; alternating units of sandstone and mudstone; minor conglomerate.
Jurassic		Fernie 0-800' (0-243 m)	Calcareous and phosphatic shale; rusty weathering shale; glauconitic siltstone; sideritic shale; thinly interbedded sandstone, shale, and siltstone.

PLATE 8

Rocky Mountain Foothills, Trutch map-area, looking southwestward from Minaker River to Besa and Prophet Rivers. Klingzut Mountain [6051 feet (1844.3 m)] is high point on first ridge right of centre. Lower terrain in foreground is underlain by Buckinghorse Formation. Ridge of Sikanni sandstone lies beyond lower limit of photograph. B.C. Photo 1206:92.

Those beds were examined in more detail by Williams (1923, p. 65b) who, in company with G.S. Hume, made a geological traverse between Fort St. John and the junction of Fort Nelson and Liard Rivers. Williams outlined 500 feet (152 m) of sandstone with lignite seams north of Fort St. John and equated those beds with the Dunvegan Formation. He reported that "650 feet or more of dark pyritiferous shales containing fish scales near the base and including several thin sandstone beds" occur along Sikanni Chief and upper Fort Nelson River, and suggested that they "may be a continuation of the marine Fort St. John Shale".

Systematic mapping within the region was undertaken only after the building of the Alaska Highway provided better access. The Lower Cretaceous marine beds lying between the Bullhead Group and the Dunvegan Formation in the vicinity of Sikanni Chief River (Plate 11) were assigned to the Fort St. John Group by Hage (1944). He subdivided the group into "a lower, or Buckinghorse formation and an upper, Sikanni formation" (Fig. 4). The Sikanni Formation, according to Hage, consisted of basal sandstone and an upper shale. In subsequent mapping, Stott (Pelletier and Stott, 1963; Stott, 1967b) subdivided the upper formation, restricted the name Sikanni to the lower, dominantly sandstone sequence, and applied the name Sully to the upper shale succession[1].

Williams (1944, p. 23) reported that "soft, sandy, dark brown or black shale", assigned to the Fort St. John Group, underlies the wide plains extending 57 miles (92 km) westward from Fort Nelson. He indicated that the shale extended southward from Fort Nelson and was apparently continuous with the Buckinghorse Formation mapped by Hage (1944). Williams also described the sandstone succession and correlated these "middle, fossiliferous sandstones with the Goodrich formation, and the upper shales with the Cruiser formation".

McLearn and Kindle (1950) summarized Williams's and Hage's reports but at that time no additional studies had been undertaken in the region. Later, Henderson (1954) described in some detail the lithology and correlation of formations presently assigned to the Fort St. John Group between Sikanni Chief and Liard Rivers. Henderson did not specifically assign the formations to the Fort St. John Group and much of his discussion concerned beds occurring in the vicinity of Tetsa River.

Distribution and thickness. The group forms the surface bedrock of much of the Plains region of the Charlie Lake and Halfway River map-areas as shown by Irish (1958, 1970) and of the Trutch map-area (Plate 8) as shown by Pelletier and Stott (1963), Taylor (1979), and the lower part of it is exposed in several synclines within the Foothills Belt. Parts of the region were re-examined by the writer and the distribution of the Fort St. John Group in those map-areas was modified by Stott (1967b; see also Taylor, 1979). Exposures are sporadic, occurring mainly along creek banks on the Trutch escarpment.

The thickness of the group cannot be measured readily at any one locality but it was estimated by Hage (1944) to be in the order of 4000 to 4600 feet (1219-1402 m) in the Sikanni Chief region. The thickness is most easily determined from data obtained from the numerous wells drilled in the area. Approximately 4700 feet (1433 m) of Fort St. John beds occur in the Texaco Texcan Blair a-71-I well (a-71-I/94-B-15) which was spudded just below the base of the Dunvegan Formation (Fig. 10). It is about 4300 feet (1310 m) thick in the Sinclair et al. N Julienne c-54-H well (c-54-H/94-G-2; see Fig. 10). In the Decalta et al. E Dahl a-67-I well (a-67-I/94-H-7) approximately 135 miles (217 km) to the northeast, the group is 2500 feet (762 m) thick. Variations in thickness and lithology along the eastern edge of the Foothills between Sikanni Chief and Muskwa Rivers are shown in Figure 13.

Eastward in the subsurface from the junction of Sikanni Chief and Buckinghorse Rivers, the Sikanni sandstones grade laterally into argillaceous siltstones and do not form a readily mappable unit (Fig. 14). Several marker horizons, including the Fish Scale marker horizon (Burk, 1963) and markers correlated with some of the Sikanni sandstone can be recognized on geophysical logs obtained from boreholes. Markers which correlate with the Peace River and Notikewin sandstones of the Spirit River region (Badgley, 1952; Alberta Study Group, 1954) can be traced northeastward into the Sikanni Chief River region (Fig. 14).

The Fort St. John Group, as shown in Figure 14, thins eastward in the subsurface from the Foothills into the Plains. The datum used coincides with the top of the Spirit River Formation of eastern British Columbia and western Alberta, being readily traced into the region of the type section which occurs in Imperial Spirit River No. 1 well (see Thompson, 1977; Fig. 4). Thompson refers to this marker as Radioactive Marker 2. In this region, the basal Fort St. John shales lie conformably on the Gething or Bluesky sediments. The Spirit River Formation is well defined lithologically in the more easterly wells but is not readily separated within the more continuous shale sequence found to the west. A significant increase in thickness occurs between the marker and the base of the Dunvegan Formation in the more westerly region, accompanied by the development of the major wedge of Sikanni sandstone. Another key marker, termed Radioactive Marker 4 by Thompson (1977) and Williams (1978), coincides with the base of the Fish Scale marker horizon recognized throughout the Western Canada Sedimentary Basin (Stelck, 1962; Burk, 1962, 1963; Williams and Burk, 1964). Although the interval between the Fish Scale marker and the base of the Dunvegan is relatively uniform in the eastern region, some decrease occurs westward. Such a decrease in thickness is more likely related to a facies change from shales included in the Fort St. John Group in the east to sandstone included in the Dunvegan in the west.

Buckinghorse Formation

Definition. The thick assemblage of dark grey, silty, marine shales overlying the Bullhead Group in the Sikanni Chief region was defined as the Buckinghorse Formation by Hage (1944, p. 9). The shales are overlain gradationally by prominent beds of fine grained sandstone included in the Sikanni Formation. Hage indicated that the greater part of the formation was exposed along Buckinghorse River and that a complete section occurred west of the Alaska Highway bridge over Sikanni Chief River in a distance of 8.5 miles (13.7 km). McLearn and Kindle (1950) assumed that the type section was on Buckinghorse River.

The type section, extending for several kilometres along Buckinghorse River, is involved in some folding and faulting and is not entirely exposed. Hage estimated that the thickness was between 3300 and 3600 feet (1006-1097 m) and gave the following summary description:

[1]For original definition of Sully Formation, see Stott, 1960b, p. 13.

	Thickness feet (m)	Height Above Base feet (m)
Overlying beds --- Sikanni Formation		
Bedded and semi-bedded, dark grey shale, with a few ironstone concretions and some interbedded thin sandstone beds	100 (304)	3300 (1006)
Fine grained, dark grey sandstone, sandy shale and shale	50 (15)	2250 (686)
Dark grey, chunky shale with sparse ironstone concretions	375 (114)	2250 (686)
Dark grey, fissile shale and thin sandstone beds with a few concretions	75 (23)	1875 (571)
Dark grey, fissile shale containing large, limy, light buff weathering concretions	100 (30)	1800 (548)
Bedded, fissile shale with ironstone beds containing a few scattered ellipsoidal concretions	825 (241)	1700 (518)
Dark grey, chunky shale with numerous ironstone concretions	100 (30)	1800 (548)
Shale containing three bentonite beds one to six inches thick	25 (8)	500 (152)
Dark grey, chunky shale with numerous ironstone concretions	475 (144)	475 (144)
TOTAL	3300 (1006)	

Contact relationships. Throughout the Foothills of the Sikanni Chief region and as far north as Tuchodi River, the Buckinghorse Formation is underlain by strata of the Gething Formation (Figs. 3, 13). Eastward beneath the Plains and north of Tuchodi River, the Gething sediments disappear and basal Fort St. John shales overlap Triassic and older beds (Fig. 15). In a syncline between Kluachesi Lake and Prophet River, Cretaceous shales rest directly on Triassic beds. No conglomerate or sandstone occurs at the contact. About 150 to 200 feet (46-61 m) above the base of the Buckinghorse, 30 feet (9 m) of sandstone occurs within the shale sequence. This occurrence is anomalous in comparison with the well exposed sections that occur farther east near Kluachesi River and at Gathto Creek (Stott, 1973, secs. 64-23 and 64-24, respectively).

In his original description of the Buckinghorse Formation, Hage (1944) considered that the basal beds were transitional from the underlying Bullhead Group. A unit of interbedded sandstone and shale, of varying thickness, does occur between Gething sandstone and Buckinghorse shale throughout much of the region. Those transitional beds are considered by the writer (Stott, 1973) to be a lateral facies of the upper Gething. The top of a persistent and readily recognized glauconitic marker bed forms a well-defined boundary between the two formations. As a result, the writer includes the transitional beds in the Gething, drawing the boundary at the distinct contact of the glauconitic sandstone and overlying shale.

The basal contact of the Buckinghorse Formation with the Gething Formation is exposed on Sikanni Chief River near Chicken Creek and also farther upstream north of Marion Lake. At Chicken Creek, Buckinghorse shale lies abruptly on conglomeratic sandstone and thin layers of pebbly mudstone and glauconitic sandy mudstone occur a few feet above the sandstone. Farther upstream, the upper Gething beds, consisting of a succession of interbedded sandstone and mudstone, separate typical Buckinghorse shale from Gething conglomeratic sandstone. At the headwaters of Chicken Creek, the basal six inches of the Buckinghorse Formation, containing argillaceous siltstone with lenses of coarse-grained sandstone, lies on fine grained sandstone of the Gething Formation. The contact was observed also at several Gething sections between Nevis Creek and Muskwa River (see Stott, 1973, secs. 62-20, 64-22, 64-23, 64-23). At those localities, Buckinghorse mudstone lies abruptly on highly glauconite sandstone and argillaceous siltstone. In a few places, small chert pebbles are disseminated throughout the lower few feet of the Buckinghorse Formation.

Distribution and thickness. The Buckinghorse Formation extends northwesterly in a broad, low-lying belt west of the Alaska Highway along the eastern edge of the Foothills between Peace and Toad Rivers (Plate 8). This belt is bordered on the east by prominent escarpments formed at the edge of the overlying Sikanni sandstone. The western boundary is commonly marked by anticlines in the Foothills in which older Mesozoic rocks are exposed (Plate 8). South of the west end of Kluachesi Lake, Buckinghorse shale, lying in the footwall, is in fault contact with overlying Cambrian rocks, and in one place, with Precambrian beds.

In the south, the formation is present in the centre of the Chowade syncline and in the core of an anticline along Cameron Creek within the Halfway River map-area (Irish, 1970). The shales are not well exposed in the Halfway River map-area and only isolated outcrops occur along the creeks and immediately below the Sikanni sandstone along the Halfway escarpment. The formation also occurs in several synclines within the Foothills of the Trutch map-area (Pelletier and Stott, 1963; Taylor, 1979; Fig. 3), being most extensive in the vicinity of Marion Lake, Nevis Creek and Besa River. The best exposures occur along Sikanni Chief and Buckinghorse Rivers immediately west of the Alaska Highway (Plates 9, 10). Numerous exposures are present along other rivers which flow across the belt, including the lower reaches of Minaker, Prophet, and Muskwa Rivers. Several hundred feet of the lowermost beds of the formation are exposed near Kluachesi River and on Gathto Creek (Stott, 1973, secs. 64-23, 64-24).

An accurate measurement of the Buckinghorse Formation is difficult to obtain along Sikanni Chief and Buckinghorse Rivers owing to covered intervals and repetitions by minor folds and faults. The thickness was estimated by Hage (1944, p. 11) to be between 3300 and 3600 feet (1006-1097 m). In the Sinclair et al. N Julienne c-54-H well (c-54-H/94-G-2), located 9 miles (14 km) southeast of the Sikanni Chief River bridge, the Buckinghorse is approximately 3700 feet (1128 m) thick. The formation decreases eastward, the equivalent interval being in the order of 1900 feet (579 m) in the Triad BP Conroy Creek c-100-A well (c-100-A/94-H-12).

In subsurface (Fig. 14), the Buckinghorse can be traced eastward to the point at which the Sikanni sandstone disappears. Equivalent beds in the centre of the basin are assigned to the undivided Fort St. John Group. Two wedges of sandstone appear eastward to southward; the lower being the Notikewin Member of the Spirit River Formation, and the upper representing the Cadotte sandstone of the Peace River Formation. The latter is poorly developed in Baysel SR CanDel Hun d-12-C well (d-13-C/94-H-2) but forms a well defined unit farther south, as shown by Stott (1968a) and Thompson (1977; Fig. 4). The Radiocative Marker 3, at the top of the Peace River Formation can be traced westward through the lower part of the Buckinghorse Formation, but its character is poorly defined in logs of the Julienne wells.

Lithology. At Buckinghorse River, the type Buckinghorse Formation lies on a massive, argillaceous and glauconitic siltstone which is recognized in many sections northward along the Foothills (Stott, 1973). The lower beds consist of rusty weathering, dark grey to black shale or mudstone with large, reddish weathering, sideritic concretions (Plate 9).

PLATE 9

Basal Buckinghorse shales, type locality, Buckinghorse River. GSC Photo 130599.

PLATE 10

Upper Buckinghorse shales, type locality, Buckinghorse River. GSC Photo 130601.

The shale contains large masses of marcasite and is heavily coated with a yellow efflorescence. Thin layers of bentonite occur in this part of the formation. The lower beds are overlain by a succession of rusty weathering, rubbly to flaky shale, containing only rare concretions. A succeeding interval of interbedded platy siltstone and silty mudstone appears equivalent to some part of the Gates sandstone of the Peace River region or to the Scatter Formation of the Liard region. The upper part of the formation contains concretionary mudstone that grades upward into blocky mudstone and argillaceous siltstone (Plate 10). All the shale weathers rusty and most is sideritic. The Buckinghorse mudstone grades transitionally upward into the overlying Sikanni sandstone. Selenite, common to Lower Cretaceous Fort St. John shales elsewhere, is not abundant in the mudstones along Buckinghorse River although it was observed on Sikanni Chief River.

Fossil content and age. **Arcthoplites** (sensu lato) cf. **A. belli** McLearn and **Beudanticeras** cf. **B. multiconstrictum** Imlay were collected by Stott from the lower part of the Buckinghorse Formation on Buckinghorse Creek and Sikanni Chief River respectively (GSC locs. 52199, 52205). Jeletzky (pers. comm.) commented as follows:

> *Although it is not possible to say definitely to which of the more refined **Arcthoplites** sensu lato (inclusive of **Subarcthoplites**) zones any of those lots belongs, the writer considers it more likely that they are somewhere in the lower part of the generalized **Beudanticeras affine** and **Arcthoplites** zone and of the early rather than mid-Albian age.*

As the Buckinghorse Formation lies below beds that are within the Late Albian **Neogastroplites** Zone, it can be dated as (?)late Early Albian to Middle Albian. **Arcthoplites**? and **Arcthoplites** cf. **indicum** Spath were reported from the lower part of the Buckinghorse Formation by McLearn and Kindle (1950) and also by Henderson (1954). **Stelckiceras liardense** (Whiteaves) (GSC loc. 14772) of the latest mid-Albian age was identified by Jeletzky (1980) from the middle part of the Buckinghorse Formation on Sikanni Chief River about 7.5 miles (12 km) above the Alaska Highway. Although the upper part of the formation in the type region has not yielded diagnostic fossils, the overlying Sikanni Formation lies within the Late Albian **Neogastroplites** Zone so the Buckinghorse can be dated as of late Early to latest Middle Albian age. Hage (1944, p. 11) reported **Neogastroplites** in shale east of Mile 182 and considered that it came from within the upper part of the Buckinghorse Formation, but that location appears to be underlain by Sikanni sandstone. Irish (1970, p. 72) collected fossils from near the top of the formation on Halfway River about three-quarters of a mile (1.2 km) above the mouth of Kobes Creek (GSC loc. 30775). The collection included **Neogastroplites** sp. indet. (a form transitional between **N. cornutus** (Whiteaves) and **N. selwyni** McLearn), **Pecten** sp. indet., and **Inoceramus**? or **Posidonomya**? sp. indet. This suggests that the Buckinghorse Formation on Halfway River includes some beds of Late Albian age, younger than the upper beds on Sikanni Chief River.

Stelck (1975b) reported arenaceous microfossils of the **Miliammina manitobensis** Zone from the upper part of the Buckinghorse shales and lower part of the Sikanni sandstone at the Alaska Highway crossing of Sikanni Chief River. Also, Anan-Yorke and Stelck (1978, p. 478) described a microfloral assemblage from the upper 80 m of the Buckinghorse Formation at Sikanni Chief River. They reported 37 species of spores and pollen, 37 species of dinoflagellates and five species of acritarchs, many of which they found to be long-ranging and to extend into the Sully Formation.

Sikanni Formation

Definition. The Sikanni Formation, as originally defined on Sikanni Chief River by Hage (1944), included all the beds between the Buckinghorse and Dunvegan Formations. Hage stated (1944, p. 11):

> *It is composed of a lower part about 380 feet thick consisting of four sandstone members separated by shale, and an upper part believed to be largely shale though observations were limited to a few outcrops.*

Subsequently, Stott (1960b, 1968b) found it useful to recognize the upper shale as a separate formation and restricted the name Sikanni to the sandstone succession. Henderson (1954, p. 2281) referred to the lower sandstone member on Sikanni Chief River as the Four-Sandstone member.

Type section. Hage indicated that the lower (i.e. sandstone) part of the Sikanni was well exposed along Sikanni Chief River at and below the highway bridge (Plate 11). The type Sikanni Formation comprises four major sandstone units, each separated by silty mudstone with interbedded platy siltstone and sandstone. Hage described a "representative section 2 miles east of the bridge" (see also sec. 62-22, this report):

	Thickness feet	(metres)
Top of Section		
Shale, dark grey	?	
Fourth sandstone member: fine grained, grey bedded and banded; small carbonaceous fragments along bedding	47	(14)
Shale, dark grey, bedded; with a few scattered ironstone concretions	44	(13)
Third sandstone member: fine grained, grey, banded interbedded with minor amount of shale	46	(14)
Shale, dark grey and sandy; a few ironstone concretions	71	(21)
Conglomerate; black chert pebbles	0.5	(0.1)
Second sandstone member: fine- to medium-grained, grey, bedded and banded	72	(22)
Shale, dark grey, banded and poorly bedded; contains ironstone concretions	65	(19)
First sandstone member: fine grained, grey crossbedded, banded	35	(11)
TOTAL	380.5	(114.1)

Contact relationships. The lower beds are transitional into the underlying Buckinghorse shale and the boundary is drawn below the lowest thick sandstone. This boundary may not be persistent, and is probably drawn at the base of different sandstones from one locality to another.

The upper contact seems to be more distinct with an abrupt change from resistant to recessive beds but the contact is nowhere well exposed.

Distribution. The Sikanni Formation extends southward from the type locality along the prominent escarpment lying east of Halfway River and Kobes Creek and caps mesa-like hills between Halfway River and the Foothills (Irish, 1970; Stott, 1967b). It is not recognized directly north of Peace River, and there is no direct continuity with Goodrich sandstones on the south side of Peace River. The formation is well exposed northward along the escarpments lying east of Minaker and Muskwa Rivers (Pelletier and Stott, 1963; Taylor, 1979; see also Figs. 12, 13). It is well exposed along the canyons of Sikanni Chief and Buckinghorse Rivers and in numerous outcrops along the small creeks flowing eastward from the Minaker Escarpment. Numerous road-cuts along the Alaska Highway expose part of the formation between Sikanni Chief River and the village of Trutch (Mile 200).

At the type section, the formation consists of four sandstone units and is 380 feet (115 m) thick (Plate 11). Irish (1970) stated that, in the Halfway River map-area, the Sikanni Formation is about 300 feet (91 m) thick and consists of three sandstone units. On the Muskwa escarpment, just beyond the northern border of the Trutch map-area, over 800 feet (244 m) of beds are included in the formation (Figs. 3, 12).

The increase in number and thickness of the sandstone is related to a lateral change in both the underlying Buckinghorse and overlying Sully shales. Henderson (1954, p. 2281-2282) outlined a section extending from Trutch Creek to Fort Nelson which includes beds from the base of the Dunvegan Formation to the base of the Sikanni sandstone. Only 195 feet (59 m) were assigned to his "sandy" member and even those beds appear to be largely shale and argillaceous sandstone. It is evident that those exposures reveal the lateral facies change eastward from sandstone to shale.

One of the better exposures occurs on the Alaska Highway south of the settlement of Trutch (sec. 62-18) where 229 feet (70 m) of the formation was measured. Although three sandstone units separated by mudstone are well defined, the relationship of individual sandstones to those of the type section is not certain.

PLATE 11

Sikanni Formation, type region, on Sikanni Chief River, downstream from highway. The prominent, lower three sandstones are separated by recessive mudstones; the top sandstone occurs at skyline and is mostly covered by trees and vegetation. GSC Photo 130605.

The Sikanni sandstone grades rapidly eastward into argillaceous siltstone and mudstone from the junction of Sikanni Chief and Buckinghorse Rivers (Figs. 3, 14). Although some of the units can be traced by means of diagnostic markers on mechanical logs, the formation loses its distinct character and would not likely be mapped as a separate unit in detailed stratigraphic studies of data obtained from boreholes in the Beatton River map-area (94H).

The type Sikanni Formation can be correlated directly with four sandstone units in the Sinclair et al. Julienne c-54-H well (Figs. 13, 14). These beds can be traced eastward across the Trutch (94G) map-area into the westernmost wells of Beatton River (94H) map-area. However, the sandstones grade rapidly eastward into shale.

Lithology. In the type section on Sikanni Chief River, the Sikanni consists of four sandstone units separated by thin intervals of silty shale (Plate 11). To the south along the escarpment east of Halfway River, only three sandstones were noted. Northward across Prophet River, the number of sandstones increases to as many as eleven, which resulted in the succession being informally designated as the 7-11 member by Henderson (1954). The increase in number and thickness of the sandstones is related to a lateral facies change in both Buckinghorse and Sully shales (Figs. 9, 12). The lower sandstone units of the western section appear most persistent. These sandstones represent the nearshore facies of the Buckinghorse sea and attain their maximum development between Prophet and Dunedin Rivers.

The sandstone grades laterally eastward into interbedded silty sandstone, siltstone, and shale, becoming much less resistant in the vicinity of the north-flowing stretch of Prophet River. Outcrops of equivalent silty, argillaceous sandstone are present along Jackfish Creek at the Alaska Highway and along Fort Nelson near Klua Creek.

The Sikanni sandstones are fine grained, finely laminated, siliceous, and weather light brownish grey. Bedding varies from flaggy to thick bedded. The major units at the type locality are 35 to 75 feet (11-23 m) thick but to the northwest, major sandstone units may be as much as 100 feet (30 m) thick. The sandstones are, almost without exception, fine- to very fine-grained. Very fine lamination is characteristic of the Sikanni sandstone. In some of the exposures in road-cuts, slump structures typical of soft sediment flow are well exposed (Plate 12). Fine cross-lamination is observed in many places and crossbedding is also present (Plate 13).

Mudstones are silty dark grey to black, and generally contain oval reddish brown weathering, sideritic concretions.

Hage indicated that the thin chert-pebble conglomerate at the top of the second sandstone was a useful marker, having observed it at Mile 152 and at several places along Sikanni Chief River. He also stated that the sandstone was of uniform character for a distance of 60 miles (96 km) from the Elbow on Halfway River east of Pink Mountain to Prophet River.

Sandstones in the more westerly sections range from very fine grained to fine-grained, and from very well to poorly sorted. Typical sandstones in the siltier facies, particularly in the eastern region, are very fine grained and poorly sorted.

Quartz grains appear to be angular to subangular but the faint trace of secondary overgrowths indicates that many grains were at least subrounded originally. Quartz is the dominant mineral in the Sikanni sandstone, ranging from 60 to 90 per cent. Most of the quartz is nonundulatory.

Chert is the second main constituent, being perhaps less abundant in the Sikanni than in some of the older Cretaceous formations. It has a microaggregate structure. The grains commonly appear slightly smaller than quartz and generally are more rounded. Rock fragments are not common and consist mainly of mudstone or carbonate. Metamorphic grains are generally lacking. Carbonate grains in some

PLATE 12

Slump structures, Sikanni Formation, in highway cut south of Trutch. GSC Photo 130597.

PLATE 13

Crossbedding in Sikanni Formation, type section, Sikanni Chief River. GSC Photo 128303.

samples commonly have a limonitic rim and appear to have been crushed, forming a cement for the more resistant quartz grains. The most important matrix constituent is clay with minor amounts of carbonate, siderite and silica, as shown by overgrowths. The quantity of matrix is generally low but may range as high as 25 per cent. Minor constituents include mica and glauconite which occurs as grains or irregular patches. A few grains of feldspar were observed, but as in the equivalent Goodrich Formation feldspar is rare to absent. Carbonaceous fragments are present but are not a major part of the rock.

Fossil content and age. The Sikanni Formation contains fauna of the Late Albian **Neogastroplites** Zone. Fauna including **Neogastroplites** and **Posidonia**? **nahwisi** was obtained by Hage (1944) from the formation at Sikanni Chief River. McLearn and Kindle (1950, p. 87) reported:

> ***Oxytoma pinania, Solecurtus****? (****Azor****?) sp., and* ***Neogastroplites*** *cf.* ***cornutus*** *Whiteaves (had been collected) on the crest of the Kobe anticline on the left bank of Halfway River ten miles below the mouth of Graham River; and* ***Posidonomya nahwisi*** *var.* ***goodrichensis*** *on Halfway River, 1 mile south of the confluence of Cypress Creek and Halfway River. The following were collected from the second sandstone member:* ***Neogastroplites*** *sp. and* ***Pteria via-media****, on the left bank of Halfway River at the confluence of Cypress Creek and Halfway River;* ***Posidonomya nahwisi*** *var.* ***goodrichensis*** *and* ***Pecten burlingi****, from talus on creek entering the right bank of Sikanni Chief River, 3 miles east of the Highway bridge;* ***Corbicula****? sp. and* ***Oxytoma*** *sp. on Buckinghorse River 2 miles east of the Highway bridge; and* ***Thracia stelcki*** *from talus on Buckinghorse River, east of the Highway bridge. The following were collected from the third sandstone member:* ***Oxytoma*** *sp.,* ***Pleuromya sikanni, Modiolus via-alaska, Thracia yarwoodi,*** *and* ***Pinna hagi****, on south bank of Sikanni Chief River near the bridge. The following are from the fourth sandstone member:* ***Pharus*** *sp.,* ***Oxytoma*** *sp., and* ***Neogastroplites****? sp., from talus on the bank of a creek entering the right bank of Sikanni Chief River 3 miles east of the Highway bridge, and* ***Tancredia stelcki*** *on Buckinghorse River 5 miles east of the Highway bridge.*

It should be noted that only two sandstone units appear along Halfway River and there is no certainty that the basal sandstone there is equivalent to the basal first sandstone at Sikanni Chief River. Warren and Stelck (1969) indicated that equivalents of the third and fourth sandstones occurred in this region.

Jeletzky (1964) reported that **Neogastroplites selwyni** of the basal subzone of **Neogastroplites** was obtained from lower beds of the Sikanni Formation just south of Trutch map-area. **Neogastroplites haasi** (Reeside and Cobban, 1960) equated with **N. selwyni** by Jeletzky (1964, 1968) but considered to be an older species by Warren and Stelck (1969) is reported by the latter to occur in the type third Sikanni sandstone. They considered that the specimen referred to by Jeletzky was referrable to **N. haasi**. **Neogastroplites** ex gr. **cornutus-muelleri** occurs in the upper sandstone at Sikanni Chief River. **Neogastroplites cornutus** var. E (Whiteaves) was reported by Warren and Stelck (1969, p. 535) from the fourth Sikanni sandstone on Halfway River just below Cameron River. These occurrences indicate that the Sikanni Formation of this region lies within the lowest two subzones of **Neogastroplites**. **Posidonia**? **nahwisi** (McLearn) sensu lato?, **Pteria** cf. **camselli** McLearn and **P. via-media** McLearn were collected by Stott from a road-cut near Beaver Creek north of Trutch (GSC loc. 52210).

Irish (1970, p. 73) reported the following fossils (GSC locs. 30772, 30773) from near the mouth of Seventy-four Mile Creek, Halfway River map-area: **Modiolus archisikanni** McLearn, **Modiolus** sp. indet. (nov. sp?), **M. via-alaska** McLearn, **Corbicula**? sp. indet., **Pecten** sp. indet., **Pinna** cf. **P. hagi** McLearn, **Pteria** sp. indet., **Arctica**? sp. indet. He also obtained (GSC loc. 30774), from the top of a ridge on the northeast side of Colt Creek: **Posidonomya nahwisi** McLearn cf. var. **P. goodrichensis** McLearn, and pelecypods, genus and species indet.

Sully Formation

Definition. The Sikanni Formation, as originally defined by Hage (1944, p. 11) consisted of two members: a lower member, 380 feet (115 m) thick, consisting of four sandstones; and an upper member about 600 feet (183 m) thick, consisting of dark marine shale. During studies in the Mackenzie-Liard region, the writer (Stott, 1960b, p. 11) found that both units were mappable and useful over a large region and proposed that both be given formation status. The name Sikanni was restricted to the sandstone and the name Sully applied to the overlying shale.

The Sully Formation occurs as a recessive interval, commonly covered by talus or vegetation, that lies between the fine-grained Sikanni sandstone and the coarse grained to conglomeratic Dunvegan Formation. It is recognized throughout the region between Peace and Mackenzie Rivers (Figs. 3, 12, 13).

The section of the Sully Formation occurring on Sully Creek (Stott, 1906, sec. 2) was designated as type. As that section occurs toward the northern limit of the formation and differs in some respects from the sections in the south, it is desirable to have a standard section in the Sikanni Chief region. The section on Sikanni Chief River between Mistahae and Kettle Creeks is so designated (sec. 62-21).

Contact relationships. The base of the Sully shale apparently lies on successively older sandstones from west to east; the shale appears to grade into Sikanni sandstone and the lower boundary changes stratigraphic position within a relatively short distance (Figs. 12, 14).

The upper boundary of the Sully Formation lies within a gradational succession of interbedded sandstone and shale at the base of the Dunvegan Formation and is drawn at the base of the lowest unit of thick- to massive-bedded sandstone.

Distribution and thickness. The Sully Formation occurs in the broad, plateau-like region east of the Alaska Highway in the Trutch map-area (Pelletier and Stott, 1963). In the standard section on Sikanni Chief River, near Mistahae Creek, the formation is in the order of 720 feet (219 m) thick. It occurs in recessive slopes below cliffs of Dunvegan sandstone and in relatively flat, poorly drained areas east of the Minaker and Halfway escarpments. The canyons of both Sikanni Chief and Buckinghorse Rivers are cut in Sully shale which can be traced downstream to the Fort Nelson River. The formation is only 300 to 400 feet (91-125 m) thick along the Muskwa escarpment to the northwest (Fig. 12).

Henderson (1954, p. 2281-2282) outlined a section between Trutch Creek and Fort Nelson River that was 1455 feet (440 m) thick and included only 195 feet (59 m) assigned to the "sandy" (Sikanni) member. Difficulty is encountered in reconciling that section with the succession near Mistahae Creek.

In the Halfway River map-area to the south, the Sully shale underlies extensive areas on the ridges between Halfway and Cameron Rivers. Irish (1970) did not separate the Sikanni and Sully Formations but the distribution of those formations in that area is shown in part by Stott (1969). Irish estimated that the Sully shale is between 550 and 650 feet (168-193 m) thick in that region. The Sully Formation underlies an area east of Kobes Creek drained by Farrell and Groundbirch Creeks. Farther north it is present in the valley of Aikman Creek, Cameron River, Blair, Townsend, and Gundy Creeks. Farther east, in the Charlie Lake map-area, equivalent beds were included in "upper Fort St. John shale" by Irish (1958) but those beds are assigned herein to the Shaftesbury Formation.

The Sully Formation can be traced in the subsurface as a discrete lithologic unit eastward from the Sikanni River through the Julienne wells into the Beatton River map-area [(94H) Fig. 14]. The disappearance of the underlying Sikanni sandstone by lateral facies change results in a continuous sequence of dark marine shales. The Fish Scale marker horizon is well defined in the well logs and is readily traced across the basin into the westernmost wells, occurring there approximately 175 feet (53 m) above the base of the Sully Formation in Sinclair et al. Julienne c-54-H well. Beds containing abundant fish scales and fragments occur in outcrop in the interval 200 feet (61 m) to 251 feet (76.5 m) above the base on Sikanni Chief River (sec. 62-21).

Lithology. Three distinctive members are recognized in the type region of the Sully Formation and similar facies are found in the Sikanni Chief region.

The basal beds of the standard section in Sikanni Chief canyon east of the highway comprise approximately 250 feet (76 m) of silty, rubbly, dark grey to black mudstone with some sideritic concretions. Argillaceous platy siltstone occurs in the middle and toward the top. A prominent unit of argillaceous siltstone with abundant fish scales and bone fragments and associated with bentonitic layers occurs about 200 feet (61 m) above the base. Presumably those beds are the "Fish Scale marker horizon" that is widespread throughout the Plains (Williams and Burk, 1964) and were so correlated by Price (1963). Those beds are exposed at various places along Sikanni Chief River and Middle Fork Creek, a tributary of Buckinghorse River. Warren and Stelck (1969, p. 530) indicated that in the Fort St. John area, the interval between the top of the Sikanni sand equivalent and the Dunvegan Formation is 801 feet (244 m) thick. They reported a thin tuff bed (Third Tuff) 761 feet (232 m) below the base of the Dunvegan, and two other tuff beds, (First and Second Tuff), to be 300 and 380 feet (91 and 116 m) below the Dunvegan. They recognized the Fish Scale marker horizon bed at 680 feet (207 m) below the Dunvegan sandstone.

The middle part of the formation, about 280 feet (85 m) thick, is not well exposed in the standard section but includes flaky to rubbly, non-concretionary, rusty weathering mudstone with much yellow efflorescence and selenite crystals. Those beds are similar to a well developed flaky shale interval that is recognized at Scatter River (sec. 65-10A) and also in the type section on Sully Creek. The total thickness of this facies is not known as part of both the upper and lower member may be present in covered intervals in the sections.

The upper member consists of at least 120 feet (37 m) of concretionary mudstone and 70 feet (21 m) of interbedded sandstone and mudstone. The mudstone is silty, dark grey to black, rubbly to blocky and contains reddish brown weathering, sideritic concretions. The uppermost beds are siltier with platy, laminated siltstone, and fine grained sandstone in 0.5-to 3-inch (12-75 mm) thick beds.

Fossil content and age. The Sully Formation on Sikanni Chief River lies above beds containing fossils lying within the **Neogastroplites cornutus** Subzone. It lies below the late Cenomanian Dunvegan Formation and, therefore, can be dated as latest Albian to early Cenomanian. The "fish-scale" beds presumably represent the Fish Scale Marker horizon in the subsurface (see Burk, 1962) which according to Stelck (1962) represents the approximate boundary between Lower and Upper Cretaceous rocks. As pointed out by Warren and Stelck (1969, p. 533) the Fish Scale marker bed occurs above the type Goodrich and type Sikanni Formations, not below them as stated by Rudkin (1964, p. 157).

A microfloral assemblage from the Sully Formation of Sikanni Chief River was described by Anan-Yorke and Stelck (1978, p. 481). They listed 37 species of spores and pollen, 29 species of dinoflagellates and four species of acritarchs. They commented (op. cit., p. 482):

> *There is no obvious break in the floral succession. A large number of species continues from the Buckinghorse shale into the Sully Formation and the microfaunal changes throughout the studied section are gradual.*

Muskwa-Tetsa region

Williams (1944), during his investigations along the Alaska Highway between Fort Nelson and Watson Lake, assigned the oldest Cretaceous beds recognized to the "Bullhead Group(?)" and overlying shales to the Fort St. John Group (Plate 14). The beds of the "Bullhead Group(?)" were described by Williams (op. cit., p. 22) as consisting of "black lignitic shale, hard siltstone, and sandstone". Apparently the contact of those beds with the underlying Triasssic succession, now exposed in a road-cut at Mile 375 (Plate 15), was not visible because Williams added:

> *The beds are crushed, folded, and faulted. On the west they lie close to the eastern side of a pronounced anticline in adjoining Middle Triassic strata. The variability of strike and dip of the the two groups suggests a faulted contact at the front of the anticline, which is closely folded and faulted on its western limb. The absence of Upper Triassic and Jurassic strata would also lend support to the occurrence of such a fault were it not possible that beds of these ages may never have been deposited in this region.*

Williams considered that there might be as much as 500 feet (804 m) or more of beds assigned to the "Bullhead Group(?)". However, in the road-cut at Mile 375 only 9 feet (2.7 m) of sandstone with minor conglomerate and interbedded, silty mudstone lie on fine grained sandstone of the Triassic Liard Formation (Plate 15). That unit is overlain by mudstone typical elsewhere of the Fort St. John Group. Although those basal beds may indeed be equivalent to some part of the Bullhead Group, they do not form a mappable unit and are included in the Fort St. John Group. McLearn and Kindle (1950), in their summary of Williams's investigations along the Alaska Highway, omitted any mention of the questionable Bullhead strata, stating unequivocally (op. cit., p. 71): "Somewhere between Pocketknife and Tetsa Rivers, the Bullhead group disappears from the geological column, for it has not been found in Tetsa and Liard Valleys". Apparently McLearn's perceptive understanding of Cretaceous stratigraphy had rectified the misconception.

PLATE 14

Tsoo Tablelands, looking southwest across Alberta Plateau between Fort Nelson and Muskwa Rivers. Low terrain in foreground is underlain by Sully and Sikanni Formations; the scarp is formed by the resistant, conglomeratic Dunvegan Formation. R.C.A.F. Photo T27R-196.

In an earlier study, Williams (1923, p. 6b) had concluded that the Fort St. John shales north of Fort Nelson were underlain by sandstones that he considered "may be equivalent to the Bullhead Mountain sandstone". Williams noted, about 20 miles (32 km) above the junction of the Liard and Fort Nelson Rivers, "100 feet of crossbedded, torrential sandstone and grits containing plant fragments in upper beds". Actually, those beds are part of the Dunvegan Formation occurring on the west flank of the Liard Syncline. Williams's miscorrelation may be attributed possibly to his inability to observe from the valley bottom the prominent west-dipping sandstones on the east flank and to his probable assumption that the conglomeratic sandstones cropping out along the river banks continued to dip eastward beneath shales occurring farther upstream.

Williams (1944) concluded that the total thickness of the Fort St. John Group in the vicinity of Tetsa River was in the order of 1500 feet (457 m) or more. He outlined the following section:

	Thickness feet (metres)	
Top of Section		
Shale	250	(76)
Sandstone and shale with **Posidonomya nahwisi** var. **goodrichensis** and **P. nahwisi** var. **moberliensis**; poorly preserved plant remains	600	(183)
Shale and sandstone	500	(152)

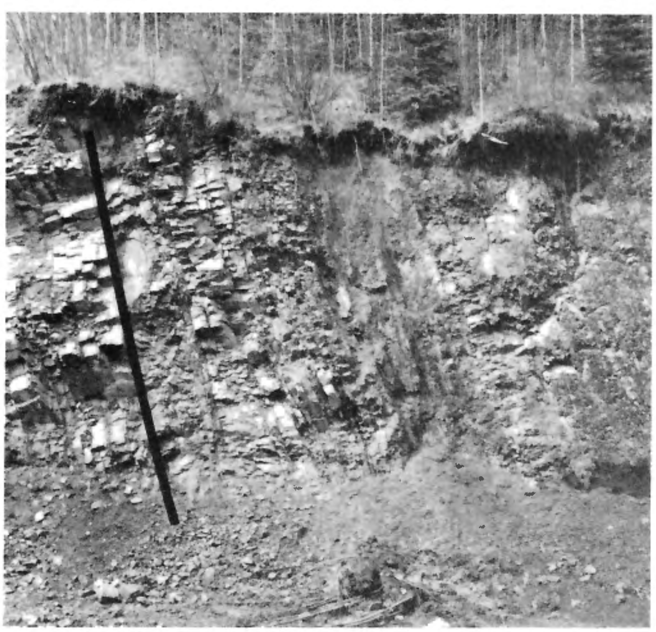


PLATE 15

Contact of Cretaceous Buckinghorse Formation with underlying Triassic Liard Formation, Mile 375, Alaska Highway. Basal 9 feet (3 m) of Buckinghorse consists of sandstone and silty mudstone with some pebbles. GSC Photo 128413.

Williams noted that the lower shales were distributed over a wide area and that their thickness might be twice his estimate. He correlated the beds with the Pine River sequence, the only reasonably well known succession at that time. He considered that the lower shales corresponded with the Hasler Formation, the middle fossiliferous sandstones with the Goodrich Formation and the upper shales with the Cruiser Formation. However, he applied no formal names to the units he recognized.

Although Henderson (1954) did not apply the term Fort St. John to the Lower Cretaceous shales of the Muskwa River region, he did outline the succession in considerable detail. He indicated that the Buckinghorse shales, lying in the Triassic Toad Formation, had a total thickness of 3617 feet (1103 m) and could be divided into three members. He indicated that those beds were overlain by 800 feet (244 m) of Sikanni sandstone which, in turn, were separated from the Dunvegan Formation by 250 feet (76 m) of shale. According to Henderson's calculations, the total succesion was in the order of 4700 feet (1433 m) thick.

Stelck et al. (1956) outlined, in chart form, a five-fold division of the Fort St. John Group that had not been described previously. Their terminology combined formational names defined by Kindle (1944) on Liard River with the Sikanni Formation as defined farther south by Hage (1944). Their succession, in ascending order, was Garbutt, Scatter, Lepine, Sikanni sandstone, and Sikanni shale. Subsequently Stelck (pers. comm., Dec. 8, 1958) provided additional information:

> *We are basing the five-fold division of the St. John group on the section west of Fort Nelson in the Chischa (Sheep Creek) region. Here we had Garbutt at the base, with the "**Lemmoceras**" (sic) fauna well shown about 800 feet above the Triassic. Down the creek the Scatter came in with the **Inoceramus altifluminis** fauna. At this point the Sikanni is sitting above us on the cliffs to the east of Muskwa River and to the north of the Tetsa River where I was able to pick up a typical Sikanni sandstone suite of Pelecypods. The Sikanni sandstone here is around 600 feet or so in thickness and the section becomes shaly again above the Sikanni sandstone before the Fort Nelson conglomerate appears to cap Steamboat Mountain.*

This five-fold subdivision is most useful in the region north of the junction of Toad and Liard Rivers. Although sandstones equivalent to the upper Scatter Formation are present in the vicinity of Chischa Creek, they have only local distribution (Taylor and Stott, 1968b). For present purposes, they are included as part of the Buckinghorse Formation, as was done by Henderson (1954). The Fort St. John Group of the Muskwa-Tetsa region, therefore, comprises the Buckinghorse, Sikanni, and Sully Formations (Table III).

The distribution of the group in this region is shown on Tuchodi Lakes, Fort Nelson and Toad River map-areas (Taylor and Stott, 1973; 1968b; 1980; see also Fig. 3). Much of the lower part is exposed on Tetsa River (Stott, 1968a, sec. 64-3) and, although exposures are not continuous, a composite section can be constructed from outcrops there and on the Muskwa Escarpment (sec. 64-25) (Fig. 12, 13). The group is about 4500 to 4700 feet (1372-1433 m) thick in the vicinity of Muskwa River but decreases in thickness eastward, being about 2500 feet (762 m) thick in wells on the eastern side of the Fort Nelson map-area.

TABLE III

TABLE OF FORMATIONS

Muskwa and Tetsa River Region

Series	Group	Formation thickness	Lithology
Upper Cretaceous		Dunvegan 500-600' (152-183 m)	Massive conglomerate; fine- to coarse-grained sandstone; carbonaceous shale and mudstone; coal.
		Sully 300' (91 m)	Dark grey, marine shale with sideritic concretions.
Lower Cretaceous		Sikanni 800-1000' (244-304 m)	Fine grained, laminated, marine sandstone; silty mudstone.
	Fort St. John 4500-4700' (1372-1432 m)	Buckinghorse 3500'± (1066± m)	Dark grey, silty marine shale with sideritic concretions; highly glauconitic, fine grained sandstone and siltstone.
Regional erosional unconformity; bevels succeedingly older rocks eastward.			

In this region, the Fort St. John Group lies unconformably on Triassic rocks in the Foothills and farther east on Mississippian beds. At Mile 375, the immediately underlying sandstone is assigned to the Triassic Liard Formation and only a few miles farther east on Tetsa River (sec. 64-3), the Cretaceous rocks are in contact with shale and siltstone of the older Triassic Toad Formation.

In the subsurface of the more southerly part of the Fort Nelson (94J) map-area, the entire Fort St. John Formation is penetrated in wells drilled on the high plateau country between Muskwa and Prophet River (Fig. 15). The upper part of the group is eroded in the region of Prophet and Fort Nelson River. From there, the line of section has a northerly trend, and the complete group is penetrated in the Imperial Island River No. 1 well (Lat. 60°09'29"N, Long. 121°08'16"W). The base of the group lies unconformably on Triassic rocks in the western sections and on Mississippian rocks to the east and northeast.

The cross-section (Fig. 16) drawn near the northern boundary of the Fort Nelson (94J) map-area, illustrates the development of a major flexure, resulting in a much thicker sequence of beds in the Muskwa-Tetsa region than in the eastern part of Fort Nelson map-area. The Radioactive Marker 3, used as datum, is well defined in the well logs, and the interval between it and the sub-Cretaceous unconformity is relatively uniform in the east but increases markedly between (Gulf States) Evie Lake No. 1 well (b-90-G/94-J-14) and Pacific SR CanDel Kledo c-14-G well (c-14-G/94-J-13). That change appears to coincide with a postulated extension of the Bovie Lake fault zone (Taylor and Stott, 1968a) where the west side has dropped relative to strata on the east side.

Buckinghorse Formation

Definition. Lower Cretaceous shales assigned to the Buckinghorse Formation in the Muskwa-Tetsa region are in direct continuity to the south with the type Buckinghorse Formation (Fig. 3).

Distribution and thickness. Silty, marine shales of the Buckinghorse Formation occur in the broad belt formed by the low-lying region between the eastern Foothills and high escarpments capped by the overlying Sikanni sandstone. The shales occur at the surface over a large part of the Plains northeast of Klingzut Mountain, outcropping in high cliffs along Prophet River. Lowermost beds of the Buckinghorse are exposed on the eastern flank of the folded belt between Bat Creek and Tuchodi River. Fairly continuous outcrops occur along Gathto and Chlotapecta Creeks, Chischa and Tetsa Rivers. In that region, the upper part of the formation is exposed in gullies along the Muskwa Escarpment. Only a few exposures are present in the valleys of the lower Muskwa River, but the formation can be recognized in wells drilled within the central part of Fort Nelson map-area.

The Buckinghorse Formation is recognized as far north as the junction of Toad and Liard Rivers (Figs. 3, 9). In that vicinity, major sandstone units appear in the lower to middle part of the shale succession and, consequently, other formational assignments are made. Only small, isolated outcrops of the Buckinghorse were noted on Dunedin River and its western tributaries. Scattered exposures occur along Dunedin Escarpment to the east.

In the middle to eastern part of the Fort Nelson map-area, Buckinghorse shales occur along the lower part of Prophet River and such western tributaries as Tenaka and Cheves Creeks. Much of the country east of the Alaska Highway is covered by muskeg and the surface bedrock consists of the Sikanni Formation or higher beds. A few exposures of the Buckinghorse Formation occur along Fort Nelson River above its junction with Muskwa River but are rare along the river below the town of Fort Nelson. No outcrops were found along Snake River to the east.

One of the most complete sections occurs on the south side of Tetsa River near Mile 367 on the Alaska Highway (sec. 64-3), where about 2000 feet (610 m) of the lower part of the formation is exposed. Upper beds of the formation are well exposed on the escarpment east of Muskwa River (sec. 64-25). An estimated thickness of about 3500 feet (1067 m) is given by this composite section (Fig. 13). Thicknesses in that order occur in Pacific Sr. CanDel Kledo c-14-G well (c-14-G/94-J-13) and CDR Pac. Sinc. Prophet d-21-B well (d-21-B/94-J-3) (Fig. 13). Farther east beyond Fort Nelson, the Buckinghorse Formation has decreased in thickness to about 2000 feet (610 m) in B.A. Shell Klua Creek b-49-F well (b-49-F/94-J-9) and slightly less than 2000 feet (610 m) in B.A. Shell Klua Creek No. 2 well (2-56-H/94-J-9).

The Buckinghorse Formation is approximately 600 feet (183 m) thicker in the Muskwa-Tetsa region than in the Sinclair et al. Julienne c-54-H well (c-54-H/94-G-2). Although the well is located southeast of Buckinghorse River, the thickness there is probably only slightly less than that of the type section. The thickness on Tetsa River is approximately the same as that encountered 25 miles (40 km) to the northeast in the Pacific SR CanDel Kledo c-14-G well (c-14-G/94-J-13).

Contact relationships. The Buckinghorse Formation south of Tuchodi River lies, possibly disconformably, on the Gething Formation. The contact is marked by an abrupt change from glauconitic, concretionary sandstone to rubbly, rusty weathering shale. A thin bed of pebbles commonly occurs at the base of the shales. Outcrop sections where this contact is exposed were described previously from Prophet River, Bat Creek, Kluachesi River, and Gathto Creek (Stott, 1963; secs. 64-21, 64-22, 64-23, 64-24).

The lower part of the Buckinghorse is exposed along the banks of Chlotapecta Creek (sec. 65-3). At that locality, 48 feet (15 m) of fine grained sandstone lies on the Triassic Liard Formation. The sandstone of the two units appears similar but the Liard sandstone is highly calcareous. The sandstone included in the Buckinghorse Formation almost certainly is equivalent to some part of the Gething Formation. It is predominantly fine grained, siliceous, grey, thick bedded, and weathers rust to grey. The contact between the sandstone and shale is abrupt and distinct.

At the westernmost exposure of Cretaceous beds along Chischa River, black shale appears to lie unconformably on Triassic rocks, although 2 to 3 feet (0.6-0.9 m) of fine grained sandstone occurs about 10 feet (3 m) above the base of the Buckinghorse. On the western flank of the next anticline downstream, the basal Cretaceous beds comprise 9 to 10 feet (2.7-3 m) of fine grained, siliceous, massive sandstone with some pebbles embedded in the upper surface.

At Mile 375 on the Alaska Highway (sec. 64-1), the basal Buckinghorse Formation is marked by 9.5 feet (2.9 m) of interbedded mudstone, sandstone, and some conglomerate which lies paraconformably on the lowermost part of the Triassic Liard Formation (Plate 15). The conglomerate consists of one-eighth to one-half inch (3-13 mm) chert pebbles with a sandy, mudstone matrix. A small remnant of the underlying Triassic is partly surrounded by conglomerate. About 235 feet (71 m) of typical Cretaceous, concretionary mudstones overlie the coarser basal beds.

Farther downstream on Tetsa River, the basal shales of the Buckinghorse Formation lie on the older Triassic Toad Formation and there is no evidence of a basal conglomeratic unit within the Buckinghorse.

Farther east, basal Cretaceous beds overlie Permian, Mississippian, and Devonian strata (Figs. 15, 16). Permian rocks lie below Cretaceous beds in a small area centred around Liard River where it crosses the 60th parallel of latitude. Mississippian rocks occur beneath Cretaceous beds in a broad belt extending from that locality southeasterly into Alberta. To the east of the British Columbia-Alberta border, Cretaceous rocks lie unconformably on progressively older Devonian beds.

The upper contact of the Buckinghorse Formation is exposed along the Muskwa Escarpment and also along the Alaska Highway at Mile 351. At these localities, Buckinghorse shale grades upward into Sikanni sandstone through an interval of interbedded sandstone and mudstone which becomes increasingly sandier toward the top.

Lithology. At Prophet River (Stott, 1973, sec. 62-20), the basal 65 feet (19.3 m) of the Buckinghorse Formation consist of very silty, black mudstone containing a few sideritic concretions, thin seams of bentonite, and traces of glauconite. These basal beds lie on a highly glauconitic unit of interbedded sandstone and concretionary mudstone assigned to the Gething Formation. Similar beds occurring above Gething sandstone are exposed north of Prophet River, near Bat Creek, between Kluachesi and Muskwa Rivers (Stott, 1973, secs. 64-21, 64-22, 64-23). Some 775 feet (236 m) of basal beds outcrop on a tributary of Gathto Creek (Stott, 1973, sec. 64-24); the lower 500 feet (152 m) of silty mudstone contain numerous large sideritic concretions but the overlying mudstone is less silty and contains only rare concretions.

In the Tuchodi-Tetsa region, the Buckinghorse Formation is readily divisible into three major units, corresponding in large part to the Garbutt, Scatter, and Lepine Formations of the Liard region. Recognition of these three units resulted in the application of those names by Stelck et al. (1956). Owing to the limited local distribution and relatively minor development of the sandstones, they are more conveniently included in the Buckinghorse Formation for the purposes of this report. Black, rusty-weathering shales with large sideritic concretions occur at the base of the formation and are overlain by rubbly to flaky shales. These basal shales are well exposed on Tetsa River and Chlotapecta Creek (secs. 64-3, 65-3) (Figs. 13, 15). In the region of Chischa River and Chlotapecta Creek, an overlying succession, consisting of two sandstone sequences separated by dark shale, is similar to the Scatter Formation. The lower sandstone sequence of interbedded, silty sandstone and shale is moderately recessive. The second succession of sandstone, separated from the first by dark shale, is approximately equivalent to the upper Scatter sandstone (Plate 16). It is well exposed at the junction of Chlotapecta Creek and Muskwa River and on Chischa River (sec. 64-29). It consists of several units of fine grained, platy to thick-bedded sandstone with intercalated silty mudstone. The upper Buckinghorse Formation, well exposed east of Muskwa River (sec. 64-25), consists of concretionary shale at the base, rusty flaky shale in the middle, and silty shale with platy siltstone in the upper part.

At Chlotapecta Creek (sec. 65-3), where 1558 feet (475 m) of section was measured, the basal Buckinghorse sandstone is overlain by blocky mudstone containing large siderite concretions. Thin seams of bentonite occur sporadically in the lower 300 feet (91 m). A few thin beds of siltstone and very fine grained sandstone occur in the succeeding mudstone and a 24-foot (7.3 m) unit of sandstone occurs about 1300 feet (396 m) above the base. The remainder of the exposed section includes mudstone and interbedded sandy siltstone.

More than 2000 feet (610 m) of the lower Buckinghorse Formation is exposed at Tetsa River (sec. 64-3). At that locality, Buckinghorse mudstone lies directly on the siltstone and shale of the Triassic Toad Formation. The lower 920 feet (280 m) of the Buckinghorse Formation consist of silty, concretionary mudstone with a few units of argillaceous, platy siltstone and sandstone. Thin seams of bentonite are present in the upper half of this unit. The overlying 500 feet (152 m) comprise flaggy to thin-bedded siltstone and sandstone with varying amounts of intercalated shale. Those beds are approximately equivalent to the lower sandstone member of the Scatter Formation. The remainder of the Tetsa section, about 500 to 600 feet (152-183 m) thick but not all exposed, contains rubbly mudstone with some very silty, blocky mudstone and argillaceous siltstone in the upper part. This upper part may be equivalent to some part of the middle and upper members of the Scatter Formation.

The upper part of the formation is exposed in gullies along the Muskwa Escarpment and also along the Dunedin Escarpment west of Steamboat Mountain. In a gully on the escarpment southeast of Kluachesi River, some 1200 feet (366 m) of Buckinghorse mudstone is fairly well exposed (sec. 64-26). The lower 925 feet (282 m) contains rubbly mudstone to flaky shale that has a yellow efflorescence and generally contains only a few concretions. This part of the section is similar to the lower middle part of the Lepine Formation at Liard River and to the upper part of the type Buckinghorse Formation. The upper 300 feet (91 m) of the section on the Muskwa Escarpment contain large, reddish brown weathering sideritic concretions, and resemble the upper Lepine Formation and the type upper Buckinghorse Formation on Buckinghorse River.

Farther north, on the escarpment east of the junction of Chlotapecta Creek and Muskwa River (sec. 64-25), about 2000 feet (610 m) of the upper Buckinghorse Formation are almost entirely exposed. The basal 144 feet (44 m) contain sandstone considered equivalent to the upper Scatter (Tussock) sandstone. On Chischa River (sec. 64-29; Plate 16); this part of the succession includes two prominent units of fine grained, silty, thin bedded sandstone overlain by several alternating units of mudstone, argillaceous siltstone, and sandstone. The sandstone is well indurated with siliceous cement and weathers brown. Henderson (1954, p. 2284) reported a thickness of 232 feet (71 m) for this sandstone unit, but the writer included 262 feet (80 m) in it. Opposite Chlotapecta Creek, the sandstone unit is overlain by 355 feet (108 m) of black, rubbly to blocky mudstone with reddish weathering, sideritic concretions. The middle part, approximately 400 feet (122 m) thick, contains rubbly mudstone with a yellow efflorescence, some thin interbeds of very silty, platy sandstone, and thin bentonitic seams. The upper part, about 1200 feet (366 m) thick, similar to the lower beds, contains mudstone with well developed sideritic concretions. These beds grade upward into the Sikanni sandstone.

PLATE 16

Sandstone equivalent of the Upper Scatter Formation, along axis of small anticline, Chischa River.

Fossil content and age. An assemblage of foraminifera, dated as Early Albian, was identified by T.P. Chamney from a sequence of samples collected from the lower 65 feet (19.8 m) of the Buckinghorse Formation on Prophet River (Stott, 1973, sec. 62-20). This assemblage included such forms as **Quadrimorphina** cf. **Q. albertensis** Mellon and Wall, **Gaudryina nanushukensis** Tappan, **Conorbina norrisi** (Mellon and Wall), **Miliammina** sp., and **Haplophragmoides** spp. Chamney suggested that the fauna may be older than the **Arcthoplites mcconnelli** Zone (Fig. 5).

It is possible that shales equivalent to the Gething Formation to the south are included in the Buckinghorse Formation within the Muskwa-Tetsa region. If so, the basal beds in that region would be somewhat older than the type Buckinghorse beds from which **Arcthoplites** and **Beudanticeras** were obtained and which overlie Gething strata. However, as discussed in the section on Correlation, this problem is unresolved.

Sikanni Formation

Definition. The Sikanni Formation, comprising the lower sandstone of Hage (1944) and as restricted by Stott (1960b), is most fully developed in the Muskwa-Tetsa region (Plate 17). Henderson (1954, p. 2282), who included all the beds between the Buckinghorse and Dunvegan Formations in the Sikanni Formation, described the Sikanni as being 800 feet (244 m) thick in the vicinity of Tetsa River and as comprising "seven strong sandstones with intervening shales and with four (or more) other thin sandstones above. These beds are referred to here as the 7-11 Sandstone member". Although the formation was defined some 100 miles (161 km) to the southeast on Sikanni Chief River, it is best developed along the Muskwa and Dunedin Escarpments.

Distribution and thickness. The formation extends from its type locality on Sikanni Chief River northwesterly along a series of prominent escarpments lying east of Minaker, Muskwa, Dunedin, and Liard Rivers (Fig. 3). It forms the surface bedrock east of Prophet River and of several large, erosional remnants east of Muskwa River, but is best exposed along the Muskwa Escarpment (Plate 17). Within the Fort Nelson map-area (94 J), the formation gradually becomes much more argillaceous and recessive eastward, and finally becomes inseparable from other beds of the Fort St. John Group. Exposures are scarce north of Mile 230 on the Alaska Highway but the formation does crop out along Jackfish Creek and for several miles along Fort Nelson River in the vicinity of Klua Creek.

The formation is exposed in a series of road-cuts along the Alaska Highway in the vicinity of Steamboat Mountain between Miles 350 and 356. There, the lower, thick-bedded sandstone units form resistant cliffs. To the north of Kledo Creek, the Sikanni beds are not well exposed but their ridge-forming character permits mapping from aerial photographs. Farther east, the Sikanni Formation is more recessive but it caps broad, flat-topped ridges extending toward Fort Nelson. Several exposures of very silty, platy to thin-bedded sandstones occur in gullies of small streams flowing off the south side of those ridges.

Twelve sections were examined between the type locality and Scatter River (Fig. 12). The Sikanni Formation of the type region increases northwesterly toward the Muskwa-Tetsa region. That increase is directly related to a lateral facies change from Sully shales in the southeast to sandstone assigned to the Sikanni in the northwest. The thickest section, consisting of more than 1000 feet (304 m) of strata, occurs on the escarpment east of Dunedin River (sec. 65-5) but the average thickness along Dunedin and Muskwa Escarpments is somewhat less. The formation is more than 800 feet (244 m) thick, opposite the mouth of Kluachesi River (sec. 64-27), over 900 feet (274 m) thick opposite the mouth of Tuchodi River (sec. 64-30), and over 900 feet (274 m) thick south of McClellan Creek (sec. 64-6).

Contact relationships. The lower beds of the Sikanni Formation are transitional into the underlying Buckinghorse shale and the boundary lies at no persistent stratigraphic horizon. These beds are well exposed at Mile 351, on the Alaska Highway and opposite the mouth of Chlotapecta Creek (sec. 64-25). At these localities, silty, blocky mudstone with well developed concretions contain more silt upward into the section and thin, platy, argillaceous sandstone and siltstone become more numerous. The contact is drawn at the first appearance of well developed and continuous sandstone beds.

The upper contact of the Sikanni sandstone with the overlying Sully mudstone is not exposed. Generally, there appears to be a very distinct change from resistant sandstone to recessive mudstone, but in all sections examined, the basal Sully beds were covered. Within the Muskwa-Tetsa region, the top of the Sikanni appears to lie at approximately the same stratigraphic horizon (Figs. 12, 15) but to the east, the upper sandstones grade laterally into mudstone and the contact is drawn at the top of the successively older sandstones from west to east.

PLATE 17

Sikanni Formation on Muskwa Escarpment east of Tuchodi River. GSC Photo 128446.

Lithology. The number of major sandstone units in the formation appears to fluctuate from one section to another. The main part of the formation between Prophet and Dunedin Rivers appears to comprise 7 major cycles of sandstone and shale (Fig. 12). The upper 150 to 200 feet (46-61 m) of the formation, commonly obscured by talus or vegetation, seems to be formed by a more continuous sandstone succession which is more argillaceous and less well bedded than the underlying sandstones. Although thin beds of silty mudstone to shale are present in this upper part, well developed units consisting only of mudstone do not occur.

Three sandstones are exposed along the Alaska Highway, a few kilometres south of the village of Trutch (sec. 62-18). There, the sandstones are argillaceous, very finely laminated, platy to thick-bedded. Some well-developed slump structures are present in the road-cuts (Plate 12).

On the Muskwa Escarpment, opposite the mouth of Chlotapecta Creek (sec. 64-25), the Sikanni Formation is well exposed but mostly inaccessible (Plate 17). Seven sandstone units, readily defined, range in thickness from 35 to 80 feet (10.7-34.4 m). The upper part of the formation, over 200 feet (61 m) thick, appears to consist mainly of sandstone with only minor interbedded mudstone. To the south, opposite Tuchodi River (sec. 64-30), seven sandstone units can be defined but these do not correlate precisely with those at Chlotapecta Creek, 15 miles (24 km) distant. Farther south, opposite the mouth of Kluachesi River (sec. 64-27), only the lower 325 feet (99 m) of the formation are well exposed.

Three sections (64-4, 65-5, 64-6) were examined in the Dunedin Escarpment. The first section north of Steamboat Mountain (64-4) is not well exposed at the top and additional beds may be present below the lowermost outcrop. The sandstones there match fairly well with similar units at the next section to the north (sec. 65-5; Fig. 12). The latter is the thickest section measured and is probably complete. The sandstone units do not match too well with the next section north (sec. 64-6) although some of the thicker units appear to be continuous. The sandstone in all these sections is very similar. However, the occurrence of 40 feet (12.3 m) of medium-grained to conglomeratic sandstone in section 6-5 is an exception to the typical Sikanni sandstone. At least 15 feet (4.6 m) of conglomerate occurs near the top, containing pebbles averaging about one-half of one inch (12.7-25.4 mm) in diameter, but some are as much as one and one-half inches (38.1 mm). These pebbles are dominantly chert.

Sandstones of the Sikanni Formation vary from flaggy to thick-bedded (Plate 18), and units range from less than one foot (0.3 m) to as much as 100 feet (30.4 m). Thin, platy bedding and crossbedding are common (Plate 19). Slump structures (Plate 12) are well developed in the more easterly section and are well exposed in road-cuts along the Alaska Highway.

The sandstones are mainly fine grained, very finely laminated, siliceous and weather light brownish grey. Sorting varies from very good to poor. Typical sandstones in the siltier facies are very fine grained and poorly sorted.

The main constituent is quartz, ranging from 60 to 90 per cent. Quartz grains appear to be angular to subangular but the faint traces of secondary overgrowths indicate that many grains were at least subrounded originally. Chert is the second main constituent of the Sikanni sandstones, although perhaps less abundant than in some of the older Cretaceous formations. It generally has a microaggregate structure. The grains commonly appear smaller than the quartz grains and are more rounded. Rock fragments are not common in the Sikanni sandstone but consist mainly of argillaceous or carbonate grains. Metamorphic grains are rare. Carbonate grains commonly have a limonitic rim and some appear to have been crushed, forming a cement for the more resistant quartz grains. Minor constituents include mica flakes and many thin sections include traces of glauconite, which occurs as grains or irregular patches. A few grains of feldspar were observed, but as in the equivalent Goodrich Formation, feldspar is rare to absent. Carbonaceous fragments are present but do not consitute a major part of the rock. The most important matrix constituent is clay with minor amounts of carbonate, siderite, and notable silica, as shown by the overgrowths. Matrix is generally low, averaging between 5 and 10 per cent but ranging as high as 25 per cent of the total rock.

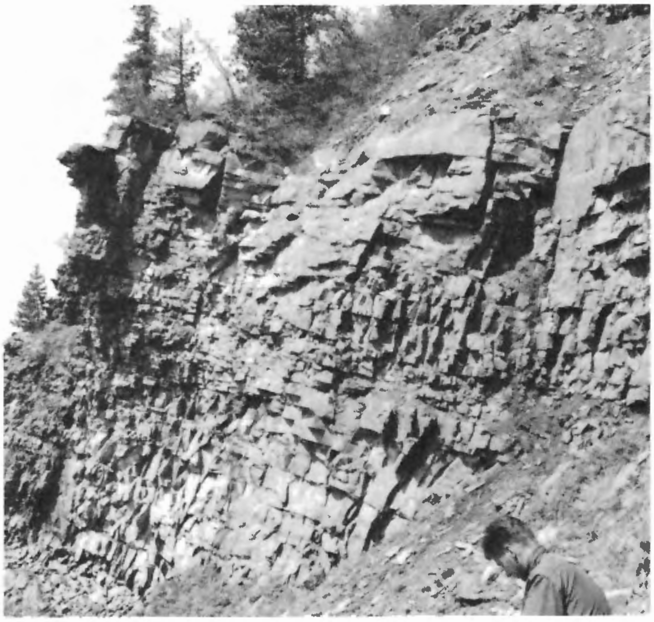


PLATE 18

Bedding in Sikanni sandstone, north of Steamboat Mountain; section 64-4. GSC Photo 128422.

PLATE 19

Crossbedding in Sikanni Formation, Dunedin Escarpment; section 65-5. GSC Photo 128466.

The shales occurring between the major sandstone units are dark grey to black, rubbly to blocky and contain some concretions. They are commonly silty and thin beds of sandstone and siltstone may be present within the shale units.

The main sandstone facies grades laterally eastward into interbedded silty sandstone, siltstone, and shale, becoming much less resistant in the vicinity of the north-flowing part of Prophet River. Outcrops of equivalent beds are present along Jackfish Creek and along Fort Nelson River near Klua Creek. In the region, the strata consist of thin, flaggy beds of very fine-grained, grey laminated sandstone and argillaceous siltstone with interbedded rubbly, rust-weathering shale.

Along the Tsoo Tablelands, (Plate 14) Sikanni sandstones are fine grained, finely laminated, siliceous, and weather brownish grey. Bedding is fairly uniform but can vary from flaggy to thick-bedded. Shales are silty and commonly include sideritic concretions that weather reddish brown. East of the Tablelands, the Sikanni Formation consists of platy to flaggy, silty sandstone with interbedded siltstone and shale, and loses its prominent ridge-forming character. Its recognition on the flat ridges of the Poplar Hills south of Fort Nelson is based on a few scattered outcrops and on the topographic expression.

Fauna and age. **Posidonia**? **nahwisi** var. **goodrichensis** (McLearn) and **P.**? **nahwisi** var. **moberliensis** (McLearn) were collected by Stott at Mile 353 on the Alaska Highway (GSC loc. 65921); **Posidonia**? **nahwisi** (McLearn) f. typica was collected from the talus of the Sikanni Formation north of Steamboat Mountain (GSC loc. 65926); and **P.**? **nahwisi** (McLearn) sensu lato? was collected from a road-cut near Beaver Creek north of Trutch (GSC loc. 52210). A similar fauna, including **Neogastroplites**? was collected by Williams (1944) from road-cuts near Steamboat Mountain. This fauna is considered by Jeletzky to represent part of the **Neogastroplites** Zone of Late Albian age.

Sully Formation

Definition. The Sully Formation comprises those marine shales lying between the Sikanni and Dunvegan Formations. In the Muskwa-Tetsa River region, it forms a thin, recessive unit below the massive cliffs of the Dunvegan and can be readily mapped throughout the region. The formation is commonly covered by talus or vegetation.

Distribution and thickness. The Sully Formation underlies a large area between Klua Lakes and Fort Nelson on the east side of the Fort Nelson map-area. Exposures along Klua Creek consist of rusty weathering, black, rubbly shale. Directly east and just beyond the eastern boundary of the map-area, the Sully is exposed along the lower part of Sikanni Chief River where several large cliffs are formed of soft muddy shale coated with a yellow efflorescence and containing abundant small selenite crystals.

The Sully Formation, well developed although not totally exposed at any one locality in the Sikanni Chief region, shows a marked change in thickness from 700 feet (213 m) to about 400 feet (122 m) or less in the Muskwa-Tetsa region (Figs. 12, 13). The formation is eroded in much of the Plains area to the east but equivalent beds appear again in the north part of Petitot River (94P) map-area and Trout River (95 SE) map-area. The Fish Scale marker horizon, recognized to the south (Fig. 14) and north (Fig. 18) has not been identified in the western area. However, it probably lies at or near the top of the Sikanni Formation along the Dunedin-Muskwa Escarpments.

Only a few outcrops of Sully shale were found along the Muskwa and Dunedin Escarpments (Figs. 3, 12). The formation appears to range from about 250 to 400 feet (76-122 m) in thickness in that region, although it maintains a fairly uniform thickness of about 300 feet (91 m) along the escarpments but increases eastward to as much as 700 feet (213 m). The increased thickness is directly related to the lateral eastward facies change from Sikanni sandstone to shales included in the Sully Formation.

Contact relationships. The base of the formation apparently lies on successively older sandstones from west to east; the shales appear to intertongue with Sikanni sandstones and the lower boundary changes stratigraphic position. The base appears to lie at approximately the same stratigraphic position along the Muskwa and Dunedin Escarpments, as the formation shows little variation in thickness. However, the succession included within the Sully increases in thickness farther east, and presumably additional beds are included there.

The upper boundary lies within a gradational succession of interbedded sandstone and shale at the base of the Dunvegan and is drawn at the base of the first unit of thick- to massive-bedded sandstone. That contact appears to lie at approximately the same stratigraphic horizon, lying below a remarkably persistent sandstone of the Dunvegan along the Muskwa and Dunedin Escarpments (Figs. 3, 12).

Lithology. The Sully Formation is poorly exposed in this region and generally only the beds immediately below the Dunvegan cliffs are visible. In this region, the formation appears to consist of silty, dark grey to black mudstone with reddish weathering sideritic concretions. Interbedded argillaceous siltstone and fine grained sandstones in half-inch to three-inch beds occur near the top. The sandstone is similar to that found in the more massive beds at the base of the Dunvegan Formation.

The formation is best exposed on the ridge north of Steamboat Mountain (sec. 64-4), although the contacts with the enclosing formations are covered. The Sully strata, 290 feet (88.4 m) thick, comprise rubbly to blocky, dark grey to black mudstone. Some concretions and thin beds of silty sandstone and siltstone occur in the upper half.

Age. The Sully Formation, lying between the Late Albian Sikanni Formation and the Late Cenomanian Dunvegan Formation, is dated as latest Albian to early Cenomanian. The basal shale strata of the formation in the type region in the District of Mackenzie and also at Sikanni Chief River are represented apparently in Tuchodi Lakes and western Fort Nelson map-areas by the upper Sikanni sandstone. Therefore, the base of the Sully Formation in that region is presumably younger than at the type locality. At the type section on Sully Creek and in the standard section at Sikanni Chief River, the Sully Formation lies above beds containing **Neogastroplites cornutus** (Whiteaves). It appears that the top of the Sikanni Formation in the Muskwa-Tetsa region coincides approximately with the Fish Scale marker horizon. The latter is considered by Stelck (1962) to approximate the boundary of Lower and Upper Cretaceous rocks. Therefore, the total interval of the Sully Formation in the Muskwa-Tetsa region may represent only early Cenomanian (earliest Late Cretaceous).

Scatter-Liard region

Cretaceous rocks of the Liard region were described first by R.G. McConnell (1890, p. 20D) as follows:

> *Fossiliferous Cretaceous beds were not recognized in descending the Liard until the plateau belt which borders the eastern foothills was reached. . . . The beds here consist of soft, finely laminated shales, interstratified with a few beds of sandstone and ironstone. . . . Near the eastern edge of the plateau belt the shales are overlain by massive beds of rather soft sandstone and conglomerates.*
>
> *The Cretaceous sections along the Liard thus show two great shale and sandstone series separated by a heavy band of sandstones and conglomerates. . . .*
>
> *The Cretaceous rocks cross the Liard with a width of over a hundred miles. . . ; southwards they are connected with the great Cretaceous basin of the plains.*

The Cretaceous sequence was not described in any detail by William Ogilvie (1893) who traversed up the Liard River from Fort Simpson and followed the Fort Nelson and Sikanni Chief Rivers, eventually reaching Fort St. John. Ogilvie, a land surveyor, was in a hurry to leave the country before winter set in and, as a result, his observations were incomplete. He referred to the report of McConnell for rock exposures along Liard River although he did report some of the rock occurrences south of Fort Nelson.

As noted previously, M.Y. Williams (1923, p. 69b), in his reconnaissance down the Fort Nelson and Liard Rivers, observed the Cretaceous sequence along lower Fort Nelson River, stating:

> *. . .The crossbedded sandstone of lower Fort Nelson River may be equivalent to the Bullhead Mountain sandstone; the thick shale series with fish scales in at least one member, may be a continuation of the marine Fort St. John shale; and the upper sandstones, containing lignite and plant remains, may be a northern equivalent of the Dunvegan sandstone. . .*

Williams correctly surmised that the shales are part of the Fort St. John Group, but incorrectly interpreted the succession because only one sandstone formation, the Dunvegan, is present in that region. Williams was accompanied by G.S. Hume (1923) who reported on the country north of the 60th parallel, and indicated that no exposures, other than those described by McConnell, were found in Liard River below its junction with the Fort Nelson River.

The Cretaceous sediments were studied in detail by E.D. Kindle (1944) who descended Fort Nelson River and then ascended Liard River as far as Hell Gate. He reported (1944, p. 10):

> *Approximately 4500 feet of marine shales and sandstones of Lower Cretaceous age are exposed along Liard and Toad Rivers east of their junctions. This thick column of rock has been subdivided on a basis of lithology into three formations, the Garbutt, Scatter, and Lepine. These marine shales and sandstones are the equivalent to the Fort St. John Group of Peace River district.*

Kindle described the formations (Fig. 4) in some detail, outlining their distribution, lithology, and fossil content. He also described the overlying succession of conglomerate and sandstone which he assigned to the Fort Nelson Formation, and which the writer now includes in the Dunvegan Formation.

In 1944, the year after Kindle's exploration in northeastern British Columbia, C.O. Hage (1945) undertook similar investigations below the junction of Liard and Fort Nelson River, but most of his work was concentrated north of the 60th parallel.

McLearn and Kindle (1950), in their summary of the geology of northeastern British Columbia, did not expand on Kindle's original description of Cretaceous rocks in the vicinity of Liard River. However, they did provide additional comments on correlation and paleogeographic outlines.

More information on Lower Cretaceous and Dunvegan rocks was given by W.R.S. Henderson (1954) although most of his report dealt with the region between Sikanni Chief and Tetsa Rivers. Henderson traced the Dunvegan Formation northward from Steamboat Mountain "by helicopter (without landing)". Owing to lack of sufficient ground control, Henderson's correlation of basal beds of the Fort Nelson (Dunvegan) Formation opposite the mouth of Scatter River with the Sikanni Formation to the south is erroneous.

The work of Kindle was relied upon in subsequent summaries. Rudkin (1964), in attempting to extrapolate from subsurface records to the sections described by Kindle, placed the "Fish Scale" marker at the base of the Sikanni sandstone, and indicated that the Sikanni was of Cenomanian age. As was pointed out by Warren and Stelck (1969, p. 533), the Fish Scale marker lies at or near the top of the Sikanni sandstone and the formation is of Albian age.

The Fort St. John Group of this region is a thick succession of marine shale containing two major sandstone sequences, neither of which is present everywhere (Figs. 9, 10, 11, 12). From Tetsa River northward beyond the junction of Toad and Liard Rivers, the Sikanni sandstone, occurring in the upper third of the group, overlies Buckinghorse shale and underlies the Sully Formation (Figs. 3, 12). The Sikanni can be readily mapped as far north as Scatter River, although it loses its distinctive character eastward in the northern part of Fort Nelson (94 J) map-area (Taylor and Stott, 1968b) and Maxhamish Lake (94 O) map-area Taylor and Stott, 1968a). In the vicinity of Scatter River, another major sandstone succession, the Scatter Formation, occurs in the lower third of the group (Figs. 9, 11; Plate 20) the basal shales are included there in the Garbutt Formation, and the shales between the Scatter and Sikanni are placed in the Lepine Formation. The Scatter sandstone is not mappable between Toad and Tetsa Rivers, but the upper part of the sandstone succession reappears farther south and is present between Chischa and Tuchodi Rivers.

Farther east, in the region north of Fort Nelson River and east of Maxhamish Lake, the Sikanni sandstones do not appear to be present and the Fort St. John Group is not subdivided for the purposes of surface mapping. Much of the Fort St. John Group is exposed along Petitot River (sec. 57-112) in the vicinity of Bovie Anticline, where a thickness of 3000 feet (914 m) or more occurs. Sandy strata, occurring in the lower part of the group, represent some part of the Scatter Formation of the Liard region. However, those sandstones are not recognized as a formal mapping unit within the Maxhamish Lake map-area. Similarly, in subsurface, east of Maxhamish Escarpment, a sandy to silty unit occurring near the base is likely the equivalent of the Scatter Formation.

The Fort St. John Group is not completely exposed at any one locality in the region of Scatter River. However, measurements of several sections relatively close to each other result in a composite section which appears reasonably reliable (Fig. 17). The most questionable correlation is that of the bed of cone-in-cone structures within the Lepine Formation, which is the only lithologic marker that could be found in common between the two neighboring sections. The thickness of the composite section very closely approximates that penetrated in the IOE Dunedin d-75-E well (d-75-E/94-N-8), thereby providing some confirmation as to its validity.

The Fort St. John Group, based on composite outcrop sections (Fig. 17), attains a maximum of about 6500 feet (1981 m) at Scatter River. This thickness closely approximates that found in the nearest well, IOE Dunedin a-75-E well (a-75-E/94-N-8), where slightly more than 6700 feet (1024 m) are included in the group (Fig. 17). The group thins fairly rapidly eastward, particularly in Maxhamish Lake map-area where structure related to the Bovie Fault apparently has influenced Cretaceous deposition. The group is almost 4400 feet (1341 m) thick in Imperial Pan Am La Biche b-55-E well (b-55-E/94-O-13) and 4100 feet (1250 m)

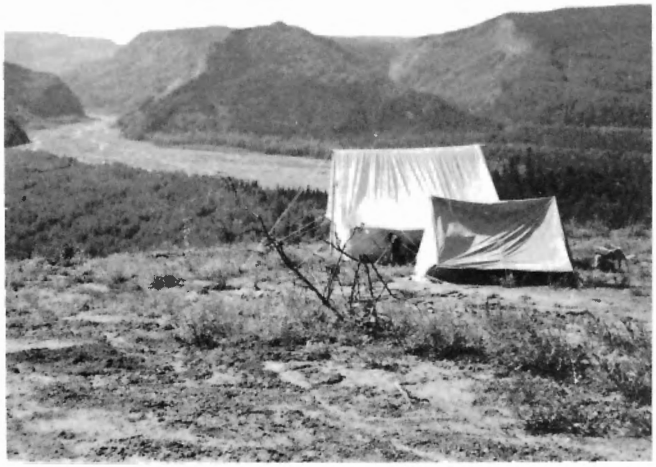


PLATE 20

Type locality of Scatter Formation. View westward up valley of Scatter River, from about the junction with Liard River. The cliffs and hogbacks are formed of Scatter sandstones. The Lepine shales lie along the Liard River valley in middle foreground. GSC Photo 128485.

TABLE IV

TABLE OF FORMATIONS

Scatter River Region

Series	Group	Formation thickness	Lithology
		Wapiti ?	Coarse-grained, conglomeratic sandstone.
		Kotaneelee 600' (183 m)	Dark grey, marine shale; some fine grained sandstone.
		unconformity	
Upper Cretaceous		Dunvegan 500-600' (152-183 m)	Massive conglomerate; fine-to coarse-grained sandstone; carbonaceous shale and mudstone; coal seams.
		Sully 300-1000' (91-305 m)	Dark grey, marine shale with sideritic concretions; flaky, black shale.
		Sikanni 350-1000' (107-305 m)	Fine grained, laminated, marine sandstone, silty mudstone.
Lower Cretaceous	Fort St. John 4500-6500' (1372-1981 m)	Lepine 3000-3600' (914-1097 m)	Dark grey, marine shale with sideritic concretions; fine grained silty sandstone.
		Scatter 1143' (348 m)	Fine-grained, highly glauconitic sandstone and siltstone; silty marine shale.
		Garbutt 950' (290 m)	Silty shale and mudstone, and siltstone; sideritic concretions.
Regional erosional unconformity; bevels succeedingly older rocks northward and eastward			

in the Imperial Pan Am Viscount a-77-D well (a-77-D/94-O-11; see Fig. 18). A marked reduction in the thickness of the basal shale unit occurs east of the Bovie Fault, indicating that the fault was active in pre-Cretaceous time and possibly during deposition of Cretaceous sediments. An accurate thickness is impossible to obtain at most places because the upper Fort St. John is eroded over much of the Maxhamish Lake map-area. However, well data from Pan Am A-1 Komie well (a-51-A/94-O-8) and the occurrence nearby of the overlying Dunvegan Formation indicate an approximate thickness of 2000 feet (610 m) in the eastern part of the map-area (Fig. 18).

The base of the succession is a regional unconformity that truncates successively older beds in a northward and eastward direction (Figs. 9, 18). Basal Cretaceous beds lie on Triassic Liard sandstone at Mile 375, Alaska Highway; on Lower to Middle Triassic Toad siltstone and shale beyond there into the District of Mackenzie. Similarly, in an eastward direction, the unconformity bevels Triassic, Permian, and Mississippian strata. In wells west of Maxhamish Escarpment, the group lies unconformably on Triassic sediments. Along Petitot River, on the west flank of the Bovie Anticline, the Fort St. John Group appears to lie unconformably on the Mississippian Mattson Formation and, farther east along the river, on the older Carboniferous Flett and Banff Formations and to the north, on Upper Devonian Kotcho Formation (Williams, 1978).

The basal beds at Petitot River on the west flank of Bovie Anticline comprise 38 feet (11.6 m) of fine grained, lithic sandstone that weathers to brown and rust. Beds are thin and somewhat irregular and the uneven appearance is further intensified by numerous worm burrows. These beds are 900 feet (274 m) in horizontal distance from the Cretaceous sequence described in section 57-112. The covered interval between the two exposures probably represents some 600 feet (183 m) of basal Fort St. John beds.

Garbutt Formation

Definition. The Garbutt Formation was named and described by Kindle (1944) from exposures on Garbutt Creek in Toad River map-area (94N). The creek more or less parallels the strike of the shales and a continuous measurement is difficult to obtain. Slides, large slump blocks, and a tangle of thick vegetation now cover most of the shale at creek level, making access extremely slow and difficult. The basal 200 to 300 feet (61-91 m) of the formation are exposed in a cliff near the Triassic contact about 4 miles (6 km) (map distance) upstream from Liard River. In addition, the upper 200 to 250 feet (61-76 m) of shale is exposed beneath the Scatter sandstone on cliffs along the east side of the creek.

Type and standard sections. Kindle (1944) indicated that the type locality of the Garbutt Formation was on "Garbutt Creek, where it is well exposed". Although a large part of the formation may be examined in a series of outcrops, no continuous sequence of beds is exposed there. The basal beds on Garbutt Creek consist mainly of rusty weathering mudstone with a few thin, platy beds of sandstone, some thin seams of bentonite, and some concretions. The upper part of the formation is similar, containing black, rubbly to blocky mudstone, with some siltstone, sideritic concretions, and abundant small crystals of selenite on bedding surfaces.

The most complete section of the Garbutt Formation is found on a small tributary, Toreva Creek, on the south side of Scatter River (sec. 65-13; Plate 21) and that section is designated as a standard. The contact of Garbutt mudstone with the underlying Triassic Toad Formation is exposed at the base of the measured section. A covered interval of 250 feet (61 m) occurs almost at the base but the remainder of the Garbutt Formation is well exposed and its contact with the overlying Scatter Formation appears at the base of a cliff of massive sandstone (Plate 21). The basal part of the formation outcrops farther west on Scatter River (sec. 65-12) and also on Garbutt Creek.

Distribution and thickness. Measurements of the Garbutt Formation were obtained on Chimney Creek between Lepine Creek and Scatter River (sec. 65-7) and at two localities within the westernmost exposures along Scatter River (secs. 65-12, 65-13). Those three measurements agree closely, indicating that the Garbutt shales are in the order of 950 feet (290 m) thick in this area. It is evident that the 2000 feet (610 m) determined by Kindle is excessive[1].

The Garbutt Formation in the IOE Dunedin a-75-E well (a-75-E/94-N-8) is in the order of 1350 feet (411 m) about 350 feet (107 m) more than that found at Scatter River. The apparent increased thickness in that region is not readily explained, but may be related to depositional or lateral facies variations or to the angle at which beds were penetrated in the drillhole. A decrease to about 800 feet (244 m) is found in the Imperial Pan Am La Biche b-55-E well (b-55-E/94-O-13) and the thickness is about 875 feet (267 m) in the Imperial Pan Am Viscount a-77-D well (a-77-D/94-O-13), where basal Scatter sandstone has graded laterally eastward into mudstone. A marked decrease occurs across the Bovie Fault where the thickness changes from 640 feet (195 m) in the Imperial Pan Am Tattoo a-26-B well (a-26-B/94-O-11) to less than 60 feet (18 m) in Pan Am Deer Lake A-I well (a-90-I/94-O-6) in a distance of 4 miles (6.4 km) (Fig. 21).

The Garbutt shale extends along the western side of Liard River as far south as Toad River. Beyond there, equivalent beds are included in the Buckinghorse Formation. Basal Cretaceous shale occurs in several small synclines near Hell Gate on Liard River but were not examined during this study. To the north of the type locality, Garbutt shale extends as a narrow, recessive belt across Crow River to Beaver River, and apparently occurs on the flanks of the Kotaneelee Anticline.

Contact relationships. As indicated by Kindle (1944), the type Garbutt shale is underlain by 4 to 5 feet (1.2-1.5 m) of fine grained, argillaceous sandstone. Those beds include some disseminated chert pebbles, wood fragments, and glauconite. Although Kindle suggested a Jurassic age for those beds, their gradational contact with the overlying shale, channel-structures at the base of the succession, essentially marine character, and similarity to basal sandstones at Mile 375, Alaska Highway, indicate that they are the initial deposits of the Cretaceous transgression. On Scatter River, basal Garbutt shale lies directly on Triassic sediments without any intervening sandy deposits (sec. 65-12). There, a thin seam of bentonite occurs 6 inches (15.2 cm) above the base of the Garbutt, and a second bentonite occurs 2 feet (60.6 cm), above the base in greenish, glauconitic mudstone.

Lithology. The Garbutt Formation on Chimney Creek (sec. 65-7) and Scatter River (secs. 65-12, 65-13) consists of two main subdivisions. The lower one comprises silty mudstone, argillaceous siltstone, sideritic concretions, and a few thin seams of bentonite (Plate 22). The basal mudstone is glauconitic and overlying beds include platy, glauconitic siltstone and sandstone. The numerous thin, silty lenses and beds give the unit a banded or striped appearance. Within this sequence, units of crossbedded siltstone and mudstone appear in conformable relationships with uniform, horizontally stratified units (Plate 23). This type of crossbedded unit within mudstone is unusual throughout most of the Cretaceous marine shales. Slump structures also occur in parts of this succession. Flaggy to thin-bedded, fine-grained, silty sandstone occurs at the top of the lower subdivision, producing a prominent ledge in cliff exposures.

The upper subdivision consists dominantly of rubbly mudstone with rows of reddish brown weathering, sideritic concretions. It becomes siltier toward the top, grading into a massive unit of argillaceous siltstone. These mudstones, similar in some aspects to those of the lower part of the formation, weather rusty but are dark grey to black on a fresh surface. In the upper part, where siltstone is present, crossbedded units and channel structures reappear (Plate 24).

The shales of the Garbutt Formation contain 40.74 per cent quartz, 2.49 per cent Na feldspar, illite, chlorite and kaolinite. The ratio of 2:1 expandable clay is 76:24, and the percentage of 2M illite polymorphs in discrete illite is 21 (Foscolos and Stott, 1975, p. 18).

Age. No macrofossils were obtained from the Garbutt shale. The formation lies below beds that are within the Middle Albian Zone of **Gastroplites** and it is equated with basal Buckinghorse shale on Tetsa River.

A meagre microfauna assemblage was recovered from lower beds of the Garbutt Formation at Scatter River (sec. 65-12). Wall (pers. comm., 1979) commented on the foraminifera from the basal beds:

> *This assemblage, characterized by ammodiscinids, has much in common with one present in cores between 800 and 825 feet (from the lower part of Loon River Formation in the IOE Steen River 16-19 well in Tp. 121, R. 22, W5, Mer., Alberta) which probably is of Early Albian age.*

---

[1]Although a number of discrepancies are found in Kindle's work, the reader should realize that those earlier studies were made by foot and canoe traverse without benefit of adequate maps, covered an extremely large and unknown area in a relatively short time, and involved a thick and unknown succession of Paleozoic and Mesozoic rocks. It is to Kindle's credit that the distribution of major map units remains little changed and that many of the modifications are necessary only to maintain consistency with successions more firmly established in other regions.

PLATE 21

Garbutt and Scatter Formations, Toreva Creek, south tributary of Scatter River; section 65-13. Talus in foreground comes from Triassic Toad Formation. GSC Photo 128505.

PLATE 22

Basal Garbutt shales, upper Scatter River; section 65-12. GSC Photo 128504.

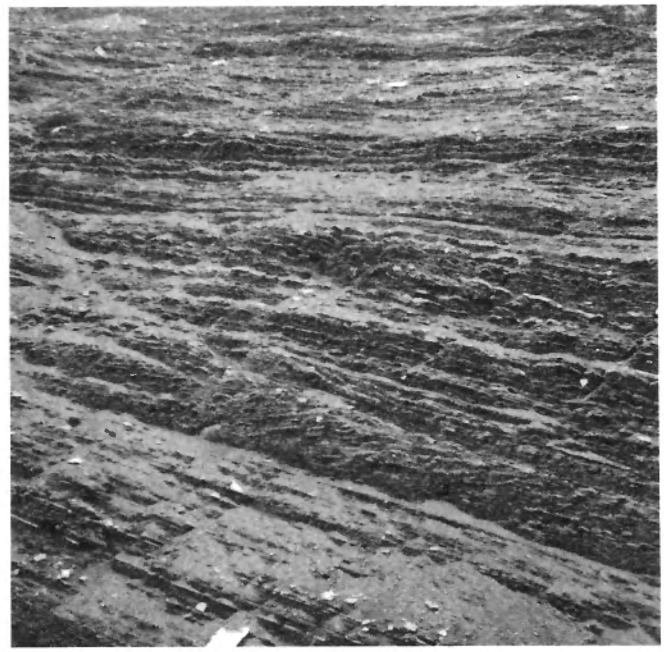


PLATE 23

Crossbedding in upper Garbutt shale; Chimney Creek; section 65-8. GSC Photo 128477.

PLATE 24

Channel structures in shale, top of Garbutt Formation, Chimney Creek; section 65-8. GSC Photo 128476.

However, Wall also stated:

> *As those forms (in the assemblage) are quite simple and probably not restricted in range, a strong possibility exists of their occurrence in older beds, so an Aptian age cannot be discounted.*

Fauna from beds 60 to 115 feet (18.3-35.0 m) above the base were considered by Wall to indicate an Early to Middle Albian age.

Scatter Formation

Definition. The Scatter Formation, defined on Scatter River by Kindle (1944) consists of two major sandstone members separated by a thick shale member; Kindle indicated that the succession comprises three sandstones separated by two shale units, totalling 750 feet (229 m) but it is difficult to reconcile that description with the outcrop. Present studies show that the thickness of the lower sandstone member is more than 400 feet (122 m); that of the middle shale member to be in the order of 450 feet (137 m); and that of the upper sandstone member to be 250 feet (76 m). The total thickness of the type section was determined to be 1143 feet (347 m).

Kindle defined the Scatter Formation as follows:

> *The succession of sandstones and shales that overlie the Garbutt Formation have been named the Scatter Formation, the type locality being along Scatter River where the beds are exposed for over ten miles, commencing at a point one and one-half miles west of the Liard.*

Type section. The basal sandstone of the Scatter forms prominent cliffs along the top of the canyon of Scatter River and also forms the surface bedrock extending both north and south of the river (Plate 20). Almost the entire sequence is well exposed and readily examined at river level where the beds dip eastward. A description is given in section 65-11 (Lat. 59°37'N, Long. 124°44'W; Fig. 3).

Distribution and thickness. The Scatter sandstones are well exposed in the canyon of Scatter River where immense blocks have slumped into the valley. Some caution must be exercised to avoid mistaking those blocks at river level for true bedrock. The sandstone becomes much more massive and contains much less interbedded shale as it is traced westward along the canyon walls. Both upper and lower sandstone members extend northward, being well exposed on Crow River and traceable along the west flank of La Biche Syncline in Yukon Territory (Fig. 3).

At Chimney Creek, south of the type section, the formation has apparently increased, by almost 100 feet (30.4 m), to 1241 feet (378 m) in thickness (sec. 65-8). The thickness of the middle shale member was estimated and may be too large. No section of the total formation was measured south of Chimney Creek, although the formation can be traced beyond the junction of Toad and Liard Rivers (Figs. 3, 11).

The formation is well developed in the IOE Dunedin a-75-E well (a-75-E/94-N-8) where 1150 feet (350 m) were assigned to it. It is 890 feet (271 m) thick in the Imperial Pan Am La Biche b-55-E well (b-55-E/94-O-13), decreasing to less than 600 feet (183 m) in Imperial Pan Am Viscount a-77-D well (a-77-D/94-O-11). Eastward beyond the Bovie Fault, silty to argillaceous sandstone equivalent to part of the Scatter Formation has a thickness of only 190 feet (58 m) in BA Pan Am Playmate b-6-G well (b-6-G/94-O-7).

Contact relationships. Both upper and lower boundaries of the formation are gradational. The lower contact with the Garbutt is drawn at the change from thick bedded sandstone to argillaceous siltstone or mudstone. The upper contact with the Lepine Formation is represented only by a change from sandy siltstone to silty mudstone.

Lithology. Three members are recognized within the Scatter Formation. The basal member, Bulwell, comprises a thick, resistant succession of flaggy to thick-bedded, glauconitic sandstone. The middle, or Wildhorn Member, consists of silty, concretionary mudstone. The upper sandstone, or Tussock Member, comprises alternating units of silty, glauconitic sandstone and silty mudstone.

The Cretaceous succession on Petitot River, assigned to the Buckinghorse Formation (Stott, 1960b, sec. 3; see section 57-112 in appendix), contains beds that are equivalent to the Scatter Formation. The lower 186 feet (56.7 m) of exposed beds consist of interbedded glauconitic sandstone, argillaceous siltstone and mudstone. These beds resemble in many respects the type Scatter sandstone. An additional 600 feet (183 m), overlying the sandy unit, also contain some thin sandstone but the interval is dominantly mudstone and correlates with probably the middle Scatter Formation or younger beds.

Bulwell Member

Definition. The basal sandstone of the Scatter Formation in the type section of the formation occurring about 1.5 miles (2.4 km) upstream on Scatter River above its junction with Liard River, is defined as the Bulwell Member, the name being derived from Bulwell Creek map-sheet (94N/11). The member is continuously exposed along a short gorge, and the locality is designated as type (sec. 65-11); Lat. 59°37'N, Long. 124°44'W; Fig. 3; Plate 25).

Distribution and thickness. At the type locality, the Bulwell Member has a thickness of 422 feet (129 m). Kindle (1944, p. 11) included 459 feet (140 m) in the equivalent part of the section, with a shale unit of 150 feet (46 m) thickness occurring 75 feet (23 m) above the base. The writer's description of this part of the section indicates that sandstone is dominant through the lower 250 feet (76 m).

The Bulwell sandstone extends southward from the type locality to the junction of Toad and Liard Rivers (Plate 26), but becomes indistinct about two miles (3.2 km) farther south and is not mappable. Equivalent beds between there and Chischa River are included in the Buckinghorse Formation (Fig. 11). On Chimney Creek between Scatter River and Lepine Creek, the Bulwell Member appears to be 512 feet (156 m) thick (sec. 65-8), although much of the upper part of the member is not well exposed. The basal part of the member, consisting mainly of sandstone, apparently is about 100 feet (30 m) thicker at this locality. Although no measurements were made, the southward decrease in thickness, attributed to a facies change to shale, is clearly evident in the exposures along the east side of Liard River, opposite Garbutt Creek (Plate 26).

The Bulwell Member is well exposed in a narrow canyon of the next gully to the north of the type section. The basal sandstone extends westward along the rim of the Scatter canyon for 10 miles (16 km) and then trends northeasterly across Crow River to the west flank of the La Biche Syncline. At Crow River, on the west flank of a small anticline (sec. 65-19), the member is in the order of 400 feet (122 m) thick, although its base is below river level there.

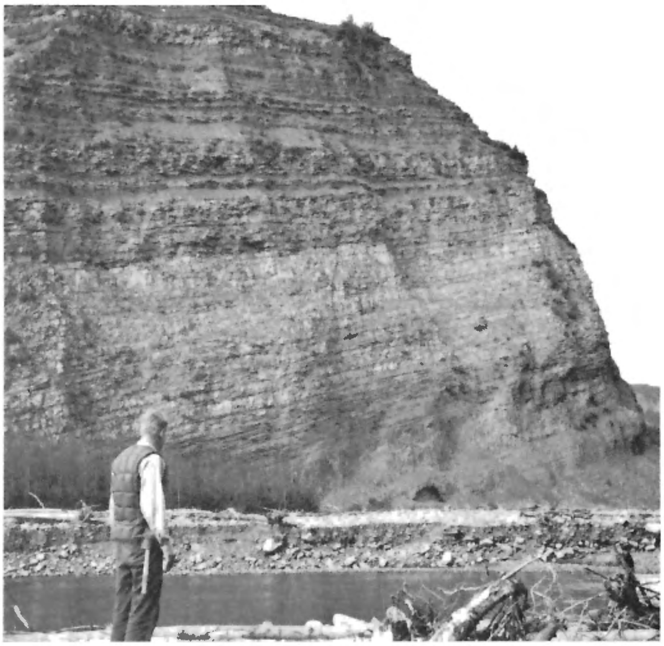


PLATE 25

Bulwell Member (basal sandstone) of Scatter Formation, type locality, looking south across Scatter River. GSC Photo 128496.

PLATE 26

Bulwell Member of Scatter Formation, looking east across Liard River from Garbutt Creek. Sandstone is grading laterally southward and eastward into mudstone. GSC Photo 128470.

Contact relationships. The basal beds of the Bulwell Member are gradational into the underlying mudstones of the Garbutt Formation. At Chimney Creek (sec. 65-8), there is no distinct break but only a downward decrease in the number and thickness of sandstone beds until the succession becomes entirely mudstone. At the type section, the boundary is less transitional, although the upper beds of the Garbutt are very sandy, argillaceous siltstone. There, the basal sandstone has a more distinct contact with the underlying beds. The contact is drawn at the change from thick bedded sandstone of the Bulwell to argillaceous siltstone or mudstone of the Garbutt Formation.

The upper contact of the Bulwell Member has a transitional appearance. It is drawn at the change from sandstone and sandy siltstone of the Bulwell to silty mudstone of the overlying Wildhorn Member.

Lithology. The Bulwell Member at Chimney Creek (sec. 65-8), Scatter River (type section), and at Crow River (sec. 65-19), is characterized by two major parts; a lower unit of thick bedded, fine grained sandstone (Plate 27), and an upper unit of interbedded silty mudstone and argillaceous sandstone. Both to the south and to the north of these localities, the whole member apparently becomes more shaly and the more resistant basal unit grades laterally into interbedded silty mudstone and argillaceous sandstone, and then finally into shale.

Sandstones of the lower member in the type region are commonly laminated, grey to greenish grey. They contain abundant ripple-marks, worm burrows, trails, and castings. Channel-fill structures and crossbedding are common (Plate 28). Large-scale slump features, with highly convoluted bedding, are present in the basal beds of the type section on the south side of Scatter River. Large **Spirophyton**-like structures occur on many bedding planes. Glauconite is extremely abundant throughout and several beds, 1 to 4 inches (2.5-10 cm) thick, of glauconite are present.

The sandstones of the Scatter Formation in the vicinity of the type section are fine- to very fine-grained, and many approach siltstone in average grain size. The latter generally contain abundant matrix. The rocks therefore grade from quartz arenites to quartz wackes.

Quartz appears to be the main constituent, with little or no chert and only minor amounts of carbonate. In the well sorted sandstones, the grains have a welded texture, showing slightly irregular to straight boundaries. Secondary growth of silica can be determined but because of the fine grain size is not always obvious. In those sandstones containing abundant matrix, the grains are separated from one another and commonly have irregular shapes. Carbonate grains, where present, are not abundant. Carbonate cement is present in a few patches but is not common. Glauconite is abundant throughout the Scatter sandstones and in several beds, gives a very distinct green colour to the rock. It occurs as disseminated discrete grains and also as patches and irregularly shaped masses surrounding sand grains.

Age. The Bulwell Member is not well dated. It overlies the Garbutt Formation, which according to Wall (pers. comm.) contains microfauna of Early to Middle Albian age. It is separated, by the Wildhorn and Tussock Members, from beds containing the typical Middle Albian **Gastroplites** fauna. Some part of those two upper Scatter members may lie within the Middle Albian Zone of **Pseudopulchellia pattoni**. The Bulwell Member appears to occupy a stratigraphic position largely equivalent to that of the Gates Formation at Peace River. If so, the Bulwell Member lies within the **Arcthoplites** Zone of Early Albian age.

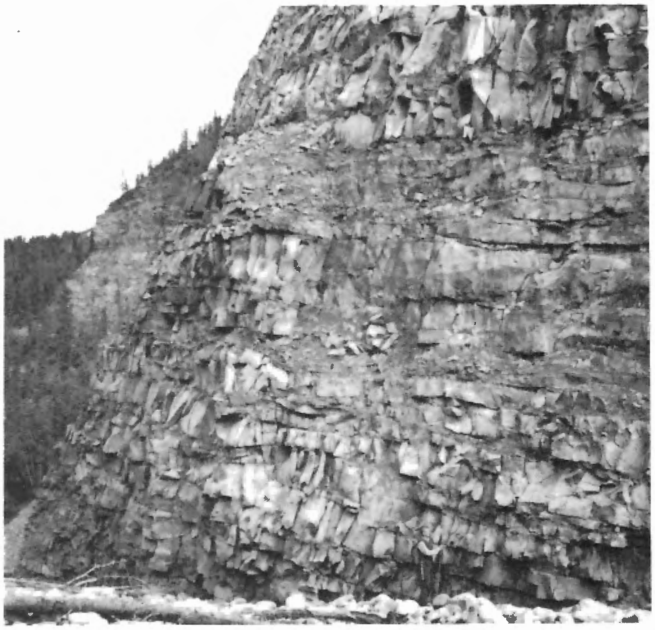


PLATE 27

Bedding in Bulwell Member at type section on north side of Scatter River. The crossbedding, channel-fill, and jointing developed here are characteristic. GSC Photo 128497.

PLATE 29

Tussock and Wildhorn Members, type Scatter Formation, north side of Scatter River. GSC photo 128508.

PLATE 28

Crossbedding and uniform lamination, Bulwell Member, type section of Scatter Formation. GSC Photo 128498.

Wildhorn Member

Definition. A thick succession of mudstone, occurring between the two resistant sandstone members of the Scatter Formation, is defined as the Wildhorn Member. The name is taken from Wildhorn Creek, a tributary of Scatter River. The member is fairly well exposed in the type section of the formation along the north bank of Scatter River, near its junction with Liard River, and that is considered to be the type section (sec. 65-11, Lat. 59°37'N, Long. 124°4'W, Fig. 3; Plate 29).

Distribution and thickness. The Wildhorn Member is about 480 feet (146 m) thick at Scatter River. Kindle (1944, p. 11) underestimated the thickness of these recessive beds, indicating that only 200 feet (61 m) were present. This discrepancy accounts in part for the reduced thickness of the total Scatter Formation as outlined by Kindle. To the south of Chimney Creek (sec. 65-8), about 600 feet (183 m) above the Bulwell Member are covered, much of which represents the Wildhorn Member. On the east side of Liard River, opposite Garbutt Creek (sec. 65-16), equivalent beds have about the same thickness, but, because the Tussock Member of the Scatter Formation has graded laterally into argillaceous shale and siltstone, the member is poorly defined.

The Wildhorn Member is mapped as far south as Garbutt Creek, on the west side of Liard River. Equivalent beds beyond there are continuous with the Lepine shales and are not recognized as a separate member (Plate 26). The member occurs in the centre of a small anticline north of Scatter River and is readily recognized in the outcrop band that extends from Scatter River, across Crow and Beaver Rivers. The Wildhorn is well exposed along Crow River in several exposures on the south side of the main westerly outcrop band, and also farther downstream on the west flank of the small anticline whose core is formed by the Scatter sandstones.

Contact relationships. The lower contact of the Wildhorn is drawn at the change from mudstone to sandstone and sandy siltstone of the Bulwell Member. The upper contact is drawn at the change from silty mudstone to argillaceous sandstone of the Tussock Member. Both boundaries have a transitional appearance.

Lithology. The Wildhorn Member consists of silty, concretionary mudstone. These mudstones are dark grey to black on a fresh surface, but weather dark grey to rust. Reddish-brown weathering sideritic concretions occur sporadically throughout the mudstone, but are more numerous in the upper beds. The silt content of the mudstone increases upward and thin beds of argillaceous siltstone and sandstone appear in the uppermost beds. Fragments of large pelecypods are common in the upper part of the member, where they occur mainly within the sideritic concretions.

Fossil content and age. **Stotticeras crowense** Jeletzky and **Inoceramus** cf. **I. cadottensis** McLearn were collected from the Wildhorn Member on Crow River (GSC loc. 69198). Jeletzky (1980) tentatively interpreted this fauna "as a faunal phase of **Pseudopulchellia pattoni** Zone" but indicated that there is some possibility of it being somewhat older and corresponding to his Zone F between the **P. pattoni** Zone and the generalized **Arcthoplites** Zone.

Tussock Member

Definition. The upper sandstone unit of the Scatter Formation is named the Tussock Member, and the type section is that of the sequence of beds found in the type Scatter Formation on Scatter River. The member is underlain by mudstone of the Wildhorn Member, and is overlain by mudstone of the Lepine Formation. The member is well exposed in the type section of the Scatter Formation on the north side of Scatter River, near its junction with Liard River (sec. 65-11; Lat. 59°37'N, Long. 124°44'W, Fig. 3; Plate 29).

Distribution and thickness. The type section is 250 feet (76 m) thick. No measurement of the Tussock Member was made north of there, although it can be recognized in the westernmost locality on Scatter River and on the western flank of the anticline to the east. The Tussock grades laterally eastward into argillaceous siltstone and shale, becoming recessive and indistinct on the east flank of the anticline on Crow River and disappearing almost completely on the flanks of Kotaneelee Anticline.

The Tussock does not extend as far south as Lepine Creek, although it is present on Chimney Creek (sec. 65-8). The member is represented on the east side of Liard River south of there only by silty concretionary mudstone included, for convenience, in the Lepine Formation. Equivalent beds are difficult to recognize on the Liard Escarpment, but some very argillaceous siltstone to silty mudstone opposite Garbutt Creek probably marks the approximate top of the member (sec. 65-16).

Contact relationships. The basal contact at Scatter River and Chimney Creek is gradational with the Wildhorn becoming increasingly silty. The contact is drawn at the change from silty mudstone to cycles of argillaceous siltstone and sandstone with interbedded mudstone. The upper boundary is drawn above the last argillaceous to silty sandstone unit, but the contact is not sharp and sedimentaton appears to have been more or less continuous in this region.

Lithology. The Tussock Member comprises alternating units of silty, glauconitic sandstone and silty mudstone. Only one prominent sandstone occurs within the member on Scatter River (Plate 29).

The Tussock is represented only by recessive, argillaceous siltstone and shale on the east flank of the anticline on Crow River, and appears to grade into shale on the flanks of Kotaneelee Anticline.

Opposite Garbutt Creek (sec. 65-16), beds equivalent to the member consist of argillaceous, blocky siltstone and black, silty mudstone. These beds weather rusty and contain large, reddish brown weathering, sideritic concretions.

On Chimney Creek (secs. 65-8B, 65-8C), the Tussock Member comprises units of mudstone, siltstone, and sandstone, ranging from 5 to about 30 feet (1.5-9.1 m) in thickness. The mudstone is black, silty, and weathers blocky and rusty. The siltstones are argillaceous, dark grey, finely laminated, and weather grey to rust. The sandstone is silty to argillaceous, very fine grained and finely laminated. The succession on Scatter River (sec. 65-11), is sandier with cleaner sandstone. Bedding is better developed, ranging from platy to thin. The sediments show some reworking by burrowing organisms, with mottling and worm trails being common. Some large **Spirophyton**-like structures occur on a few bedding surfaces, but are not so abundant as in the basal member.

Fossil content and age. Indeterminate gastroplitid ammonites were obtained from beds considered equivalent to the Tussock at the type locality of the Lepine Formation. At the type section of the Tussock, **Gastroplites kingi** McLearn, **Gastroplites** aff. **G. canadensis** (Whiteaves) and **G. spiekeri** McLearn were collected from talus at the base of the overlying Lepine mudstone (GSC loc. 69170); **G. canadensis** (Whiteaves) and **G. kingi** McLearn, from talus 75 to 90 feet (23-27 m) above the top of the Scatter (GSC loc. 69168) and **G. kingi** McLearn and variants were collected about 80 feet (24 m) above the top of Scatter (GSC loc. 69171). As the Wildhorn Member contains a fauna that is closely related to that of the zone of **Pseudopulchellia pattoni** and the Tussock Member underlies beds included in the **Gastroplites** Zone, the upper member is no younger than late Middle Albian. It may lie within the **Pseudopulchellia** Zone and/or the basal part of the generalized **Gastroplites** Zone.

Lepine Formation

Definition. The Lepine Formation was defined by Kindle (1944, p. 12) as a 2000-foot (610 m) thick series of grey and black marine shales overlying the Scatter and underlying Upper Cretaceous conglomerate assigned to the Fort Nelson Formation. As used herein, the Lepine includes the shale succession between the Scatter and Sikanni Formations.

Type section. McLearn and Kindle (1950, p. 90) implied that the type Lepine Formation is opposite the mouth of Lepine Creek, but Kindle (1944) described the section opposite the mouth of Scatter River, 15 miles (24.1 km) to the north. Unfortunately, the successions at those two localities differ greatly in thickness and stratigraphic interval, which resulted in confusion during later attempts at correlation. It is clearly evident that the sandstone overlying the shale succession opposite Lepine Creek is the Sikanni Formation, whereas Kindle's described succession, opposite Scatter River, is overlain by much younger conglomeratic beds herein included in the Dunvegan Formation (see Fig. 21). Furthermore, present studies show that the upper Scatter sandstone has graded laterally into mudstone opposite Garbutt Creek, so the base of the shale succession there is

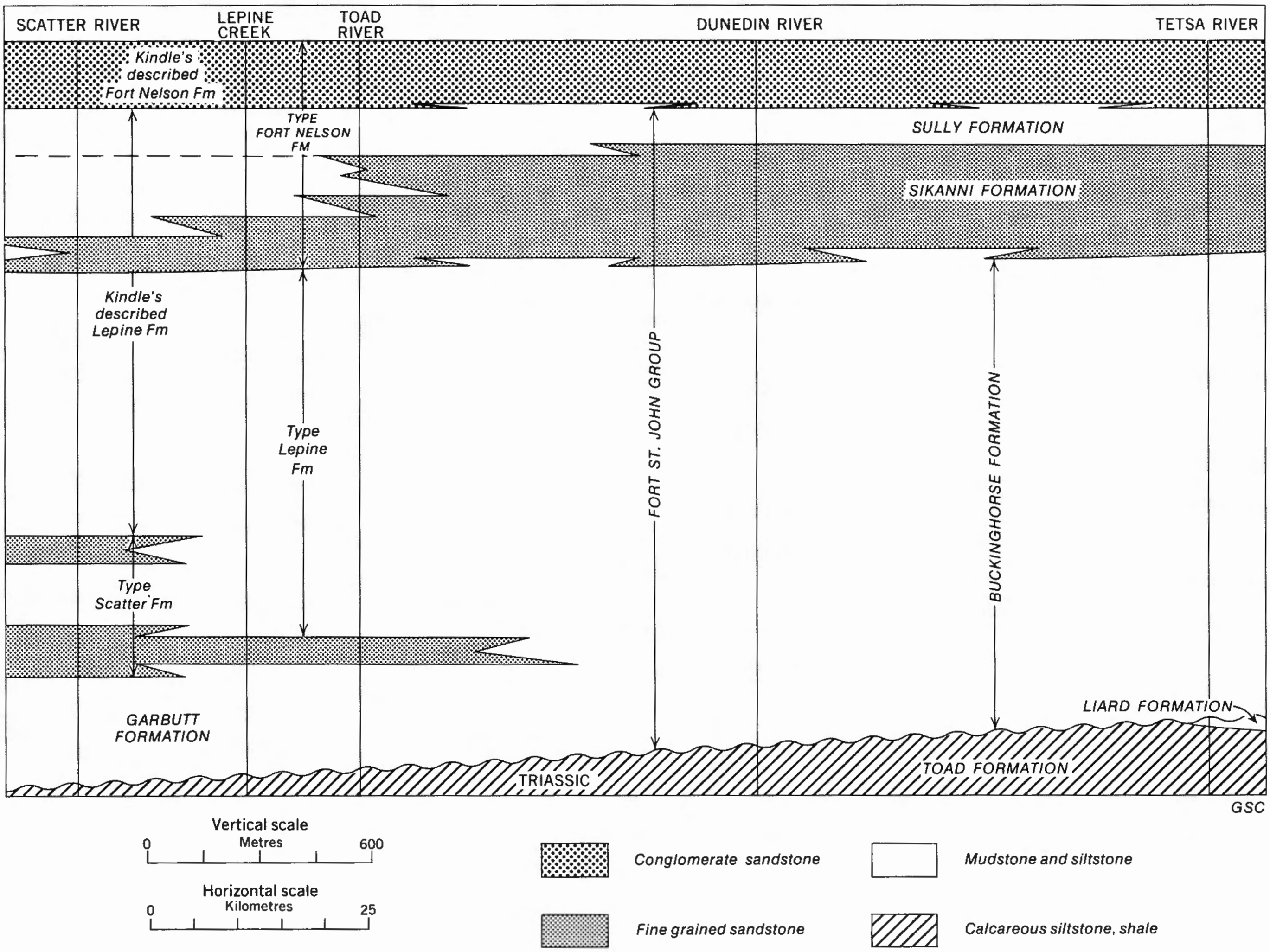


FIGURE 21. *Schematic diagram illustrating facies and approximate thicknesses of Fort St. John Group, northeastern British Columbia.*

underlain by the lower Scatter sandstone (Bulwell Member) rather than by the upper Tussock Member as it is at Scatter River. It is most useful to assign only the shale succession between the Scatter and Sikanni Formations to the Lepine Formation.

Kindle (1944) included all the shales below the Dunvegan (Fort Nelson) Formation in the Lepine, and estimated that the thickness between the type Scatter and the conglomerates at the top of the ridge was about 2000 feet (610 m). A sum of the composite Lepine, Sikanni, and Sully, as defined by the writer, indicates the total to be in the order of 4400 feet (1341 m) (secs. 65-9, 65-10, 65-11, Fig. 17). That thickness is only slightly in excess of the same interval in the IOE Dunedin d-75-E well (d-75-E/94-N-8) located 16 miles (25.7 km) southeast of the outcrop section.

Distribution and thickness. The Lepine Formation is exposed in many steep gullies along the Liard Escarpment, although the upper part of the formation is not exposed at the type locality opposite Lepine Creek. The most complete description and measurement is based on a composite of sections opposite Chimney Creek. The thickness of mudstone lying between the top of the Tussock of the Scatter Formation and the Sikanni sandstone is in the order of 3000 feet (914 m). The formation extends northward across low-lying land between Crow and Beaver Rivers and into Yukon Territory along the axis of La Biche Syncline (Fig. 3).

South of the type section, between Garbutt Creek and Toad River, the Lepine Formation includes equivalents of the middle and upper Scatter members and the formational thickness increases by 600 to 700 feet (183-213 m). South of the junction of Toad and Liard Rivers, where the Scatter is not recognized, equivalent beds are included in the Buckinghorse Formation (Figs. 3, 9).

A similar shale succession, lying between upper Scatter equivalents and the Sikanni Formation, is about 2000 feet (610 m) thick along Muskwa Escarpment (sec. 64-25), indicating thinning of that interval in a southeasterly direction.

In the IOE Dunedin d-75-E well (d-75-E/94-N-8), 2930 feet (893 m) of strata are assigned to the Lepine Formation. The overlying Sikanni sandstone disappears eastward and the interval between Scatter sandstone and the base of the Dunvegan Formation is dominantly mudstone and argillaceous siltstone in wells within the Liard Syncline. In IOE Pan Am Viscount a-77-D well (a-77-D/94-O-11), beds equivalent to the Lepine Formation are about 2100 feet (640 m) thick (Fig. 18).

Contact relationships. As previously mentioned, the upper beds of the Scatter Formation at the type section are more or less gradational with the overlying Lepine mudstone. Farther south, the distinct sandstone of the Tussock Member disappear and there is no real break between the Lepine mudstone and underlying mudstone equivalent to the upper Scatter. Opposite Garbutt Creek, the base of the Lepine is drawn at the top of the lower or Bulwell Member of the Scatter Formation, and the boundary is fairly distinct (Plate 26). However, as the Scatter sandstone grades laterally into more argillaceous sediments, the contact has a more transitional appearance.

Lithology. The Lepine Formation consists of a monotonous sequence of silty mudstone. Opposite Garbutt Creek (sec. 65-16) where the Lepine Formation includes equivalents of the middle and upper Scatter members, the basal 655 feet (200 m) consists dominantly of mudstone that becomes increasingly silty upwards and numerous large sideritic concretions occur at the top of that unit. Elsewhere, the basal unit of the Lepine Formation above the Tussock (and equivalent beds where the Tussock is not recognized), comprising 300 to 400 feet (91-122 m) of silty, concretionary mudstone, is abundantly fossiliferous and contains numerous ammonites enclosed in concretions. A succeeding unit of black, flaky to fissile shale, about 400 feet (122 m) thick, is overlain by more concretionary silty mudstone. Sandy siltstone to sandstone occur near the middle of this rather monotonous succession. A layer of cone-in-cone, lying within those sandy beds near Scatter River, appears to extend for some distance and may be a useful marker.

The most complete section occurs opposite Chimney Creek (sec. 65-9) where the base of the exposure appears to be near or just above the base of the flaky shale member. The shales are black, flaky to fissile, and commonly are coated with a yellow efflorescence and selenite crystals occur along the bedding surfaces. Rows of reddish brown concretions are present near the base in this section but decrease in abundance in the lower 600 feet (183 m). The upper part of this section, representing the middle of the formation, contains silty mudstone that weathers rubbly to blocky and includes interbedded platy siltstone. Sideritic concretions become more numerous toward the top.

The upper 930 feet (283 m) of the Lepine Formation is exposed on Liard Escarpment opposite Scatter River (sec. 65-10A). The mudstones are similar to those occurring lower in the formation, being silty, rubbly to blocky and containing concretions. These beds grade upward into the overlying Sikanni sandstone.

The Lepine shales at Liard River (secs. 65-9, 65-10A, 65-10B) can be divided into four mineralogical associations (Foscolos and Stott, 1975, p. 18). The lower zone (unit 1, sec. 65-9) contains 40.74 per cent quartz, 2.04 per cent Na feldspar, 3.46 per cent organic matter, with gypsum, illite, vermiculite, and kaolinite. The percentage of illite in the mixed layers is 76 and the percentage of 2M illite polymorphs in discrete illite is 25. The middle zone (units 2-24, sec. 65-9) contains 38.25 per cent quartz, 3.02 per cent Na feldspar, with illite, vermiculite, kaolinite, and traces of chlorite. The percentage of illite in the mixed layers has decreased to 74 per cent and the percentage of 2M illite polymorphs in discrete illite remains at 25. The third zone (units 25-40, sec. 65-9 units 1-5, sec 65-10A) contains 14.97 per cent quartz, 0.25 per cent K feldspar, 3.64 per cent Na feldspar, with dolomite, illite, vermiculite, kaolinite and traces of chlorite. The ratios of illite to 2:1 mixed layers is 76:24 and the percentage of 2M illite polymorphs in discrete illite is 25. The upper part of the formation has a similar composition to the overlying Sikanni shales.

Faunal content and age. At the type section of the Lepine Formation situated on the east side of Liard River opposite Lepine Creek, the following sequence of **Gastroplites** s. str. fauna was collected by the author and identified by J.A. Jeletzky. Common **Gastroplites kingi** McLearn and transitional forms to **G. canadensis** (Whiteaves) as well as common **G. allani** McLearn and transitional forms to **G. kingi** McLearn were collected from talus at the base of the formation as defined by the siltstone equivalent of the upper Scatter Formation (GSC loc. 69196). This fauna may be well out of place, which would account for the presence of typical **G. allani** McLearn so low in the sequence. About 100 feet (30.5 m) stratigraphically above the base (GSC loc. 69193), common **Gastroplites allani** McLearn and transitional forms between this species and **G. kingi** McLearn, rare **G. canadensis** (Whiteaves), rare **G.** aff. **canadensis** (Whiteaves), and rare **G. (Paragastroplites)** cf. **spiekeri** McLearn were collected from talus and may be out of place, having rolled down from higher levels. A collection from 100 to 150 feet (30.5-45.7 m) above the formation base includes only **Gastroplites allani** McLearn (GSC loc. 69195). A collection about 150 feet (45.7 m) above the base includes common **Gastroplites allani** McLearn and transitional forms between this and **G. kingi** McLearn, rare G. **canadensis** (Whiteaves) and rare G. **(Paragastroplites) spiekeri** McLearn. A single poorly preserved specimen each of **Gastroplites** cf. **stantoni** McLearn and **Gastroplites** sp. indet. was obtained about 150 feet (45.7) above the base (GSC loc. 69194). Another collection (GSC loc. 69172) situated also about 150 feet (45.7 m) stratigraphically above the formation base has yielded **Gastroplites allani** McLearn, G. **canadensis** (Whiteaves), G. cf. G. **(P.) spiekeri** McLearn, and **Gastroplites** sp. indet.

Above those collections at about 200 feet (61 m) (GSC loc. 69191), the collections from talus contain many typical representatives of **Gastroplites allani** McLearn and a solitary specimen of **Stelckiceras liardense** (Whiteaves).

The stratigraphically higher fossil localities of this section still contain **Gastroplites allani** McLearn but are interpreted by Jeletzky (1980) to form part of the **Stelckiceras liardense** Zone because of a common to prevalent occurrence of the latter ammonite.

The Lepine Formation in a small gully on the east side of Liard River, across from Garbutt Creek, yielded the following sequence of **Gastroplites** faunas. The lowest collection (GSC loc. 69178) obtained from talus about 100 feet (30.5 m) stratigraphically above the upper Scatter siltstone equivalent and about 750 feet (230 m) above the top of the lower Scatter sandstone yielded only **Gastroplites kingi** McLearn and its morphological variants. GSC locality 69173 collected from talus at the level about 250 feet (77 m) stratigraphically above the previously mentioned siltstone has yielded **Gastroplites** cf. **kingi** McLearn, **G.** cf. **canadensis** (Whiteaves), and **Gastroplites** sp. indet. Another collection (GSC loc. 69177) at about the same level yielded **Gastroplites (Paragastroplites) spiekeri** McLearn and **Gastroplites** sp. indet. Farther upslope but again from talus (GSC loc. 69175), numerous **Gastroplites** forms transitional between **G. kingi** McLearn and **G. allani** McLearn were obtained. Among them, forms approaching G. **kingi** are more common than those approaching **G. allani.** Other than these transitional forms this fauna includes only common G. **canadensis** (Whiteaves) and its variants.

Fossils obtained in place (GSC loc. 69176) 300 feet (91.5 m) stratigraphically above upper Scatter siltstone yielded predominant **Gastroplites** aff. **allani** McLearn, less common **G. allani** McLearn, rare **G. canadensis** (Whiteaves) and a solitary representative of **G.** aff. **stantoni** McLearn (=**G. flexicostatus** Jeletzky, 1964 non Imlay, 1961). The highest collection (GSC loc. 69174) of this section, about 375 feet (115 m) stratigraphically above the siltstone, only yielded indeterminate gastroplitinid ammonites.

Beds of the basal Lepine Formation overlying the type section of the Scatter Formation on Scatter River contain the following sequence of **Gastroplites** s. str. faunas. Fossils (GSC loc. 69170) collected from talus just above the top of the upper Scatter (Tussock) sandstone yielded prevalent **Gastroplites kingi** McLearn, rare **G.** aff. **canadensis** (Whiteaves), and rare G. (**Paragastroplites**) **spiekeri** McLearn. A collection (GSC loc. 69168) obtained from talus 75 to 90 feet (25-30 m) above the top of the Scatter yielded prevalent **Gastroplites canadensis** (Whiteaves) and rare **G. kingi** McLearn. Fauna (GSC loc. 69171) collected in place about 80 feet (27 m) stratigraphically above the top of the Scatter yielded only **Gastroplites kingi** McLearn and its variants.

Stelckiceras liardense (Whiteaves) occurs 300 to 750 feet (91-229 m) above the base of the Lepine Formation along the eastern side of Liard River (GSC locs. 69179, 69180, 69185, 69187). It was also collected from shales on Crow River (GSC loc. 69181). Jeletzky (1980) believes that this fauna characterizes a zone of its own, being younger than the generalized zone of **Gastroplites** but older than any part of **Neogastroplites** and **Posidonia**? **nahwisi** Zone. The **Stelckiceras liardense** Zone is interpreted by Jeletzky as latest Middle Albian.

Sikanni Formation

Definition. The Sikanni Formation extends northward from the Muskwa-Tetsa region along the prominent Dunedin and Liard Escarpments (Plate 30). In the vicinity of the junction of Scatter and Liard Rivers, most of the Sikanni sandstone has graded laterally into siltstone and mudstone (Fig. 21; Plate 31). However, a few units of platy sandstone permit the delineation of the formation at that locality. Those sandstone beds were described by Kindle (1944) in his "Lepine" section as lying 1160 feet (354 m) above the base. Henderson (1954, p. 2283) realized that the Sikanni sandstone was disappearing northward, but erroneously correlated the Sikanni with 190 feet (58 m) of sandstone and shale lying below massive conglomerate, herein assigned to the Dunvegan Formation. The sandstone and shale lie within the Dunvegan and are characteristic of the basal part of the formation throughout the region. The Sikanni sandstone equivalent opposite Scatter River lies almost 1000 feet (305 m) below those beds.

Distribution and thickness. Only 433 feet (132 m) of sandy beds are included in the formation at Scatter River, although overlying, silty units are equivalent to upper sandstones occurring farther south. On the Liard Escarpment (Plate 30), northeast of Lepine Creek (sec. 65-15), about 460 feet (140 m) of thick bedded sandstone and mudstone are assigned to the Sikanni Formation, but the top of the formation is not exposed and the actual thickness may be greater.

The Sikanni Formation is not readily traced northward from Scatter River, although some part of it may be represented by a sandstone outcrop below the Dunvegan Formation at the big bend of Liard River. It is assumed to extend northeasterly along the east flank of the Kotaneelee Anticline (Fig. 3).

The Sikanni Formation is not recognized farther east around the margin of the Etsho Escarpment in Maxhamish Lake map-area and presumably it has graded into a shale facies. Electric log characteristics from well records suggest that equivalent beds can be traced eastward from Dunedin and Liard Escarpments. To the north on Petitot River, a sandstone unit occurring just within the Fort Liard map-area may represent some part of the Sikanni Formation but it also may occupy a stratigraphic position similar to the upper Scatter sandstone. About 125 feet (38 m) of sandy beds are exposed there, consisting mainly of fine grained sandstone with some argillaceous siltstone and mudstone.

Contact relationships. The basal beds of the Sikanni Formation are gradational with those of the underlying Lepine Formation. The contact is drawn at the base of the lowermost unit of sandstone, which is more than five feet (1.5 m) thick.

In the Scatter River region, the upper beds of the Sikanni Formation are gradational with those of the overlying Sully Formation, although the contact between sandstone and mudstone is distinct.

Lithology. Three sandy units are present in the section on Liard Escarpment opposite Scatter River (sec. 65-10A; Plate 31). To the south, on the escarpment, four prominent sandstone units are present in the exposed section (65-15; Plate 30).

Sandstone of the Sikanni Formation in this region is similar to that found elsewhere along the eastern Foothills Belt. It is mainly fine grained, very finely laminated, siliceous, and weathers light brownish grey. In the section near Lepine Creek, some coarse sandstone occurs at the top and conglomeratic sandstone blocks in the talus indicate the presence of that lithology at or near the top. Relationships are not sufficiently well defined to show if that conglomerate is equivalent to conglomerate at the top of the Sikanni farther south on Dunedin Escarpment (sec. 65-5). A thin bed of conglomerate occurs near the base of the formation opposite Scatter River.

The sandstone units range from less than one foot (0.3 m) to as much as 100 feet (30.5 m), although opposite Scatter River the units are poorly developed.

Mudstone of the Sikanni Formation is similar to that found elsewhere. It is dark grey to black, rubbly to blocky and contains some concretions.

The shales of Sikanni Formation on Liard Escarpment (sec. 65-10A) contain 29.87 per cent quartz, 1.23 per cent K-feldspar, 2.04 per cent Na feldspar, with illite, vermiculite, chlorite, and kaolinite (Foscolos and Stott, 1975, p. 19). The contributions of the illite in the mixed layers is 76 per cent, and the percentage of 2M illite polymorphs in discrete illite is 20.

The Sikanni Formation on the Liard Escarpment opposite Scatter River has lost its prominent, resistant character, and much of it has graded into argillaceous mudstone. The sandstones appear as fine ribs that form small ledges along the cliffs (Plate 31). These sandstones are argillaceous and show fine laminations, crosslaminations, and crossbeds.

PLATE 30

Sikanni Formation, Liard Escarpment; section 65-15. The sandstone grades laterally northward into silty mudstone and the prominent resistant nature of the formation is disappearing at this locality. The ridge at the skyline is formed by the Dunvegan Formation. GSC Photo 128516.

PLATE 31

Top of the Sikanni Formation, shales of the Sully Formation and basal beds of the Dunvegan Formation, cliffs above Liard River opposite Scatter River; section 65-10. GSC Photo 128482.

Fossil content and age. No fossils were obtained from the Sikanni Formation in this region. The Fish Scale marker horizon probably occurs above the Sikanni sandstone opposite Scatter River, occupying a position more or less similar to that found at the type Sikanni Formation on Sikanni Chief River. The formation in the Scatter-Liard region is assumed to occupy a stratigraphic position similar to that of other neighbouring regions and to be of approximately the same age.

Sully Formation

Definition. The Sully Formation extends southward from the type locality on Sully Creek in the District of Mackenzie (Stott, 1960b, p. 13) to the Scatter River locality (sec. 65-10). Beds lying in a similar stratigraphic position can be traced southward through Fort Nelson and Trutch map-areas (Taylor and Stott, 1968b; Pelletier and Stott, 1963) to Sikanni Chief River where they overlie the type Sikanni sandstone. The formation, occurring as a recessive unit between two prominent ridge-forming sandstones, is commonly covered by talus or vegetation.

Distribution and thickness. The Sully Formation, between 300 to 400 feet (91-122 m) thick on the Dunedin Escarpment, increases to about 1000 feet (305 m) thick opposite Scatter River (sec. 65-10; Plate 31). It is well exposed in gullies along the Liard Escarpment between Ruthie Creek and Scatter River, but is accessible only in a few places.

The Sully shales form the upper part of that section described by Kindle (1944) as Lepine (see Fig. 21).

Contact relationships. The contact of the Sully mudstone with underlying Sikanni sandstone is rarely seen, but appears to lie above different sandstone units from one locality to another. Opposite Scatter River (sec. 65-10A), the top of the uppermost Sikanni sandstone has been channelled and the uneven surface filled with 4 to 5 inches (101-127 mm) of conglomeratic sandstone. The pebbles, mainly chert, are as much as one inch (25.4 mm) in diameter.

Lithology. In the Scatter River region, the Sully is divided readily into the three members which were recognized in the type section (Stott, 1960b).

The lower concretionary member, about 280 feet (85 m) thick opposite Scatter River (sec. 65-10A), comprises silty, dark grey to black mudstone that weathers rusty (Plate 32). Reddish brown weathering, sideritic concretions occur in rows and also are disseminated in the member. In these exposures, the mudstone is softer and crumbles more easily than similar mudstones that occur within the folded Foothills Belt.

The flaky shale member (sec. 65-10A), over 400 feet (122 m) thick, consists mainly of soft, flaky to fissile shale which weathers medium to light grey (Plate 33). On a fresh surface, this shale is black. The surface of the weathered slopes is coated with a yellow efflorescence. A few hard silty beds appear to form the base for water seepage, and the associated wet shale has a darker appearance than the remaining parts of the member. In contrast to the enclosing members, this one contains few, if any, concretions.

The upper concretionary member (secs. 65-10A, 65-10B) is about 300 feet (91 m) thick, and is similar to the basal member. Thin beds of sandstone occur throughout this member, but the dominant lithology is silty mudstone with sideritic concretions. The member becomes extremely silty in its upper part and grades into overlying sandstone of the Dunvegan Formation.

The Sully shales on Liard Escarpment, according to Foscolos and Stott (1975, p. 19) have a composition similar to the shale of the Sikanni equivalents. They contain 29.87 per cent quartz, 1.23 per cent K feldspar, 2.04 per cent Na feldspar, with illite, vermiculite, chlorite and kaolinite. Illite contributes 76 per cent and the percentage of 2M illite polymorphs in discrete illite is 20.

PLATE 32

Lower concretionary shale member of Sully Formation, cliffs opposite Scatter River; section 65-10. GSC Photo 128493.

PLATE 33

Fissile shale member of Sully Formation, cliffs across from Scatter River; section 65-10. GSC Photo 128492.

Fossil content and age. The Sully Formation at its type section in the District of Mackenzie lies above beds containing **Neogastroplites cornutus** (Whiteaves) (see Stott, 1969b, p. 12-13). Similarly, on Sikanni Chief River, the Sully lies above beds tentatively dated by Jeletzky as lying within the **N. cornutus** subzone. The Sully Formation on the Liard Escarpment occupies about the same stratigraphic interval as the type section and is considered to be approximately the same age.

Lithologic correlations indicate that the lower member and probably part of the middle member are equivalent to upper sandstone of the Sikanni Formation in the western region between Dunedin and Kluachesi Rivers (Fig. 12). The section at Liard River is very similar to the type section in the District of Mackenzie and, although the latter is several hundred feet thicker, the stratigraphic interval appears to be approximately the same.

Liard and La Biche region

Definition. McConnell (1890, p. 53D, 55D), in his descent of Liard River, noted Cretaceous shales at the mouth of Petitot (Black) River and also seven miles (11.3 km) downstream from Fort Liard. Hume (1923, p. 48B), as did McConnell, visited the mountains west of Fort Liard and reported the occurrence of conglomerate and coarse grained sandstone, "presumably of Cretaceous age", overlying steeply dipping Cretaceous shales. Hume's traverse apparently was in the vicinity of Kotaneelee River where the Dunvegan Formation is prominently developed at the north end of Liard Syncline. Camsell and Malcolm (1921), in their summary of the geology of the "Mackenzie River Basin", quoted extensively from the report of McConnell.

During 1944, Hage (1945) made a geological reconnaissance along Liard River from below the mouth of Fort Nelson River. He made traverses up La Biche, Kotaneelee, Petitot, Muskeg, South Nahanni, and Blackstone Rivers. Hage's map showed the distribution of the Dunvegan (Fort Nelson) Formation and Fort St. John Group in the vicinity of La Biche and Liard Ranges and eastward along Petitot River.

In the region between Liard and La Biche Ranges, Douglas and Norris (1959) divided the Fort St. John Group into six separate map-units. Their lowest unit (10) undoubtedly includes beds older than Cretaceous. The next three units (11, 12, 13), assigned to the Buckinghorse Formation, were recognized by them as being equivalent approximately of the Garbutt, Scatter, and Lepine Formations of the Liard region to the south. The Sikanni Formation was divided into two parts, the lower (15) consisting mainly of sandstone, and the upper (16) mainly of shale. Subsequently, the writer (Stott, 1960b) restricted the name Sikanni to the sandstone, and defined the shale as the Sully Formation.

Later work by the author in the vicinity of Fantasque Lake revealed that the Scatter sandstone is well developed and readily mapped (Fig. 3; Plate 34). The extension of the Scatter and Sikanni Formations from the Scatter-Liard region into the region of the Liard Range was also confirmed. Consequently, in that region, the Fort St. John Group comprises a five-fold subdivision consisting of the Garbutt, Scatter, Lepine, Sikanni, and Sully Formations (Table V; Figs. 6, 19, 20). Marked facies changes result in the disappearance eastward of the major sandstones forming the Scatter and Sikanni Formations and in the variation of terminology from one area to another.

Standard section. The most continuous section in the western part of this region occurs on Sully Creek (Stott, 1960b, sec. 2; see also Fig. 19), where both the lower and upper contact are exposed. Representative parts of all the formations are exposed although large intervals, as much as several hundred feet, are covered. Most of the Garbutt Formation, the basal or Bulwell Member of the Scatter Formation and most or all of the Sikanni Formation appear in outcrop. The upper Scatter sandstone is not evident on either Sully or Murky Creeks and may not be developed in this region. However, despite the covered intervals, the section on Sully Creek serves as the best available standard section in the region.

The section on Murky Creek (Stott, 1960a, sec. 1) is almost continuously exposed in the lower 1300 feet (396 m), providing good sections of the Garbutt and Scatter Formations. However, 1500 feet (457 m) in the middle of the group is covered, and presumably represents almost the entire Lepine Formation. The Sikanni Formation is well exposed but almost none of the overlying Sully shale outcrops and the contact of the group with the overlying Dunvegan cannot be determined at that locality.

In the Plains, the lower part of the Fort St. John Group outcrops along Petitot River on the western flank of the Bovie Lake structure. Beds equivalent to the Garbutt Formation are not exposed there and the main exposure appears to consist of strata largely equivalent to the Scatter Formation. The upper part of the group is exposed in the lower part of the Petitot canyon but the Sikanni sandstone is not definitely recognized in this region.

Distribution and thickness. The distribution of Cretaceous rocks in this region was shown originally on Fort Liard and La Biche map-areas (Douglas and Norris, 1959) and in maps compiled by Douglas and Norris (in Stott, 1960b). In those earlier reports, a moderately recessive unit of dark shale and siltstone was included in map-unit 10 and, in some places, in the basal map-unit 14 of Douglas and Norris (1959). Most or all of those beds are now assigned by the writer to the Triassic Toad and Grayling Formations and were shown as such on recent maps by Douglas (1976a, b). Therefore, the

PLATE 34

Scatter sandstone south of Fantasque Lake, Yukon Territory. GSC Photo 128511.

areal extent of the Fort St. John Group in some areas, particularly within the Beaver River Basin, is less than shown in previous publications (see Fig. 3).

In the eastern half of the La Biche River (95C) map-area, the Fort St. John Group extends along the axis of the Fantasque Syncline and farther east, along the Kotaneelee and La Biche Synclines. The best exposures are on Murky and Sully Creeks which flow off the western slopes of the Liard Range. In the Fort Liard (95B) map-area, the group is poorly exposed along the Liard Syncline between Pointed Mountain and Liard Range. It underlies most of the Plains region to the east, being best exposed along Petitot River on the western flank of the Bovie Anticline.

The most complete section of the Fort St. John Group occurs on Sully Creek on the west flank of Liard Range (Stott, 1960b, sec. 2) where a measurement, including covered intervals, in the order of 4650 feet (1417 m) was obtained. A graphic calculation, prepared for the author by Geophoto Services Limited, gave a cumulative thickness of 4044 feet (1231 m) for the Fort St. John Group on Sully Creek. If the group is only about 4000 feet (1219 m) thick in this region, it is considerably thinner than shown in Figures 9, and 19, which would indicate substantial reduction in deposition between Scatter River and the Liard Range. In Imperial Pan Am La Biche b-55-E well (b-55-E/94-O-13) to the southeast, the thickness of the group is in the order of 4400 feet (1341 m) (Fig. 19). Williams (1978) outlined the general distribution, thickness and facies trends of the Fort St. John Group in the region of Trout Lake, east of Liard River in the District of Mackenzie. He shows that the thickness decreases eastward from the Bovie Lake structure from slightly more than 1700 feet (518 m) to approximately 900 feet (274 m) excluding basal Cretaceous and/or Upper Paleozoic sandstone and not including transition beds above the Fish Scale marker.

Although some of the group is exposed along Petitot River, its total thickness west of the Bovie Lake structure is not known with any certainty. The Imperial Sun Netla Raven F-73 well was spudded in the Dunvegan Formation and the base of the Cretaceous succession is 2100 feet (640 m) below the top, so the total thickness of the Fort St. John east of the Bovie Lake fault does not exceed 2000 feet (610 m) and is probably 200 to 300 feet (61-91 m) less in most places. In Maxhamish Lake map-area to the south, but on the west side of the Bovie Fault, the thickness of the group is about 3700 feet (1128 m) in the Imperial Pan Am Tattoo 26-B well. Based on these relationships, it seems likely that the Fort St. John Group along Petitot River is in the order of 3500 feet (1067 m) thick. The thickness of the group farther east in Imperial Island River No. 1 well (Lat. 60°00'55"N, Long. 121°90'00"W) is approximately 1500 feet (457 m), although the base of the Dunvegan Formation is not well defined in that well.

Contact relationships. The regional unconformity at the base of the Cretaceous succession is most pronounced in this region. Within the Beaver River Basin, the Cretaceous succession is assumed to lie on the Triassic Toad and Grayling Formations that extend into the region from Toad River [94N map-area (Douglas, 1976a, b; Taylor and Stott, 1980)]. To the northeast on Tika Creek, a tributary of La Biche River, Cretaceous beds lie on the Carboniferous to Permian Mattson Formation, and similar relationships were observed on Murky Creek on the west flank of Liard Range. The Fort St. John Group at the south end of Pointed Mountain lies on micaceous grey shales of questionable but probably Triassic age. Williams (1978, Fig. 4) illustrated the pre-Cretaceous geology indicating that throughout much of the area in the vicinity of Trout Lake, the Fort St. John Group lies on Mattson and Flett Formations but north towards Mackenzie River lies on upper Devonian beds.

TABLE V

TABLE OF FORMATIONS

Liard and La Biche Region

Series	Group	Formation thickness	Lithology
Upper Cretaceous		Wapiti	Coarse grained, conglomeratic sandstone.
		Kotaneelee 600'± (183 m)	Dark grey, marine mudstone; some fine grained sandstone.
		unconformity	
		Dunvegan 450-600'? (137-183 m)	Massive conglomerate, fine- to coarse-grained sandstone; carbonaceous mudstone.
Lower Cretaceous	Fort St. John 900-4500' (274-1372 m)	Sully 1500'± (453± m)	Dark grey, silty, marine shale with sideritic concretions; flaky black shale.
		Sikanni 0-350' (0-107 m)	Fine grained, laminated, marine sandstone; silty mudstone.
		Lepine 1600-1700' (487-518 m)	Dark grey, silty marine mudstone with sideritic concretions.
		Scatter 247-1000?' (72-304 m)	Fine grained glauconitic sandstone and siltstone; silty marine shale.
		Garbutt 650-872' (198-265 m)	Silty mudstone and siltstone; sideritic concretions.
Regional erosional unconformity; bevels succeedingly older rocks northward and eastward.			

The section on Petitot River is not completely exposed and neither structural nor stratigraphic relationships are obvious. However, on the west flank of the Bovie Lake structure, the basal Cretaceous beds apparently consist of 38 feet (11.6 m) of fine grained, grey, brownish grey sandstone that is thin bedded. As far as can be determined, those beds lie on either the Mississippian Mattson Formation or the younger Permian Fantasque Formation (Williams, 1978). Farther east, the Cretaceous succession lies on the older Mississippian Flett Formation.

In a small area north of the Bovie Lake Anticline, the Fort St. John shale, according to Williams (1978, Fig. 4) lies on a "basal Cretaceous and/or upper Paleozoic sandstone". He reported that the sandstone, as much as 170 feet (52 m) thick, consists of poorly sorted quartz sandstone and medium grey, sandy shale. Some chert pebbles occur at the top of the unit.

Lithology. Except in the Beaver River Basin, the Fort St. John Group of this region consists mainly of silty marine mudstone with some units of fine grained, marine sandstone. The Scatter sandstone appears as a resistant unit in the Fantasque Syncline of the Beaver River Basin (Plate 34) but in the Kotaneelee and Liard Synclines, it is much less prominent.

Age. The lower beds of the Fort St. John Group of this region have yielded fossils of Early Albian age and the group is overlain by the Cenomanian Dunvegan Formation. The group is therefore dated as Early Albian to earliest Cenomanian.

Garbutt Formation

Definition. Dark marine shale, lying above Paleozoic rocks in the vicinity of Liard Range, was assigned to the Buckinghorse Formation by Douglas and Norris (1959) and by the writer (Stott, 1960b). That interval is largely equivalent to the type Buckinghorse proposed by Hage (1944). Hage (1945) had examined Lower Cretaceous strata on La Biche and Petitot Rivers, but did not assign them to specific formations. In the recent revisions of the earliest mapping, a sandstone within the succession is assigned to the Scatter Formation (Fig. 3; Douglas, 1976a, b). The shales at the base of the succession can therefore be assigned to the Garbutt Formation and are in continuity with the type Garbutt shales of the Scatter-Liard region (Fig. 3).

The Garbutt shales are well exposed on both Murky and Sully Creeks and both lower and upper contacts can be observed.

Contact relationships. The basal Cretaceous contact has been observed at several localities in the La Biche-Kotaneelee region. Sandstone, 35 feet (10.7 m) thick and presumed to be basal Cretaceous, lies unconformably on Permian sediments on La Biche River (Lat. 60°38'N, Long. 124°45'W) in the northern part of Fantasque Syncline. This sandstone is mottled, crossbedded, thick bedded, and brown weathering. The contact with underlying quartzose sandstone is sharp but not particularly distinct. The Permian sandstone grades downward into dark grey shale containing abundant sponge spicules. Slightly farther along the exposure, the Permian sandstone is eroded and the Cretaceous beds rest directly on the dark grey mudstone. On Kotaneelee River (Lat. 60°36'N, Long. 124°14'W), where it cuts the east flank of the La Biche Syncline, the basal Cretaceous sandstone and glauconitic mudstone lie on the Permian Mattson Formation. The Permian sandstone has pebbles as much as 1 inch (25.4 mm) in diameter embedded in its upper surface, which is also a surface of pyrite deposition. Pebbles occur also in the overlying Cretaceous shale. On Sully Creek (Stott, 1960b, sec. 2), 33 feet (10 m) of cherty conglomerate to breccia is overlain by medium grained sandstone, which in turn is overlain by typical Cretaceous shale. The conglomerate lies on dark grey calcareous mudstone containing Permian brachiopods.

Distribution and thickness. The Garbutt Formation is exposed along La Biche River in the axis of the Fantasque Syncline, on Kotaneelee River in the La Biche Syncline and along the flanks of the Kotaneelee Syncline. The main exposures of the formation are on two tributaries of Chinkeh Creek, Murky and Sully Creeks (Stott, 1960b, secs. 1, 2). The thickness at Murky Creek is 872 feet (265.2 m); at Sully Creek only 834 feet (222.5 m) are included but estimates of covered intervals may be slightly in error.

Beds assigned to the Garbutt Formation are mapped (Douglas, 1976a; see also Fig. 3) west of Kotaneelee Range, southward across La Biche and Beaver Rivers, and also in the Beaver River Basin. At the northern end of the Kotaneelee Syncline, 245 feet (74.7 m) of silty mudstone with two thin seams of bentonite are exposed approximately 100 feet (30.4 m) below the Scatter sandstone. The lower part of the formation is not exposed.

About 650 feet (198 m) of beds, mostly covered, on Petitot River appear to be equivalent to the Garbutt Formation of the more westerly region.

Lithology. In the original mapping of the region by Douglas and Norris (1959), moderately recessive dark shale and siltstone, occurring at the base of the Cretaceous succession, were included in the Buckinghorse Formation. Those beds are shown as part of map-unit 10 and, in some places, in map-unit 14 of Douglas and Norris. However, much or most of that unit is now considered to be Triassic strata of the Toad and Grayling Formations (see Douglas, 1976a, b).

On the west flank of Liard Range, along Murky and Sully Creek, the Garbutt Formation consists of a basal conglomeratic sandstone and shale. On Sully Creek the basal conglomerate lies with erosional unconformity on the Permian Mattson shale. The conglomerate, 33 feet (10 m) thick, consists mainly of chert pebbles, in a matrix of medium- to coarse-grained quartz grains. The conglomerate at that locality is overlain by 20 feet (6.1 m) of brownish grey, massive, medium grained, quartzose sandstone. A unit of conglomerate, 35 feet (10.7 m) thick, was reported by Hage (1945) to occur on Pointed Mountain.

The Garbutt shale, approximately 900 feet (274 m) thick, is micaceous, rubbly, rusty weathering, and contains some sideritic concretions, pyrite, glauconite, and thin layers of bentonite. A massive quartzose, glauconitic sandstone, 30 feet (9.1 m) thick, lies about 150 feet (45.7 m) above the base of the formation on Kotaneelee River. The Garbutt shale and mudstone are black on fresh surfaces. As noted previously, two thin seams of bentonite occur within the exposed Garbutt succession south of Etanda Lakes.

Age. **Puzosia** (s. lato) aff. **P. sigmoidalis** Donovan and **Arcthoplites** cf. **A. belli** (McLearn) were found in the lower shales of the Garbutt Formation near Chinkeh Creek (GSC locs. 32855, 32856). Jeletzky (1968) considered **Puzosia** as representative of the Early Albian **Leymeriella** Zone. Jeletzky (pers. comm., 1979) also reports the occurrence of **Pachygrycia**, an index fossil of Early Albian age, from the basal beds of the Garbutt Formation at Jackfish Gap, west of Liard Range.

Basal Cretaceous sandstone at Jackfish Gap was found by Braman and Hills (1977) to contain Cretaceous palynomorphs including:

Alisporites grandis (Cookson) Dettmann
Baltisphaeridium multispinosus Singh
Cicatricosisporites cf. **C. australiensis** (Cookson) Potonie
Cycadopites sp.
Cyclonephelium cf. **C. distinctum** Deflandre and Cookson
Gleicheniidites senonicus Ross
Laevigatosporites ovatus Wilson and Webster
Lycopodiumsporites marginatus Singh
Odontochitina operculata (Wetzel) Deflandre
Oligosphaeridium complex (White) Davey and Williams
Tigrisporites scurrandus Norris
Trilobosporites apiverrucatus Couper
dinoflagellate sp.
fungal spores

In his unpublished thesis (Braman, 1976) dated this assemblage as Hauterivian to Albian in age.

Scatter Formation

Definition. The Scatter Formation can be traced northward from the type locality along the flanks of the La Biche Syncline and Kotaneelee Anticline (Fig. 3). Although the beds are not continuous, sandstone in an equivalent stratigraphic position occurs in the vicinity of Fantasque Lake (Plate 34) and also within Kotaneelee Syncline between Liard and Kotaneelee Ranges (Fig. 3). These beds were designated as map-unit 12 by Douglas and Norris (1959) who indicated that they "appear to be equivalent in part to beds mapped by Kindle (1944) as Scatter Formation on Beaver River".

The sandstone exposed on both Murky and Sully Creek, along the western slopes of the Liard Range, appears to be the basal Scatter sandstone (Bulwell Member). The upper sandstone either is not exposed or is not developed in that region. However, in the vicinity of Fantasque Lake, a resistant unit above the massive basal sandstone (Plate 34) probably is equivalent to the Tussock Member and the intervening recessive unit is assumed to be the Wildhorn shale.

Both the lower and upper contacts are gradational. The Garbutt shale grades upward into silty mudstone with thinly bedded siltstone and very fine-grained sandstone to siltstone of the Scatter. Argillaceous siltstone at the top of the Scatter is overlain by silty mudstone of the Lepine Formation.

Distribution and thickness. The Scatter Formation is mapped within the La Biche map-area (Fig. 3; see also Douglas, 1976b), occurring between Liard and Kotaneelee Ranges. The beds are 247 feet (72.3 m) thick on Sully Creek (Stott, 1960b, sec. 2, units 13-20) and 168 feet (51.2 m) on Murky Creek (Stott, 1960b, sec. 1, units 18-24). The sandstone appears at the north end of Fantasque Syncline but was not measured. As previously mentioned, all three members of the type Scatter Formation appear to be present in the vicinity of Fantasque Lake but are mostly inaccessible and not easily measured. The formation is not well exposed on the flanks of La Biche Syncline nor on Kotaneelee Anticline.

An outcrop on Kotaneelee River southeast of Pointed Mountain was included in the Sikanni Formation by Douglas and Norris (1959). Based mainly on that exposure, the Sikanni was extended southward to La Biche River, where it was shown to be cut off by a fault. It now seems probable that the outcrop is, in reality, part of the Scatter Formation and that it is continuous with map-unit 12 (lower Scatter) along the east flank of Kotaneelee Anticline (Fig. 3; see also Douglas, 1976a, b).

The sandstone sequence exposed in outcrop along Petitot River above its junction with Liard River is assigned to the Scatter Formation. Hage (1945) described the sequence:

> *About 200 feet of sandstone and interbedded shale is exposed in a cliff on the south bank of Petitot River close to its mouth. The sandstone member is overlain by dark grey shale containing concretions, and is interbedded with thin, fine-grained sandstone beds.*

Hage considered that the lower sandstone could be correlated with the Scatter Formation and the upper fissile shale with the Lepine Formation, as described by Kindle (1944). Hage reported that **Neogastroplites cornutus**? was collected from the lower half of the fissile shale unit.

In subsequent mapping (Douglas and Norris, 1959), the sandstone oucrop near the Petitot River was included in the Sikanni Formation which was linked with other sandstone outcrops on Muskeg River, Rabbit Creek and other tributaries near their junction with Liard River. Stott (1960b, secs. 5, 6) assigned these beds to the Sikanni Formation, stating (p. 11):

> *The Sikanni Formation is partly exposed on Petitot River near its junction with Liard River where 250 feet of strata were measured.... High water prevented the examination of the formation along Muskeg River (near junction with Arrowhead River) where it forms the cliffs of a small canyon. The formation is exposed at the junction of Muskeg and Liard Rivers where 85 feet outcrop.*

Based upon more recent interpretations and investigations, the sandstone near the junction of Petitot and Liard Rivers has been mapped as the Scatter Formation (Fig. 3; Douglas, 1976a).

A siltstone succession, about 360 feet (110 m) thick, on the west flank of the Bovie structure represents some part of the Scatter Formation (Stott, 1960b, sec. 3, units 2-15). Those beds are separated by a covered interval of approximately 650 feet (198 m) from sandstone of presumably Cretaceous age that lies on Mississippian strata. The siltstone unit is overlain by 450 feet (137 m) of mudstone which is equivalent to the middle Scatter shale. Exposures farther downstream are discontinuous, but the shale beds assume a vertical position and appear to be faulted. Beyond there, the beds dip more gently to the southwest toward the axis of the Liard Syncline. About 120 feet (36.6 m) of fine grained sandstone oucrops on the north bank of Petitot River and can be traced northward on aerial photographs. Although that sandstone was at one time assumed by the writer to be part of or equivalent to the Sikanni Formation, it now seems more likely that it is equivalent to the upper Scatter (Tussock) sandstone. There is a development of sandstone below Radioactive Marker 3 (Figs. 18, 20) which is considered to be upper Scatter.

Lithology. The Scatter sandstone on Murky and Sully Creeks is quartzose, fine grained, greenish grey, finely crossbedded and glauconitic. The sand grains consist of about 95 per cent quartz. The sandstone is very silty to argillaceous, poorly bedded, brown weathering and includes intercalated mudstone. The colour of the weathered surface, rather than the prominence of the sandstone, makes this unit distinctive. Two prominent resistant units are present on Sully Creek, but become more argillaceous northward and are much less conspicuous on Murky Creek.

Both the upper and lower sandstone members of the Scatter Formation are exposed along Kotaneelee Canyon on the west flank of Kotaneelee Syncline. The upper member appears to be dominantly mudstone and siltstone, as in the type region. The lower member contains much interbedded mudstone and evidently is grading laterally northeastward from the prominent, cliff-forming sandstone at Fantasque Lake (Plate 34) into the very argillaceous sequence found at Murky and Sully Creeks.

The Scatter Formation on Petitot River, about a mile above its junction with Liard River, consists of interbedded argillaceous, rusty weathering siltstone and very fine to fine-grained, grey, laminated sandstone. Farther upstream, on the west flank of the Bovie structure, the basal part of the succession consists of thin beds of fine grained sandstone, argillaceous siltstone and rusty weathering shale. The overlying beds are dominantly greyish black, blocky mudstone, rusty weathering with sideritic concretions and minor beds of laminated sandstone and siltstone. Some sideritic concretions are present. The sandstone now considered to be equivalent to the upper part of the Scatter includes fine grained, laminated sandstone, with thin interbeds of shale and argillaceous siltstone.

This upper sandstone on Petitot River is described follows:

	Thickness feet (m)	Height Above Base feet (m)
Top of Section		
Overlain gradationally by silty, rusty weathering, platy shale with a few lenses of sandstone		
Sandstone, fine grained, laminated grey flaggy	25 (7.6)	123 (37.5)
Sandstone, platy to flaggy	10 (3.05)	98 (29.9)
Mudstone, silty, platy, rusty weathering	9 (2.7)	88 (26.8)
Sandstone, fine grained, laminated, crosslaminated, grey, brownish grey weathering; few thin beds of shale	22 (6.7)	79 (24.1)
Sandstone, fine grained, laminated, crosslaminated, brownish grey; shale at base	9 (2.7)	57 (17.4)
Sandstone, silty, laminated, crosslaminated; thin bedded; some argillaceous siltstone	31 (9.4)	48 (14.6)
Sandstone and shale	4 (1.2)	17 (5.1)
Sandstone, fine grained, laminated; thin bedded	13 (4.0)	13 (4.0)

Williams (1978, Fig. 6) indicates that he recognizes the sandy facies of the Scatter equivalent in wells in the more westerly part of the Plains but that it disappears east toward Trout Lake.

Age. The Scatter Formation in this region is not well dated. No fossils were found in these beds in the vicinity of Liard Range. However, microfossils were identified by J.H. Wall from the middle to upper portion of the shales on the west flank of the Bovie structure along Petitot River. Wall reports (pers. comm., 1975):

> *. . .several specimens of **Haplophragmoides multiplum** Stelck and Wall, described originally from the Commotion[1] Shale on the Peace River near Hudson Hope and also reported from the Harmon Shale of the lower Peace River valley area. This would indicate a Middle Albian age for this sample. . .*

Lepine Formation

Definition. The Lepine shale within the La Biche Syncline is continuous with the type section (Fig. 3). It occupies a wide recessive interval between the resistant Scatter sandstone at the base and the Sikanni sandstone at the top.

Distribution and thickness. The Lepine formation is in the order of 1600 to 1700 feet (487-518 m) thick on the west side of Liard Range (Stott, 1960b, sec. 1, units 25-29; sec. 2, units 21-32 previously assigned to Buckinghorse Formation). The shale is not continuously exposed in the region, is mostly covered on Murky Creek, and only partly outcrops along Sully Creek. Several exposures occur along the headwaters of the La Biche River (Douglas, 1976b).

The Lepine is not mapped east of Liard River where the Sikanni sandstone apparently is not developed and the sequence between the Scatter and Dunvegan Formation is entirely shale. Douglas (1976b) indicated that concretionary, gypsiferous and rusty weathering shale in that region was "equivalent to Lepine and Sully Formations". No measurement of outcrop thickness was obtained. Hage (1945) reported that an upper, fissile shale unit along Petitot River above the junction of Liard River was about 1625 feet (494 m) thick.

The thickness of beds between the Radioactive Marker 3, considered to lie at the top of the Scatter Formation, and the Dunvegan Formation is almost 2700 feet (823 m) in the IOE Pan Am Viscount a-77-d well (a-77-d/94-O-11). On the east side of the Bovie Lake Fault, the thickness appears to be in the order of 1400 to 1500 feet (427-457 m) although the base of the Dunvegan is not defined (Fig. 20). The interval between Radioactive Markers 3 and 4, corresponding to the combined Lepine-Sikanni succession is between 800 and 900 feet (244-274) in the eastern wells (Fig. 20). This contrasts markedly with the 4400 feet (1341 m) of the type Lepine on Liard River (Fig. 17).

Lithology. In the region of Murky and Sully Creeks, the basal part of the succession appears to consist of rubbly, rusty weathering mudstone with ironstone concretions. Similar shales outcrop along the Sully Creek although shale, about 250 feet (76 m) below the top, appears more fissile and flaky.

Age. The Lepine Formation lies below the Sikanni Formation which, on Sully Creek contains **Neogastroplites cornutus** (Whiteaves) of Late Albian age (GSC loc. 32852). It appears to be mostly equivalent to the type Lepine of late Middle to earliest Late Albian age.

Sikanni Formation

Definition. The Sikanni Formation of this region is predominantly a massive silty sandstone lying within the upper third of the Fort St. John Group. A standard section on Murky Creek was outlined by the writer (Stott, 1960b, sec. 1).

Distribution and thickness. The Sikanni Formation is recognized along several small streams flowing down the western slopes of Liard Range, north of Pointed Mountain. It is about 350 feet (107 m) thick in that region (Stott, 1969b, sec. 1 and 2).

The Sikanni apparently occurs in a recessive silty facies east of Pointed Mountain and is inseparable from upper Fort St. John shales. As indicated previously, sandstone southeast of Pointed Mountain and also near the junction of Petitot and Liard Rivers was mapped by Douglas and Norris (1959, and included by Stott, 1960b) in the Sikanni Formation. However, it now appears that this sandstone should be assigned to the Scatter Formation.

The Sikanni sandstone is not recognized farther east in the wells in the Plains (Figs. 18, 20).

Williams (1978, Figs. 5, 8) recognizes the Sikanni marker, which he considers to correspond approximately to the top of the Sikanni Formation in western outcrops, throughout the Trout Lake map-area. However, he indicates (1978, Fig. 8) that a sandstone facies below the marker grades eastward into silty shale. Nevertheless, Williams did not consider that the sandstone facies was sufficiently strongly developed to justify the recognition of the Sikanni Formation as a distinct stratigraphic unit in this region.

---

[1]The shale referred to here is part of the Hulcross Formation of this report.

Lithology. The author (Stott, 1960b, p. 12) described the Sikanni sandstone as follows:

> *West of the Liard Range, the Sikanni Formation consists of fine grained sandstone, argillaceous siltstone and shale. The sandstone is greenish grey, thickly bedded, commonly calcareous, and much of it is finely crossbedded. Glauconite is commonly found as small pellets and also as irregular masses around the grains. The sandstone, which is classed as a quartz arenite, is composed of about 80 per cent quartz, 5 per cent chert, and 10 to 15 per cent matrix and minor constituents. Some bitumen was noted. The siltstone is argillaceous, massive to thickly bedded, dark grey to brownish grey, may be glauconitic, and frequently contains small sideritic concretions. It shows fine laminations and crossbeds. The glauconite of sandstones has recrystallized from pellets and has spread around the sand grains. The cleaner sandstones have a "welded" texture in which silica binds the quartz grains together, forming a mosaic resembling a quartzite.*

Age. The Sikanni Formation in the west flank of the Liard Range yielded **Posidonia** cf. **P. nahwisi** McLean sensu lato (GSC loc. 32850) and **Neogastroplites cornutus** (Whiteaves) GSC loc. 32852). Jeletzky refers **N. cornutus** to the second oldest **Neogastroplites** zone and assigns it a late Albian age.

Sully Formation

Definition. The Sully Formation was defined originally in this region by the writer who stated (1960b, p. 13):

> *The Sully Formation is defined as those shale beds lying below the sandstones and conglomerate of the Fort Nelson Formation and above the sandstone and siltstone of the Sikanni Formation as herein restricted. The formation is partly exposed on Kotaneelee River and at the type section on Sully Creek, where it is approximately 1500 feet thick; it has an estimated thickness of 1000 feet on Petitot River and 655 feet in the Imperial Island River No. 1 well.*

Since that time, the name Fort Nelson has been abandoned in favour of Dunvegan.

The type section on Sully Creek (Stott, 1960b, sec. 2) is not completely exposed. However, three distinctive members can be recognized; a basal and upper member consisting of concretionary mudstones, separated by a middle member of dark grey, fissile shale.

The basal member, 500 feet (152 m) thick, consists of rubbly, sideritic, dark grey, rusty weathering mudstone, very similar to other Cretaceous concretionary mudstone. These beds are well exposed on Kotaneelee and Petitot Rivers.

The middle part of the formation contains flaky, fissile shale that is greyish black and stained by much yellow efflorescence. Selenite occurs as small rosettes and crystals, and some bentonite is present. These non-concretionary beds are exposed on the west flank of Liard Range, on Petitot River, and are present farther east on the Cameron Hills and north on Horn Plateau.

The upper member, about 700 feet (213 m) thick, is similar to the basal beds, consisting of rusty weathering, concretionary mudstone. The content of silt and sand increases toward the top, with thin interbeds of platy sandstone appearing in a transitional sequence between the concretionary mudstone and the basal thick bedded, fine- to coarse-grained sandstone of the overlying Dunvegan Formation.

East of Liard River, the Sikanni sandstone is not recognized as a separate formation and the Fort St. John Group is not subdivided. Beds equivalent to the Sully Formation of more western exposures include the interval between the "Sikanni marker" of Williams (1978) and the base of the Dunvegan Formation.

Williams (1978) described the beds above the "Sikanni marker" in the Trout Lake region, showing the development of the "Fish Scale marker" or "Radioactive Marker No. 4" within the interval. He outlined a sequence of "Transition beds" as much as 650 feet (198 m) thick occurring below beds assigned to the Dunvegan Formation. Williams stated that the dominant lithology is a "poorly consolidated claystone-siltstone mixture". Although he suggested that "they are probably nonmarine in part", he considered that "these beds have more in common with the Fort St. John Group than with the Dunvegan Formation". He also suggested that:

> *The transition beds, in part at least, are the time equivalent of the lower part of the Dunvegan Formation - the prodeltaic facies of the Dunvegan conglomerates and sandstones.*

Age. **Posidonia nahwisi** McLearn var. **goodrichensis** was collected from the basal shales of the Sully Formation on Kotaneelee River (GSC loc. 32880). According to Jeletzky, this fauna is of Late Albian age. **Neogastroplites** was collected on Sully Creek from the underlying Sikanni Formation. Warren and Stelck (1969, p. 538) reported the occurrence of **Neogastroplites cornutus**? var. D in beds 400 to 500 feet (122-152 m) below the base of the Dunvegan Formation on Petitot River about 7 miles (11.2 km) above the mouth.

Correlation

The correlation of the various stratigraphic units within the Fort St. John Group is based on lateral continuity and occurrence of index fossils. Macrofossils are not abundant within the succession, and although a reasonably refined zonation based on invertebrates is available (Jeletzky, 1964, 1968, 1980; Stelck et al., 1956, 1958; Warren and Stelck, 1969), some relationships remain obscure. The interested reader is referred to those references for detailed analyses of faunal relationships.

Although microfauna from various parts of the group have been studied (Chamney, 1973a; Stelck et al., 1956, 1958; Sutherland and Stelck, 1972; Caldwell et al., 1978), no complete analysis has been made. The most comprehensive summary is by Caldwell et al. (1978) but they have not studied the microfauna from several large intervals of the Fort St. John Group. Only limited palynological investigations have been made, although work of Singh (1971, 1976) in the Peace River Plains has demonstrated the validity of this approach within rocks of the Fort St. John Group. Macroflora occur in the Gates and Boulder Creek sandstones south of Peace River, but no collections from the Fort St. John Group were obtained north of there. Abundant macroflora in parts of the Dunvegan Formation appears to be diagnostic (Bell, 1963).

Early Albian

***Pre-Arcthoplites* beds.** Positive evidence or rocks older than those occurring in the **Arcthoplites** Zone is meagre. The recorded occurrences of **Arcthoplites** and **Beudanticeras** from the Fort St. John Group are not from the lowermost shales. The basal and middle beds of the Moosebar Formation are not well dated by macrofossils, and fossil occurrences in the basal Buckinghorse and Garbutt Formations are also lacking.

'Puzosia' sigmoidalis Donovan, collected by the author, from lower shales of the Fort St. John Group on Sully Creek is reported by Jeletzky (1968) to occur in the Early Albian **Leymeriella** Zone. According to Jeletzky (*ibid.*, p. 17) this **Puzosia**? sp. occurs in the Clearwater Formation of the lower Athabasca River.

Recently, **Pachygrycia** of Early Albian age was reported (Jeletzky, pers. comm., 1979) from basal Garbutt shales west of Liard Range. Also, the microfauna from the Garbutt Formation at Scatter River was dated by Wall as probably of Early Albian age. This evidence discounts the presence of beds older than Albian in the basal Fort St. John shales in the region of Scatter and Liard Rivers and Liard Range.

Microfauna, obtained from basal Buckinghorse shales on Prophet River include such forms as **Quadrimorphina** cf. **Q. albertensis** Mellon and Wall, **Gaudryina nanushukensis** Tappan, **Conorbina norrisi** (Mellon and Wall) **Marginulinopsis** sp., rare **Serovaina** Sliter (Chamney in Stott, 1973, p. 143). This microfauna assemblage, dated by Chamney as Early Albian, "possibly pre-Clearwater Sea (pre-**Arcthoplites mcconnelli**)", occurs below an Early Albian assemblage including **Marginulinopsis collinsi** and **Dictyomitra** sp. If so, it would represent the lower part of the **Gaudryina nanushukensis** Zone of Caldwell et al. (1978).

The relationship of the Garbutt and basal Buckinghorse shales of the Muskwa-Tetsa region to the Gething Formation at Peace River is not well defined. During the early part of this study, the writer (Stott, 1968, p. 7) suggested that basal shales of the Buckinghorse Formation at Tetsa River were in part equivalent with the Gething. Subsequently, (Stott, 1973), although the Gething was shown to grade northward from Peace River into marine mudstone and siltstone, the problem was not resolved. The Moosebar and Buckinghorse shales of the Prophet River region, which lie above the Gething Formation, contain an Early Albian (but not earliest Albian) fauna and therefore the Gething must be earliest Albian or older. The thickness of the Gething appears to represent substantial deposition over a long time and, therefore, the formation may include pre-Albian beds. However, the limited paleontological evidence presently available indicates that the basal Garbutt is of Early Albian age, and there is no good reason to consider that the Buckinghorse shales of the Muskwa-Tetsa region are any older. If the Gething is older and not equivalent to those shales, then the northward extension of the marine Gething embayment remains undefined.

***Arcthoplites* spp. Zone.** The lower (but not lowest) beds of the Fort St. John Group in the Sikanni Chief and Peace River regions appear to lie within some of the **Arcthoplites** spp. Zone (Fig. 5; see also McLearn and Kindle, 1950; Stott, 1968a) of late Early Albian age (Jeletzky, 1968). **Arcthoplites** cf. **A. indicum** Spath or **A. belli** McLearn and **A. irenensis (Freboldiceras)** (McLearn) occur in upper Moosebar shale near Peace River and fauna of the zone occurs also in the overlying Gates Formation. **Arcthoplites** sensu lato cf. **A. belli** and **Beudanticeras (Grantziceras)** cf. **B. (G.) multiconstrictum** Imlay occur in the Buckinghorse Formation in the Sikanni Chief region, and **A. belli** was found in lower shales of the Buckinghorse Formation near Chinkeh Creek. These beds correlate in part with the Clearwater Formation of the lower Athabasca area where **Arcthoplites irenensis** occurs some 200 feet (61 m) above the base of the formation (Jeletzky, 1968, p. 17).

The Fort St. John beds that lie with the **Arcthoplites** spp. Zone can be correlated with the Arctic Red River Formation which contains **Arcthoplites** cf. **belli** McLearn and **Beudanticeras affine** in the region of lower Peel River (Jeletzky, 1968) and **Beudanticeras (Grantziceras)** cf. **affine** in the fossiliferous concretionary shale member on Hume River (Aitken et al., in press).

An Early to Middle Albian microfaunal assemblage, including **Marginulinopsis collinsi** Mellon and Wall and **Saracenaria trollopei** Mellon and Wall and **Quadimorphina albertensis** Mellon and Wall was obtained from Moosebar shale (Stelck et al., 1956; Mellon et al., 1963; Chamney in Stott, 1968a, p. 55) and a related assemblage occurs in the Buckinghorse Formation in the region of Prophet River (Chamney, 1973a). A similar microfaunal assemblage occurs at Cadomin, Alberta (Mellon and Wall, 1963; Mellon, 1967), lying above shales containing ostracodes. The latter are correlated with the widespread "Ostracod Zone" or Calcareous Member of the Blairmore Group which can be traced throughout much of the subsurface of Alberta (Loranger, 1951; Glaister, 1959; Rudkin, 1964; Mellon, 1967). The Moosebar shale tongue in the central and southern Foothills was included by Mellon (1967) at the base of his Beaver Mines Formation, which comprises approximately the upper two-thirds of the Blairmore Group. Microfauna, including **Marginulinopsis collinsi** Mellon and Wall and **Quadrimorphina albertensis** Mellon and Wall was reported by Stelck et al. (1956, p. 11) from the lower Clearwater shale of Athabasca River. They also noted similarities between that fauna and the ones occurring in the Loon River Formation and the Wilrich Member of the Spirit River Formation. Mellon and Wall (1956, p. 11), using similar microfauna evidence, correlated the lower Moosebar with the upper McMurray and basal Clearwater Formation, with part of the Loon River, the lower part of the Falher Member of the Spirit River Formation and the Cummings Member of the Mannville Formation of east central Alberta. Mellon et al. (1963) considered the Moosebar microfauna to be similar to that of the Sans Sault Group of the Norman Wells region. Calwell et al. (1978) established the **Gaudryina nanushukensis** zone (Fig. 5) which

> *. . .embraces the beds deposited during the first, major pulsatory transgression and regression of the boreal sea into the southern Interior Plains. . .*

The **G. nanushukensis** Zone was subdivided into six Subzones, the basal two, **Rectobolivina** sp. and **Trochammina mcmurrayensis,** were not reported from the basal Fort St. John Group of the Foothills regions. Caldwell et al. recognized the **Marginulinopsis collinsi-Verneuilinoides cummingensis** Subzone as the third subzone. They indicated that it is present in the Wilrich, Falher, and Notikewin Members of the Spirit River Formation, part of the Loon River, and in the Moosebar of the Foothills. They considered it to be probably equivalent of the **Arcthoplites irenensis** and **A. mcconnelli** Subzones of the **Beudanticeras affine** Zone.

The Gates Formation lies within the **Haplophragmoides gigas minor** Zone of Stelck et al. (1956, p. 14) which they indicate overlies the **Marginulinopsis collinsi** Zone. However, they report that **Beudanticeras** cf. **mcconnelli** (Whiteaves) occurs at the top of the zone within the Gates sandstone. They state that the zone extends from 110 feet (33.5 m) above the base of the Clearwater Formation into the basal portion of the Grand Rapids Formation, and also indicate that the top of the zone coincides with the top of the type Notikewin sandstone and that much of the microfaunal assemblage was originally described from the Cummings Member of the Mannville Formation (Nauss, 1947). Caldwell et al. (1978) did not separate the **Haplophragmoides gigas minor** from the **Marginulinopsis collinsi** Subzone.

A large flora obtained from the Gates Formation (Stott, 1968a) was identified by W.A. Bell, F.M. Hueber, and D.C. McGregor as the Lower Blairmore-Luscar-Gething "Aptian" flora. However, as Early to Middle Albian marine fauna occur below the Gates and in laterally equivalent beds, it is apparent that the lower Blairmore-Luscar-Gething flora must extend upwards into rocks of Middle Albian age.

The lower beds of the Fort St. John Group, including the Moosebar, Buckinghorse, and Garbutt Formations, can be correlated with the Clearwater Formation of the lower Athabasca River (McLearn and Kindle, 1950, p. 95; Jeletzky, 1968), the Loon River Formation (Wickenden, 1951, p. 4), the Sans Sault Formation of the Norman Wells region (Hume, 1954, p. 47), and the lower part of the Arctic Red Formation of the Yukon (Chamney, 1978; Young et al., 1977). These beds may be traced laterally into the Wilrich Member of the Spirit River Formation of the Peace River Plains and the Cummings Member of the Mannville Formation of east central Alberta. Equivalent beds in the central and southern Foothills of Alberta were assigned to the basal part of the Beaver Mines Formation (Mellon, 1967).

The Gates Formation is in lateral continuity with the Falher and Notikewin Members of the Spirit River Formation and correlates with upper Clearwater and lower Grand Rapids Formations, and the upper part of the Cummings Member of the Mannville Formation of east central Alberta. It appears to be approximately equivalent to the lower member of the Scatter Formation at Liard River, both units lying below the generalized Zone of **Gastroplites.** To the south, the Gates Formation is equivalent in large part to the Beaver Mines Formation of Mellon (1967), the upper part of the Blairmore Group of the Central Alberta Foothills, and the middle part of the Blairmore Group of southwestern Alberta and southeastern British Columbia.

Although marine beds of Early to Middle Albian age are widespread in northern Canada, indicating connections with the boreal seas (McLearn, 1932, 1944b; McLearn and Kindle, 1950; Jeletzky, 1968, 1971a; Williams and Stelck, 1975), equivalent marine beds are lacking in southern Alberta and the northern United States. The marine invasion from the Arctic region did not connect with that from the Gulf of Mexico during the time of **Arcthoplites-Beudanticeras.**

Middle Albian

An interval containing only **Beudanticeras (Grantziceras)** ex gr. **affine-glabrum**, termed Zone F by Jeletzky, lies between the Zones of **Arcthoplites** and **Pseudopulchellia pattoni.** On Peace River, this interval is represented by the upper Gates sandstone and the lower beds of the Hulcross Formation. At Scatter River, equivalent strata may include the upper part of the Bulwell and lower Wildhorn members.

Pseudopulchellia pattoni *Zone*. Jeletzky (1980), in revising the ammonite zonation, established the new zone of **Pseudopulchellia pattoni** which previously had formed the basal subzone of the generalized **Gastroplites** Zone (Jeletzky, 1971a, p. 8, Fig. 2). The **Pseudopulchellia pattoni** fauna of Middle Albian age (Jeletzky, 1980) occurs in the uppermost beds of the Hulcross Formation and in the overlying basal Boulder Creek Formation. Shales overlying the type Gates sandstone at Peace River and the two upper members of the Scatter Formation in the Liard region occupy a position similar to that of the Hulcross and Boulder Creek Formations.

Haplophragmoides multiplum was reported by Stelck et al. (1956, p. 15) from shales now assigned to the Hulcross Formation, and the younger "Cadotte" or **Ammobaculites** sp. microfauna, from the Boulder Creek equivalents. The interval containing **H. multiplum,** according to Stelck et al. (1956, p. 15), "is stratigraphically co-extensive with the type section of the Harmon shale of the Peace River area, Alberta" and Caldwell et al. (1978) chose the subzonal stratotype as the 370 foot-thick (112.8 m) section of the Hulcross shale above the top of the type Gates sandstone. **Haplophragmoides multiplum** was recognized recently by Wall (pers. comm.) from Fort St. John shale on Petitot River.

The microflora of the Hulcross shale has not been studied, but that of the equivalent Harmon Member, according to Singh (1971, p. 26) appears to be older than the Joli Fou microflora. Singh reported that the Harmon microflora is associated with the **Haplophragmoides multiplum** microfaunal zone, and that angiosperms make their entrance in the upper part of the member. He states also that the Cadotte microflora, associated with the **Gastroplites** fauna, indicates that at least part of the Cadotte Member is correlative with Joli Fou Formation. These relationships, together with previous microfaunal evidence (Wickenden, 1951; Stelck et al., 1956, 1958) indicate that the Joli Fou and Viking succession is slightly younger than the Harmon-Cadotte succession, and therefore also slightly younger than the Hulcross and Boulder Creek Formations.

Gastroplites *Zone*. Recently, Jeletzky (1980) revised the generalized **Gastroplites** Zone (Jeletzky, 1971a, Fig. 8), restricting its range from that previously outlined. Within this **Gastroplites** s. str. Zone, Jeletzky now recognizes two subzones; a lower **Gastroplites kingi** Subzone and an upper **Gastroplites allani** Subzone. Jeletzky (1980) notes:

> *Generally speaking, the separation of the lower **Gastroplites kingi** fauna and the upper **Gastroplites allani** fauna is quite evident. . . . The latter species appears to be a direct descendant of the former species because of the presence of numerous transitional forms between the two at the intermediate levels. **G. canadensis** (Whiteaves) and **Gastroplites (Paragastroplites) spiekeri** do not seem to have a clearcut subzonal value, even though they appear to be considerably more common in **Gastroplites allani** subzone than in the underlying **Gastroplites kingi** subzone.*

In the region of Pine and Peace Rivers, **Gastroplites kingi** fauna is found in the silty sandstone facies of the Boulder Creek Formation. The fauna, occurring on Starfish Creek (GSC locs. 9526, 9527, 46515) and farther east on Maurice Creek (GSC locs. 13799, 28117, 88031, 88033, and 88035), includes **Gastroplites** ex aff. **canadensis** McLearn, **G. (Paragastroplites) spiekeri** McLearn, **Gastroplites** aff. **stantoni** McLearn (**G. flexicostatus** Jeletzky, 1964 non Imlay, 1961). In one collection (GSC loc. 37683), **Gastroplites allani** is found in association with **G. kingi.**

The **Gastroplites kingi** fauna is present in the basal Lepine Formation at the type locality (GSC loc. 69196), on the east side of Liard River opposite Garbutt Creek (GSC locs. 69178, 69173), and at the type section of the Scatter Formation (GSC loc. 69170). Fossil collections from the upper Scatter Formation in this region yielded no diagnostic ammonites.

Jeletzky (1980) reports that:

> *Typical representatives of* ***Gastroplites kingi*** *McLearn have been identified by Reeside and Cobban (1960) and the writer. . . . from the upper third of Cadotte Member. . . . opposite the mouth of Cadotte River.*

According to Jeletzky, collections from the Cadotte, "five or six to about twenty miles below the mouth of the Cadotte River", do not contain any typical forms of the **Gastroplites kingi** Subzone, but do contain "typical representatives of **Gastroplites canadensis** McLearn and **G. allani** McLearn", which he assigns tentatively to the **G. allani** Subzone.

These collections indicate that the middle to upper Boulder Creek Formation of the Peace River region, the basal Lepine Formation of the Peace River region, the basal Lepine Formation of the Liard region, and at least part of the Cadotte Member of the Peace River Formation near Cadotte River lie within the **Gastroplites kingi** Subzone. The relationship of these beds to the upper Scatter Formation on Liard River remains uncertain, although the latter would be, at the most, only slightly older than beds containing **G. kingi.**

The **Gastroplites allani** fauna appears in the Lepine Formation 100 to 150 feet (31-46 m) above its base and higher on Liard River opposite Lepine Creek, (GSC locs. 69195, 69172, 69191) and is dominant in a collection 300 feet (91.4 m) above the base opposite Garbutt Creek (GSC loc. 69176). On Peace River, above the type section of the Gates Formation, **Gastroplites allani** McLearn et var. occurs with **G. (Paragastroplites) spiekeri** McLearn, **G. anguinus** McLearn, and **G.** ex aff. **canadensis** McLearn. Most of the collections are from float which apparently was derived from the very argillaceous Boulder Creek Member.

The **Gastroplites** fauna was reported by Henderson (1954, p. 2285) from the middle Buckinghorse Formation at Tetsa River.

Caldwell et al. (1978) reported their **Ammobaculites** sp. Subzone "spans the Cadotte Member of the Peace River Formation and Boulder Creek Member of the Commotion Formation". They state further

> *. . .it can be looked upon as ranging from the upper part of the* ***Pseudopulchellia pattoni*** *Subzone through the* ***Gastroplites canadensis*** *Subzone in the classification of Jeletzky (1971a, Fig. 2). . .*

The fauna is reported by them to occur in the Boulder Creek beds on the north bank of Peace River, three-quarters of a mile below the "Gates":

> *At this locality, the* ***Ammobaculites*** *Subzone is transitional to both the underlying* ***Haplophragmoides multiplum*** *Subzone of the Hulcross Shale and the overlying* ***Ammobaculites wenonahae*** *Subzone of the lower Hasler Shale*[1].

The occurrence of the **Gastroplites** fauna in the Fort St. John beds at Peace River and Liard River allows correlation with the Cadotte Member of the Spirit River Formation on lower Peace River (McLearn, 1932, 1944a; Stelck et al., 1956; Jeletzky, 1980), and also possibly with some part of the Sans Sault Group of the lower Mackenzie River (Hume, 1954; Stelck et al., 1956). However, Aitken et al. (in press) stated that the uppermost member of Sans Sault Formation contains fauna of the **Sonneratia** cf. **kitchini** and **Beudanticeras affine** Zones, thereby indicating an older age than **Gastroplites.**

A diagnostic flora containing angiosperms occurring in the Boulder Creek Formation, was tentatively assigned a Late Albian age (Bell, 1956). The occurrence of Middle Albian ammonites in laterally equivalent, upper beds of the Boulder Creek at Peace River suggests that the entire member, and consequently, the flora, is of Middle Albian age.

As indicated in an earlier report (Stott, 1968a), beds equivalent to the Hulcross and Boulder Creek Formations may not extend far south of Belcourt Creek. No angiosperm flora has been found in upper Blairmore beds between Grande Cache and the southern Foothills (Mellon, 1967), suggesting that sediments of this age are not present in that region. Angiosperms are known in the Crowsnest volcanic rocks and Mill Creek Member of the Blairmore Group but may represent a slightly younger phase (Stelck, 1958; see also Mellon, 1967, p. 73) than the Boulder Creek flora.

Stelckiceras liardense *Zone.* **Stelckiceras liardense** (Whiteaves), occurring at Peace River about three and a half miles (5 km) west of Halfway River, in the middle of the Buckinghorse Formation at Sikanni Chief River, and also 300 to 750 feet (90-225 m) above the base of the Lepine Formation at Liard River, and also on Crow River characterizes a zone of its own (Jeletzky, 1980), being younger than the generalized zone of **Gastroplites** but older than any part of the **Neogastroplites** and **Posidonia**? **nahwisi** Zone (Jeletzky, 1964, 1968, 1971b). The **Stelckiceras liardense** Zone is tentatively considered by Jeletzky (1980) as latest Middle Albian.

Caldwell et al. (1978) recognized the **Ammobaculites wenonahae** Subzone

> *. . .from the lower part of the Hasler Formation of the Fort St. John Group in the upper Peace River valley, near Halfway River in northeastern British Columbia. . .*

Although those beds are equivalent to the basal Hasler of the Foothills, the writer prefers to assign the beds to the basal Shaftesbury. According to Caldwell et al. this subzone "equates largely to the **Paragastroplites liardense** Subzone of the **Gastroplites** Zone in the ammonite sequence", or in the recent assignment of Jeletzky (1980), the **Stelckiceras liardense** Zone.

A thick succession of poorly fossiliferous shales occurs between the beds containing **Stelckiceras liardense** and the overlying succession containing **Neogastroplites.**

The **Haplophragmoides gigas** fauna is recognized by Caldwell et al. (1978) between the **Gaudryina nanushukensis** and **Miliammina manitobensis** Zones. The type development is in the Joli Fou Formation in the Athabasca River region of northeastern Alberta. The preceding **Ammobaculites wenonahae** Subzone is equated largely to the **Stelckiceras liardense** Zone. The fauna of **Haplophragmoides gigas** Zone has been collected from the Shaftesbury beds above the beds carrying the **wenonahae** fauna and below the beds carrying **Neogastroplites** from outcrops a mile below the mouth of Halfway River (Stelck, 1979, pers. comm.). According to Caldwell et al.

> *The* ***H. gigas*** *Zone is equivalent to the* ***Inoceramus comancheanus*** *Zone of Stelck (1975a, p. 259). It post-dates the* ***Stelckiceras liardense*** *Zone and pre-dates the* ***Neogastroplites*** *Zone.*

This correlation is more restrictive than that of Jeletzky (1968, Fig. 1), who equated the American zone of **I. comancheanus** with the upper part of the generalized **Gastroplites** Zone, his overlying Zone 6 and the **Stelckiceras**

---

[1]The shale referred to as Hasler is considered to be the Shaftesbury Formation of this report.

liardense Zone. Stelck (1975, p. 255) placed the microfossil zone of **Miliammina manitobensis** in that poorly fossiliferous interval. He stated (p. 258) that on Sikanni Chief River, the **Miliammina manitobensis** Zone extended "through the top 275 feet (83 m) of the Buckinghorse Shale and the lower 125 feet (38 m) of the Sikanni Formation". He stated also that the zone occurs at the top of the Hasler Formation in British Columbia and at the base of the Shaftesbury Formation at the town of Peace River. The microfaunal assemblage, reported by Anan-Yorke and Stelck (1978, p. 481) from the upper Buckinghorse Formation, was stated by them to be "associated with the **Miliammina manitobensis** microfaunal zone of late Albian age".

Caldwell et al. (1978) indicated that the **Miliammina manitobensis** Zone ranges from "upper beds, barren of molluscs, above the **Paragastroplites liardense** Zone. . . through the **Neogastroplites haasi** and **N. cornutus** Subzones, possibly into the **N. muelleri** Subzone". The basal subzone of **Verneuilina canadensis** is recognized in the uppermost 275 feet (83.8 m) of the Buckinghorse Formation and lower 125 feet (38.1 m) of the overlying Sikanni Formation at Sikanni Chief River. The middle subzone of **Haplophragmoides postis goodrichi** is recognized in road cuts between Moberly Lake and Hudson Hope south of Peace River and "spans the uppermost Hasler, Goodrich, and lowermost Cruiser Formations". The upper subzone of **Haplophragmium swareni** is present in the lower Sully Formation in the Sikanni Chief River region. According to Caldwell et al.

> *The stratotype is defined as the 68 feet of shales in the lower Sully Formation, directly overlying the Sikanni Formation and underlying the Fish-Scale marker within the Sully Formation $1\frac{1}{2}$ miles below the Alcan (Alaska) Highway bridge across the Sikanni Chief River.*

Based on macrofauna and microfauna, the Fort St. John Group from its base to approximately the base of the Goodrich-Sikanni sandstones can be correlated with the Arctic Red Formation of the Hume River region. According to Aitken et al. (in press), **Beudanticeras (Grantziceras)** cf. **B. affine** was collected from the fossiliferous concretionary shale member, indicating an age similar to that of the Moosebar-Gates and lower Buckinghorse successions. They reported also that **Posidonia nahwisi** and **P. nahwisi** var. **goodrichensis** occur in the lower beds of the overlying Trevor Formation, thereby indicating correlation with Goodrich-Sikanni sandstones. According to them, Chamney found that the microfauna of the Arctic Red Formation on Hume River contained fauna including **Quadrimorphina albertensis** and **Siphotextularia** spp. at the base and **Psamminopelta** and **Miliammina manitobensis** at the top. As indicated in the preceding discussion, the **Quadrimorphina albertensis** fauna occurs in the basal Buckinghorse beds on Prophet River and the **Miliammina manitobensis** fauna ranges from upper Buckinghorse shales into the basal Sikanni Formation.

The earliest record of the Lower Cretaceous sea in the Montana area immediately to the south of the Canada-United States boundary, is found in the Flood Member of the Blackleaf Formation at the base of the Colorado Group, according to Cobban et al. (1976). They state (p. 6, 10) that the member contains **Inoceramus comancheanus,** a marine species of Late Albian age. **Inoceramus comancheanus** Gragin and **I. bellvuensis** Reeside, also reported by them from the lower part of the Taft Hill Member of the Blackleaf Formation, are known from the Joli Fou shale in northern Alberta (Stelck, 1958, p. 3). Caldwell et al. (1978) suggest that **Inoceramus comancheanus** is contemporaneous with the interval above the **"Placenticeras" liardense** Zone. This relationship indicates that the Flood and Taft Members of the Blackleaf Formation are equivalent to the middle part of the Shaftesbury Formation on Peace River in British Columbia, the upper middle part of the Buckinghorse Formation and the middle Lepine Formation at Liard River. Those beds can be correlated with beds in the United States which contain **Inoceramus comancheanus,** including the Skull Creek Shale of the Black Hills, the Kiowa Shale of Kansas, and South Platte Formation of the Front Range of Colorado (Cobban et al., 1976).

Late Albian

***Neogastroplites** Zone*. The generalized **Neogastroplites** Zone has been subdivided by Reeside and Cobban (1960) in descending order, as follows:

- **Neogastroplites maclearni** Cobban and Reeside
- **Neogastroplites americanus** (Reeside and Weimouth)
- **Neogastroplites muelleri** Reeside and Cobban
- **Neogastroplites cornutus** (Whiteaves)
- **Neogastroplites haasi** Reeside and Cobban

This subdivision has been followed by Stelck (1975b) but is not accepted in its entirety by Jeletzky (1968) who considers **N. haasi** to be a junior synonym for **Neogastroplites selwyni** McLearn. Jeletzky noted that **Posidonia moberliensis** (McLearn) and **P. goodrichensis** occur in association with either **Neogastroplites selwyni** or **N. cornutus. Posidonia nahwisi** is considered a fauna facies of the **Neogastroplites** Zone (McLearn, 1944a; Jeletzky, 1968).

Posidonia nahwisi nahwisi, P. nahwisi moberliensis, Neogastroplites cornutus, starfish and a substantial microfaunal assemblage were identified by Sutherland and Stelck (1972, p. 553) from Goodrich sandstone north of Moberly Lake. **Neogastroplites haasi** was reported by Warren and Stelck (1969) from the type area of the Goodrich Formation.

Neogastroplites selwyni McLearn of the basal subzone of the Late Albian **Neogastroplites** Zone is reported (Jeletzky, 1964, p. 11) from lower beds of the Sikanni Formation on Halfway River. **Neogastroplites** ex gr. **cornutus-muelleri** occurs in upper sandstone at Sikanni Chief River. **Neogastroplites cornutus** (Whiteaves), **Posidonia**? **nahwisi** McLearn var. **goodrichensis** occur in Shaftesbury shale on Peace River between Bear Flat and Tea Creek. Varieties of **N. cornutus** and **N. muelleri** were reported by Warren and Stelck (1969) to occur along Peace River near Fort St. John. The **Neogastroplites** and **Posidonia**? **nahwisi** fauna was reported also from the region between Sikanni Chief and Liard River by Hage (1944), Williams (1944), and Stott (1968b). **Neogastroplites cornutus** (Whiteaves) was collected also from the Sikanni Formation on Kotaneelee River north of the British Columbia-Northwest Territories border (Stott, 1960b, p. 12-13). **Neogastroplites cornutus** was assigned an absolute age of about 95 m.y. by Obradovitch and Cobban (1975).

Kindle (1944) believed that the Lepine was equivalent to the Goodrich and Cruiser Formations of Peace River region and to the Sikanni Formation of Hage (1944). Although such an assumption was correct for his described section, it is untenable for the succession opposite Lepine Creek, which is equivalent to beds lying below the Goodrich and Sikanni Formations (see Fig. 21).

The relationship of the Goodrich and Sikanni sandstones is shown in Figure 12. The Goodrich sections are the most westerly ones in the vicinity of Peace and Pine Rivers and are also the thickest. The type Sikanni Formation on Sikanni

Chief River lies well to the east in a basinward position whereas the sections between there and Dunedin River again represent the most westerly ones in the region. The rather abrupt facies change in the more northerly area near Scatter River is indicative of a change in depositional strike and basin position. Although fossils are scarce, those discussed above are sufficiently diagnostic to confirm the correlation.

Somewhat younger beds occur south of Pine River in the Lone Mountain area where McLearn and Henderson (1944, p. 3) found **Neogastroplites** in upper Fort St. John (Shaftesbury) shale. **Neogastroplites maclearni** was collected in Shaftesbury shale in the Grande Cache area (Thorsteinsson, 1952, p. 30; Reeside and Cobban, 1960) and **Neogastroplites americanus** was found by Irish (1955; Reeside and Cobban, 1960) in the Adams Lookout map-area.

The Goodrich and Sikanni sandstones can be correlated with at least the lower part of the Trevor Formation of the Snake-Peel region where **Posidonia** cf. **nahwisi** s. lato and **P.? nahwisi** var. **goodrichensis** were collected (Mountjoy and Chamney, 1969; Aitken et al., in press). Aitken et al. suggest that the base of the Trevor is diachronous, becoming older in an easterly direction toward Hume River. The upper limit of the Trevor Formation is not well defined but it may be of Cenomanian to Turonian age (Aitken et al., in press), thereby being much younger than the Goodrich-Sikanni, and may include beds equivalent to the Cruiser-Sully shales and the Dunvegan Formation.

The Late Albian (**Neogastroplites**) sea spread far into the continental interior of the present United States (Reeside, 1957, p. 513-518; Reeside and Cobban, 1960, p. 9; Jeletzky, 1968, p. 20, 21, 1971a, p. 46; Williams and Stelck, 1975) where it is widely known as the Mowry Sea. Cobban et al. (1976, p. 34) state that the upper member or Bootlegger Member of the Blackleaf Formation of the Colorado Group in Montana contains **Neogastroplites** and Fish Scales, thereby correlating it with the Mowry of central Montana and the Black Hills region. The underlying nonmarine Vaughn Member is correlative with the Newcastle Sandstone of the Black Hills. These two members of Late Albian age can be correlated with the upper Hasler and Goodrich, middle to upper part of the Shaftesbury of Peace River region, upper Buckinghorse and Sikanni of Sikanni-Muskwa region, and Lepine and Sikanni Formations of the Liard River region.

Early-Late Cretaceous Boundary

On Sikanni Chief River, the Sully Formation includes a prominent "Fish Scale" marker horizon which appears to be equivalent to a similar marker used extensively in subsurface correlations (Burk, 1962, 1963; Price, 1963; Williams and Burk, 1964). That horizon is generally accepted as approximately the boundary between Early and Late Cretaceous (Stelck, 1962). Warren and Stelck (1969) reported the occurrence of **Neogastroplites muelleri** and **N. americanus** from beds below the "Fish-Scale" marker beds and **Neogastroplites maclearni** Cobban and Reeside in "Fish-Scale" sandstone of the Shaftesbury Formation. In the western interior region, the boundary between Albian and Cenomanian is placed tentatively between **Neogastroplites maclearni** and **Neogastroplites septimus** Zones (Warren and Stelck, 1958a, 1969). Warren and Stelck (1958a, 1959; see also Stelck, 1962) reported the occurrence, in the Plains northeast of Pine River, in Upper Fort St. John beds of **Pleurobema cruiserensis** Warren and Stelck, **Beattonoceras beattonense** Warren and Stelck, and **Irenicoceras bahani** Warren and Stelck which are considered to be of early Cenomanian age.

Radiometric dating of Folinsbee, Baadsgaard, and Cumming (1963, p. 75) has given ages for ash beds containing **N. maclearni** and **N. cornutus**, of 94 m.y. and 96 m.y. respectively. Obradovitch and Cobban (1975), on the basis of radiometric dating, placed the Albian-Cenomanian boundary at 94 ± m.y.

The "Fish-Scale" marker horizon is readily traced in the well logs of the cross-sections drawn in an east-west direction (Figs. 14, 15, 18, 20). Fish scale beds are recognized in Sikanni Chief River and somewhat similar beds occur along the Liard escarpment. Elsewhere, the dominance of sand apparently obscures this marker and it is not recognized in outcrop. The "Fish-Scale" marker horizon is recognized in the subsurface of the Peace River Plains (Burk, 1962, 1963) and central Alberta Plains (Glaister, 1959). No marine beds of this age are known in the Blairmore region of southwestern Alberta although some part of the Crowsnest Formation may be equivalent. The Fish Scale beds occur in the Sunkay Member of the Blackstone Formation in the central Foothills (Stott, 1963) and in the Kaskapau Formation north of Athabasca River (Stott, 1967c).

As previously noted, Caldwell et al. (1978) report that the **Haplophragmoides postis goodrichi** Subzone spans the upper Hasler, Goodrich and lowermost Cruiser Formation south of Peace River. The subzone of **Haplophragmium swareni** is reported from the basal Sully Formation at Sikanni Chief River. That interval, below the Fish Scale marker, also yielded a microfloral assemblage dated as late Albian (Anan-Yorke and Stelck, 1978, p. 481). Caldwell et al. (1978) recognized the **Textularia alcesensis** Zone within the Cruiser and Sully Formations "from the base of the Fish-Scale marker to the base of the Dunvegan Formation".

The relationship of the Cruiser and Sully Formation is illustrated in Figure 12. The Cruiser Formation is mapped south of Peace River and the Sully Formation is mapped to the north. Owing to erosion along the Peace River arch, these shale successions do not occur in direct juxtaposition. In the thick, westerly sections of the Goodrich-Sikanni sandstones, the "Fish-Scale" marker horizon appears to lie at or near the top of the sandstone. In those areas, the shales are presumably of Cenomanian age. At Sikanni Chief River, the "Fish Scale beds" occur within the Sully Formation and a similar situation holds in the exposures opposite Scatter River. At those localities, the shales presumably range from latest Albian age to early Cenomanian, but no fossils were recovered.

Dunvegan Formation[1]

Definition. A prominent sequence of sandstone and conglomerate occurs near the base of the Upper Cretaceous succession between Peace River and the District of Mackenzie. These rocks, now included in the Dunvegan Formation were examined first by Selwyn in 1875. He indicated the occurrence of four seams of coal in 90 feet (27.4 m) of alternating sandstone and shale along Pine River

[1]Owing in part to somewhat limited exposures and in part to other priorities, the Dunvegan was not studied in detail in the area south of Sikanni Chief River. This discussion, therefore, has been supplemented as much as possible from previous studies. The Dunvegan was examined more closely from Muskwa to Petitot River where better and more numerous exposures occur.

below Wartenbe ("Table") Mountain. These beds were included in his Division II to which he assigned a Mesozoic age. He indicated also the occurrence of beds on Peace River:

> *...A little above Dunvegan there are high bluffs and ledges of soft whitey-brown crumbling sand rock; the beds are massive from twenty-five to thirty feet thick...*

The Dunvegan Formation was defined by Dawson (1881) who referred to the succession also as "The Lower Sandstone and Shales". He described the succession at two main localities, one at Pine River and one near the old trading post of Dunvegan (Plate 35) on Peace River. He stated (op. cit., p. 116B):

> *...(The subdivision) is well characterized however, about the cañon and the Lower Forks of Pine River, and seems from the information at present available, to occupy the valley of Peace River for a distance of about one hundred miles, between the mouth of Pine River North (Beatton River)*[1] *and the point below the mouth of the Rivière Brûlé (Burnt River)*[1]*...*

Dawson commented on the four thin seams of coal reported by Selwyn (1877, p. 53, 74) on Pine River and on other coal occurrences on Coldstream ("Coal Brook") Creek[1].

The name Dunvegan was extended northward from the Peace River region into the Sikanni Chief region by Hage (1944) and the formation was traced from the Charlie Lake map-area (Irish, 1958) into map-areas of Halfway River (Irish, 1961, 1963, 1970) and Trutch (Pelletier and Stott, 1963). The succession northward into Trutch is continuous with the type locality but contains more coarse grained sandstone and conglomerate. Recently Thompson (1977) has shown the distribution of the Dunvegan in the Beatton Rivers, Fontas River and Petitot River map-areas (see also Fig. 3).

A sequence of coarse conglomerate occurring farther north in the vicinity of Liard River was defined as the Fort Nelson Formation by Kindle (1944), and similar beds in the vicinity of Tetsa and Muskwa Rivers were considered identical to that formation by Williams (1944). However, Kindle in his description of the type section of the Fort Nelson Formation, included more than 1000 feet (304 m) of sandstone and shale now assigned to the Sikanni and Sully Formations. Kindle defined the Fort Nelson and Lepine Formations south of Lepine Creek, but measured them opposite Scatter River where the stratigraphic interval assigned to each was quite different (Fig. 21). Stelck et al. (1958) reported the occurrence of a major conglomeratic sequence in the Dunvegan Formation north of Peace River, thereby indicating similarities in lithology between the Fort Nelson and Dunvegan Formations. As shown during the

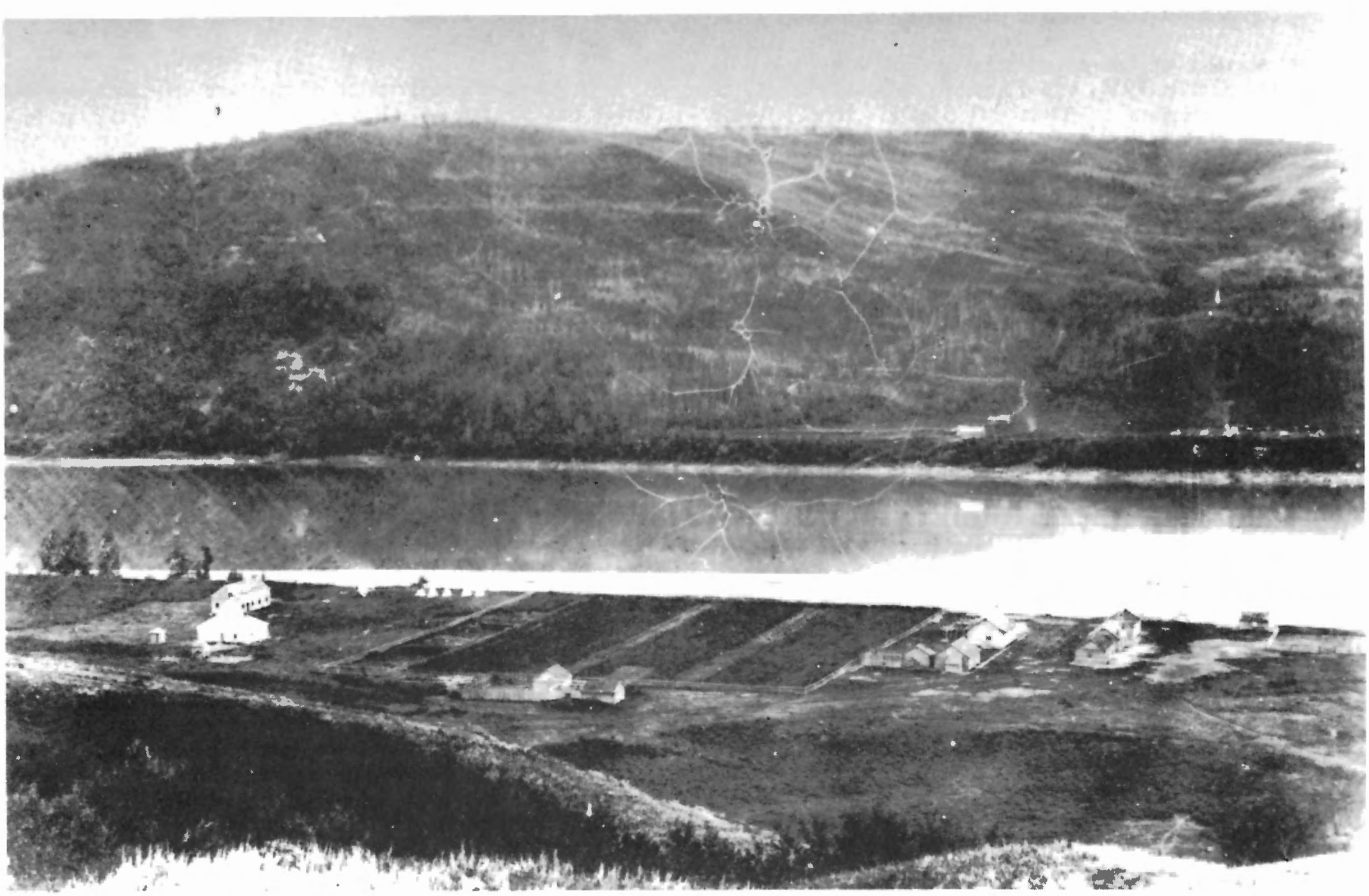


PLATE 35

Fort Dunvegan, Northwest Territories, 1879. The building of Fort Dunvegan was started by Archibald McLeod of the North West Company in 1805. The fort was for many years the centre of fur trading on the Peace River and a link in the chain of communications westward into British Columbia. (Photo by G.M. Dawson.)

[1]Current geographic name.

present investigation, the northern and southern sequences are stratigraphically equivalent. To eliminate further confusion and duplication of names, the writer (Stott, 1968b) abandoned the name Fort Nelson and extended the application of Dunvegan northward to include the conglomerate succession throughout northeastern British Columbia and southern part of the District of Mackenzie.

Type section. The name Dunvegan, applied by Dawson (1881) to these rocks, was derived from the old Hudson's Bay Company trading post of Fort Dunvegan (Plate 35). In 1932, Williams and Bocock commented on the exposures near Bear Flat on Peace River (Plate 36):

> *...The Dunvegan is well exposed in a single section on the Cache Creek scarp, situated on the north bank of Peace River about 2 miles below the mouth of Cache Creek. From Cache Creek to Peace River town the Dunvegan is everywhere present in the valley sides of the Peace, and at Dunvegan, where the type section is situated, it touches water level...*

Dawson (1881, p. 118B) had described the rocks there as follows:

> *...In the bare hills behind Dunvegan, a thickness of about 400 feet of these beds is shown, consisting of brown and grey sandstones and sandy shales, which hold numerous fossils...*

The section at Dunvegan was accepted as type by McLearn and Kindle (1950, p. 96) and the Alberta Society of Petroleum Geologists (1954). Stelck (1962) also acknowledged that "The type area is usually considered to be at Dunvegan on the Peace River".

PLATE 36

Dunvegan Formation east of Bear Flat on north side of Peace River. Resistant ribs of sandstone are separated by soft, carbonaceous mudstones. GSC Photo 130559.

Stelck et al. (1958, p. 15), noting that Dawson had described the succession at both Pine River and Dunvegan, and observing variation between the two localities, described the lower part of the Dunvegan Formation at a third section on Beatton River "north of Fort St. John, British Columbia, one mile above the mouth of the Doig River". Stelck et al. (op. cit., p. 17) indicated that the Dunvegan in that region consists of four main divisions:

(a) an upper plant-bearing deltaic sequence, 400 feet (121.9 m) thick,
(b) a middle conglomerate arkosic member up to 300 feet (91.4 m) thick,
(c) a brackish lower member, 200 feet (61 m) thick,
(d) a basal sand member, 100 feet (30.4 m) thick.

They continued:

> *...The arkosic member is known to rest at places with an erosional unconformity upon the brackish member, although there is little indication of this on Beatton River itself. The basal sand is concordant and transitional with the underlying St. John Formation at Beatton River locality, and indeed, the lower Dunvegan facies seems to be no more than the sanding up of the St. John sea...*

The Dunvegan Formation to the north of Sikanni Chief River, although similar, does not appear to be divisible into the same members.

A complete description of the type section along Peace River has not been published. Stelck et al. (1958, p. 16-17) outlined the section on Beatton River "from near the top of the continental member down to the base beds of transitional with underlying St. John shales". The section on Pine River, comprising the upper part of the formation has not been described in detail.

Contact relationships. The Dunvegan Formation in the vicinity of Peace River and southward lies conformably between the Fort St. John Group below the Smoky Group above. Northward beyond Sikanni Chief River and within most of Trutch and Fort Nelson map-areas, the Dunvegan conglomerates form the youngest bedrock, the upper surface being either exposed or thinly covered by Pleistocene deposits. Some of the uppermost beds may have been eroded. North of Muskwa River, the Dunvegan is overlain unconformably by the Kotaneelee Formation.

In the area between Smoky and Pine Rivers at the eastern edge of the Foothills, the Dunvegan Formation is underlain by marine shales of the Shaftesbury Formation. Lateral facies changes in the upper Fort St. John Group in the western Foothills result in different stratigraphic terminology, and there the beds beneath Dunvegan are assigned to the Cruiser Formation. In general, the contact is gradational and is drawn below the first massive sandstone. However, in the vicinity of Belcourt Lake, massive coarse grained sandstone and conglomerate of the Dunvegan lie directly on shale and erosion of Cruiser shales and channel-fill is evident. The erosional nature of the contact appears to be of local extent because, in neighboring areas, a gradational type of contact is evident. Shales immediately below the Dunvegan in the eastern part of Dawson Creek map-area appear to grade westward into sandstone and the basal contact is considered by Stelck et al. (1958) to be diachronous in this region.

In the vicinity of Sikanni Chief River and northward to the Liard Range and Petitot River, the basal Dunvegan sandstone is gradational into the underlying Sully shales, the contact being drawn below the first unit of thick bedded to massive sandstone. Although the base of the sandstone has been used as datum to show the relationships of the columnar sections (Fig. 12), it seems improbable that the same unit would extend for more than 300 miles (482.2 km) from Dokie Ridge to Petitot River. However, it also seems unlikely that the contact is strongly diachronous.

To the south of Peace River, the Dunvegan Formation is overlain conformably by the marine Kaskapau shales of Smoky Group (Stott, 1967c). The upper contact is drawn above coaly or carbonaceous beds and usually above a massive sandstone. In some areas where the overlying Kaskapau shales lie on a massive conglomerate, the upper contact is very distinct but in many places the formations are more transitional.

The contact between the Dunvegan and Kotaneelee Formations was not observed. On Kotaneelee River (Stott, 1960b, sec. 9), beds low within the Kotaneelee are separated from the Dunvegan beds by a short covered interval. Throughout the region, there is a distinct topographic change from the prominent, resistant Dunvegan conglomerates to the recessive marine shales of the Kotaneelee. The unconformity occurring at the top of the Dunvegan represents all of Turonian and probably most or all of Coniacian time. It is not evident whether beds of that age were not deposited or if such deposits were eroded prior to Kotaneelee deposition. To the south in the vicinity of Peace and Pine Rivers, Kaskapau deposits have a thickness of more than 2000 feet (609.6 m) (Stott, 1967c). The strong development of near-shore sandstone in that succession suggests that the Turonian marine embayment may not have extended northeasterly into the region of the present Foothills north of Sikanni Chief River. However, Thompson (1977) reported that silty shales with sideritic concretions overlie the Dunvegan Formation along Milligan Creek in the Beatton River map-area. Those shales, assigned to the undivided Smoky Group, are continuous with shales assigned to the same group in northern Alberta (Green et al., 1970).

Distribution and thickness. The distribution of the Dunvegan Formation is shown on the accompanying map (Fig. 3). The formation was mapped originally in Copton Creek map-area by Irish (1954), in the Mount Hulcross-Commotion Creek area by McLearn and Henderson (1944), and by Wickenden and Shaw (1943). Work by the latter formed the basis for the part of the compilation of Pine Pass map-area by Muller (1961) and more recently by the author. The formation was recognized in the Dunlevy-Portage Mountain area by Beach and Spivak (1944), was traced along Kiskatinaw River by Williams and Bocock (1932) and was mapped in the vicinity of Gwillim Lake and Lone Prairie by Spieker (1921).

In the area east of Fort St. John, the Dunvegan was mapped by Crickmay (1944), Russell (1943), and Jones (1968). Its distribution in the Charlie Lake and Halfway River map-areas was shown by Irish (1958, 1961, 1963, 1970) who stated that the formation ranged between 500 and 600 feet (152-183 m) thick. Three areas, Beatton River, Fontas River and Petitot River, mapped by Thompson (1977), also contain Dunvegan sediments.

Mapping of the Dunvegan Formation in more northerly areas includes the work of Hage (1944) along the Alaska Highway; Williams (1944), in the vicinity of Steamboat Mountain, and Kindle (1944) on Liard River. Hage (1945) also examined the beds in the vicinity of Petitot and Liard Rivers.

Subsequent work by the author has synthesized the data obtained by other workers and himself, resulting in the published maps for the areas of Trutch (Pelletier and Stott, 1963), Fort Nelson and Maxhamish Lake (Taylor and Stott, 1968a, b) and the open-file maps for Wapiti, Monkman Pass, Dawson Creek, and Pine Pass (Stott, 1975). In addition, the author's work has been incorporated in the revised map of Ware-Trutch by Taylor (1979), and those of Fort Liard-La Biche and Trout River (Douglas, 1976a, b, 1974).

The Dunvegan Formation has been traced from Smoky River to Petitot and Liard Rivers. As outlined in an earlier report (Stott, 1967c), the Dunvegan sandstone grades laterally southeastward along the Foothills into shale and is not mappable south of Athabasca River. North of Kakwa River and southwest of Lynx Creek, the formation is 333 feet (101.5 m) thick (sec. 58-6). Farther to the northwest, near Deadhorse Meadows at headwaters of Stinking Creek, about 550 feet (167.6 m) of strata are included in the Dunvegan Formation (sec. 58-9).

The Dunvegan Formation underlies a large area west of Gwillim Lake and forms the top of ridges near the junction of Pine and Sukunka Rivers. An erosional edge of the Dunvegan trends northeasterly along the old glacial valley of Pine River toward Peace River. No complete section was measured in this area. The formation is approximately 500 feet (152.4 m) thick in Canada Southern & Assoc. Kelly Lake No. 1 well, and its thickness appears to increase to more than 1200 feet (366 m) west of Chetwynd (Wickenden and Shaw, 1943). The writer measured more than 900 feet (274 m) on a ridge to east of the main peak of Mount McAllister (sec. 61-24, Stott, 1968a, p. 216). Although some increased thickness is undoubtedly due to increased deposition, much may be owing to facies changes. Shales above and below the Dunvegan Formation of the southeastern Foothills and Plains grade laterally into sandstones towards the northwest and these are included there in the Dunvegan Formation. Probably all the beds equivalent to the Pouce Coupé sandstone and underlying shales of the Kaskapau Formation have been included in the Dunvegan in the vicinity of Pine River (see Stelck et al., 1958).

Jones (1969, Fig. 12), illustrated by means of an isopach map, the variation in thickness of the Dunvegan in the region of Peace and Smoky Rivers, indicating an increase from less than 50 feet (15.2 m) in the southeast to more than 600 feet (183 m) in the northwest near Clear Hills in Alberta.

The thickness of the Dunvegan Formation in the vicinity of Fort St. John was considered by Stelck et al. (1958, p. 17) to be over 1000 feet (305 m). This thickness appears somewhat anomalous for the Dunvegan in the eastern region. Stelck et al. remarked on the relationships of the Dunvegan and Kaskapau Formations near Watino, suggesting that the upper continental member was missing. Elsewhere to the north, Upper Cretaceous beds lie unconformably on the Dunvegan and all the Kaskapau is apparently missing. Two explanations can be offered for the apparently over-thickened sequence. The continental member may represent a nonmarine facies equivalent to the older part of the Kaskapau Formation, as was suggested by the author for the sequence on Mount McAllister. Or, erosion may have removed part of the formation in the area north of Beatton River, with the only evidence now remaining being the unconformity between the Dunvegan and Kotaneelee Formations.

Outcrop sections of the Dunvegan Formation are illustrated in Figure 12, extending from Dokie Ridge and Mount McAllister south of Peace River northward to Petitot River. Although the base of the formation has been used as datum, it is likely to be slightly diachronous from one locality to another. The section on Mount McAllister (61-24), more than 900 feet (274 m) thick, is the thickest one known but in its upper part may include beds equivalent to the basal Kaskapau marine shales to the east (Stott, 1967c). No definite upper contact could be determined for any of the outcrop sections, although the Kotaneelee Formation is known to overlie the Dunvegan unconformably north of Fort Nelson (Fig. 3). The relatively uniform thickness suggests either extensive peneplanation or a fairly uniform depositional thickness, or a combination of both.

The base of the formation is marked consistently by a well bedded, commonly fine grained sandstone which grades downward into the upper shales of the Fort St. John Group. The remainder of the formation is dominated by massive conglomerate and conglomeratic sandstone separated by units of carbonaceous mudstone.

The Dunvegan beds are exposed almost continuously in vertical cliffs at the top of the Sikanni Chief and Buckinghorse canyons, along the Trutch escarpment and around mesa-like remnants extending north to Klua Lakes. The more massive beds are well exposed between Muskwa and Prophet Rivers but vegetation and talus covers much of the lower part in many places. The formation is 491 feet (149.7 m) thick at Klua Lakes (sec. 65-1).

Massive Dunvegan sandstone and conglomerate is well exposed along Muskwa escarpment where the formation is about 500 feet (152 m) thick; 594 feet (181 m) were measured at the headwaters at Akue Creek (sec. 65-2; Plate 37). It is readily mapped in the vicinity of Steamboat Mountain (Plate 38) and northward along Dunedin and Liard escarpments (secs. 64-2, 64-4; Plates 39, 40). It occurs in spectacular cliffs along the edge of the Tsoo Tablelands (Plate 14) where it is 570 feet (173.7 m) thick (sec. 65-6). A remarkably narrow canyon is cut in the formation along Dunedin River. Several sections were described in this area and are in the order of 500 feet (152 m) thick (secs. 64-5, 65-4; Fig. 12). The Dunvegan Formation is 600 feet (183 m) thick on the Liard escarpment (secs. 65-10, 65-17; Plate 41) opposite Scatter River and only slightly less (1524 feet-159.7 m) at the big bend of the Liard (Plate 42, sec. 65-18). Kindle (1944) originally included more than 1000 feet (305 m) of sandstone and shale in the Fort Nelson Formation, which he examined between the mouth of Toad River and Beaver River. However, as shown in Figure 21, the lower part of the described sequence in that region contains sandstone and shale now assigned to the Sikanni and Sully Formations respectively. Farther east the formation occurs in the massive walls of the canyon of Fort Nelson River and good exposures occur along the escarpment east and south of Maxhamish Lake. No exposures were discovered along the Etsho escarpment where the whole region is covered by dense forest. However, stratigraphic cross-sections that include wells located in that immediate vicinity strongly support the assumption that this high area owes its prominence to the presence of the more resistant Dunvegan sandstones. It is assumed that the Dunvegan sediments are much finer-grained and less well-indurated in that area and have a greater tendency to disintegrate. For this reason no prominent cliffs develop.

A partial section was measured on Beaver River (65-14) where the exposed part of the formation is 377 feet (115 m). Similar beds are present on Crow River (Plate 43).

The main outcrops of the Dunvegan Formation in the District of Mackenzie are along Petitot River, where massive beds in the trough of a syncline form the walls of a narrow canyon. Exposed beds measured 449 feet (136.8 m) thick (sec. 8, Stott, 1960b; Fig. 12). To the west the formation is exposed in isolated outcrops on Sully Creek and near Chinkeh Creek, and Kotaneelee River. The formation is mapped on Martin Hills and in the vicinity of Trout Lake (Douglas, 1974) but exposures are poor. Sandstones are assigned to the Dunvegan in various wells in this region with about 500 feet (152 m) of strata assigned to the formation in the Imperial Island River No. 1 well (Belyea in Stott, 1960b, p. 32).

PLATE 37

Massive conglomeratic beds of Dunvegan Formation, Akue Creek east of Muskwa River; section 65-2. GSC Photo 128458.

PLATE 38

Escarpment formed by Dunvegan conglomerate, looking northwest from Teepee Mountain toward Steamboat Mountain. GSC Photo 128415.

PLATE 39

Massive conglomerate of the Dunvegan Formation northeast of section 64-5, and McLellan Creek at headwaters of northeast tributary of Dunedin River; looking north to west flank of Liard Syncline; escarpment in distance is capped by east-dipping Dunvegan conglomerate, underlain by Sully shales; valley is floored by Sikanni sandstone. GSC Photo 128419.

PLATE 41

Basal Dunvegan Formation overlying Sully shales on cliffs above Liard River opposite Scatter River; section 65-17. Lowermost resistant bed is sandstone overlain by two smaller ribs of sandstone and mudstone, with coarse conglomeratic sandstone appearing at the top. GSC Photo 128519.

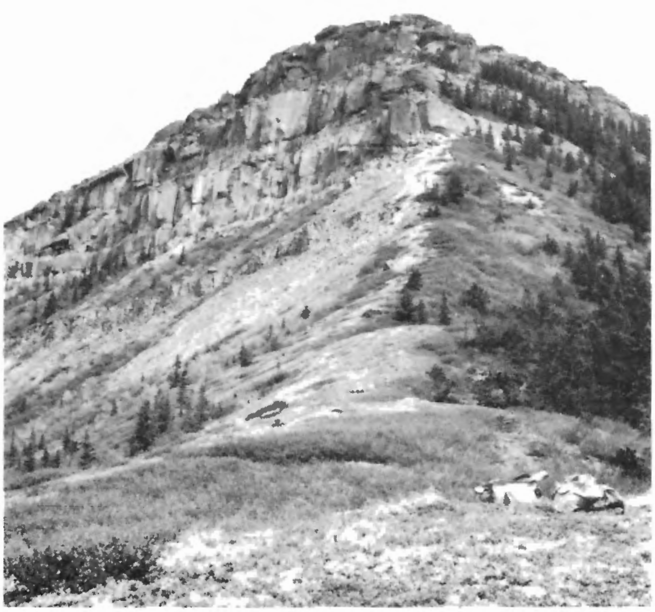


PLATE 40

Massive cliffs of Dunvegan Formation at top of ridge with underlying Sully Formation on lower slope, Dunedin Escarpment. Top of Sikanni Formation lies in immediate foreground; section 64-4. GSC Photo 128423.

PLATE 42

Cliffs of massive Dunvegan conglomerate at "big bend" of Liard River; section 65-18. GSC Photo 128520.

Williams (1978, Fig. 5) indicated that the Dunvegan sandstone is less widely distributed in the vicinity of Trout Lake than shown by Douglas (1974). Some of the difference in interpretation can be attributed to the inclusion by Williams of a thick sequence of "transition beds" in the Fort St. John Group. The mapped interval of the Dunvegan Formation in that area (Fig. 3) reflects the distribution of the "transition beds" as outlined by Williams, showing both the extent of that unit and the reduced areal distribution of typical Dunvegan strata. Williams also stated: "The pre-glacial Trout Lake highlands may have been capped by sandstone, but glaciation has destroyed most of the cap rock".

Lithology. The Dunvegan Formation, containing both marine and nonmarine beds, includes a heterogeneous assemblage of clastic rocks, grading from clay shale and mudstone to boulder conglomerate. The major conglomeratic and nonmarine facies are dominant in the area northwest of Sikanni Chief River (Fig. 22) and finer grained sandstone and shale of marine origin become more abundant in the area of Peace River and southeastward along the Foothills. Fine sandstone and shale also apparently occur in the eastern part of Maxhamish Lake, Petitot River and Great Slave map-areas.

In the region south of Pine River, the Dunvegan Formation contains both marine and nonmarine beds but is dominantly marine south of Smoky River (Stott, 1967c). In this region, the formation consists mainly of sandstone and shale or mudstone. Sandstones are generally fine grained, brown, slightly calcareous, and generally carbonaceous. The sandstones are finely crosslaminated and characteristically show fine crossbedding. Conglomerate is rare and, where present, occurs in the upper part of the formation. The marine shales are dark grey and silty; nonmarine shales and mudstones are green, brown, or black, and may be carbonaceous and coaly. Thin beds of coal are associated with the shale but no thick seams are known to occur. Plant fossils, including large angiosperm leaves, are fairly abundant.

PLATE 43

Dunvegan Formation, mouth of Crow River. GSC Photo 128513.

Carbonaceous shale and coal appear to be more abundant in the upper part of the formation in the vicinity of Pine River. Spieker (1921, p. K. 19) applied the name "Sukunka beds" to this part of the Dunvegan.

Coarser sediments appear in the northwestern part of Dawson Creek map-area and in the northeastern corner of Pine Pass map-area. Dunvegan sandstones near Moberly Lake are mainly fine grained with only thin beds of coarse sandstone with disseminated pebbles. Farther west at Dokie River and Mount McAllister, sandstones are medium grained and some conglomerate units occur, one to 15 feet (0.3-4.6 m) in thickness.

Farther north, much of the Dunvegan Formation consists of thick units of coarse grained conglomeratic sandstone and conglomerate separated by units of carbonaceous mudstone with minor amounts of fine grained sandstone and siltstone (Fig. 22). The coarse grained sandstone is moderately well to poorly sorted. Scour-and-fill structures, evidence of local erosion and channel development occur throughout the succession. Cross-stratification is a common feature.

Along the Muskwa escarpment, the basal beds consist of massive- to thick-bedded, fine- to medium-grained sandstone overlain by a few tens of feet of shale. Three units, 50 to 100 feet (15.2-30.4 m) thick, of massive conglomerate occur in the upper part. Thin, recessive intervals between the conglomerates contain poorly exposed sandstone and carbonaceous shale. The conglomerate, composed mainly of chert with some quartzite, contains pebbles ranging from one-eighth to three inches (3.1-76.2 mm) in diameter. The matrix consists of medium- to coarse-grained sandstone.

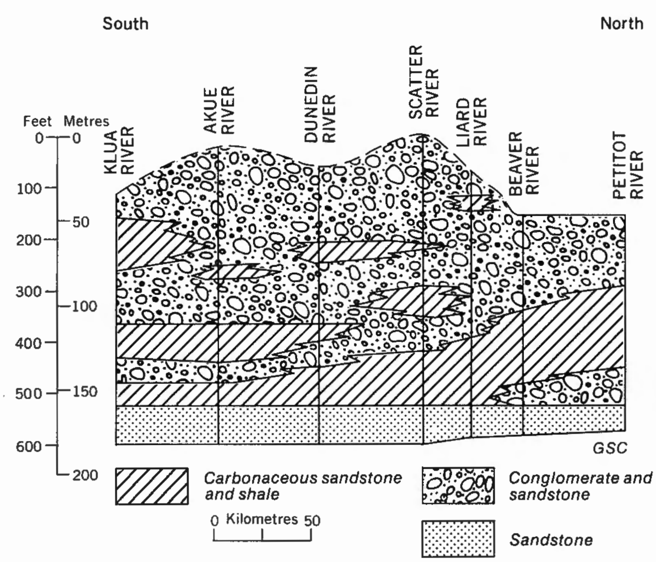


FIGURE 22. *Schematic diagram illustrating facies and approximate thicknesses of Dunvegan Formation.*

The Dunvegan Formation in the Beatton River map-area was described by Thompson (1977):

> *...The Dunvegan comprises a basal succession of medium- to fine-grained sandstone with interbedded carbonaceous mudstone, and an upper more resistant succession of interbedded medium- to coarse-grained sandstone and pebble conglomerate with a few thin mudstone interbeds...*

Thompson indicated that the average grain size of the Dunvegan decreases eastward, with conglomerate being rare and silty shale interbeds increasing in numbers. No outcrop of the Dunvegan sandstone was found by Thompson on the rim of the Etsho Escarpment in the Petitot River map-area.

Between Muskwa and Scatter Rivers, the formation comprises basal sandstone overlain by three cycles of carbonaceous mudstone, massive conglomerate, and coarse grained sandstone (Figs. 12, 22). Within those cycles, there is some variation from one locality to another in thickness and number of conglomeratic units. The basal sandstone is fine- to coarse-grained, porous, laminated, crossbedded and grades into the silty shales of the underlying Sully Formation. This unit weathers light brown. Sections in which the basal unit contains abundant conglomerate occur in Muskwa Escarpment east of Tuchodi River (sec. 64-31) and north of Kledo Creek on the eastern edge of Tsoo Tablelands (sec. 65-6). In exposures opposite Scatter River, the basal unit lacks distinct bedding and is overlain by one foot (0.3 m) of coal.

The upper conglomeratic units are thick bedded to massive, forming sheer cliffs. The conglomerates contain rounded to well rounded clasts, dominantly of quartz, quartzite and chert of various shades of green, black, blue, grey, and white. The clasts range from one-eighth to six inches (3.1-152.4 mm) in diameter and are commonly embedded in a matrix of coarse grained cherty sandstone (Plate 44).

Measurement of the largest clasts in various sections gives some indication of main trends. The largest boulders, in the order of 6 to 7 inches (152.4-177.8 mm) in largest dimension, occur at the big bend of the Liard River (sec. 65-18) and in the vicinity of Steamboat Mountain (secs. 64-2, 65-2). With the exception of those two areas, the largest cobbles range from 3 to 5 inches (76.2-127 mm) along the Muskwa-Dunedin-Liard escarpments. In the easternmost section at Klua Lakes (sec. 65-1), the largest cobble was 2.5 inches (63.5 mm) and on the eastern margin of Tsoo Tablelands, east of Steamboat Mountain, the largest cobble was 3 inches (76.2 mm). The decrease in the size of the largest clasts is also accompanied by a decrease in average size of pebbles and by a general decrease in total conglomerate with corresponding increase in coarse grained sandstone. The average pebble size is much reduced at the headwaters of Adsett Creek (sec. 65-1) where much of the upper massive units consist of coarse sandstone.

On Dunedin River, about 5 miles (8 km) upstream from its mouth, a unit of carbonaceous mudstone and platy sandstone occurs at the top of the formation. It is not known if this unit occurs farther south, although some additional sandy beds, which may be equivalent, are present at the top of the formation along the escarpment between Toad and Scatter Rivers. These beds may possibly be equivalent to the "upper plant-bearing deltaic sequence" on Beatton River described by Stelck et al. (1958).

Basal Dunvegan beds on Kotaneelee River are mainly medium grained sandstone with chert pebbles. Farther north on Sully Creek, the basal beds consist of fine grained, very soft and porous, finely laminated, crossbedded sandstone.

On Petitot River, the basal coarse grained, crossbedded, massive sandstone grades upward into blocky mudstone containing coal and lenses of conglomerate. Upper beds consist of conglomerate and coarse grained sandstone. Pebbles in this region range from one-eighth to half an inch (3.1-12.7 mm) in diameter.

Farther east in the Imperial Island River No. 1 well, some 550 feet (167 m) were included in the Dunvegan Formation but some of the upper part may represent the Kotaneelee Formation. The basal 260 feet (79 m) contains coarse grained sandstone with carbonaceous material and plant fragments, and apparently grades downward into shale. The middle 160 feet (49 m) contains shale and fine grained sandstone; and the upper part contains coarse grained sandstone. Williams (1978) described the Dunvegan Formation in this region around Trout Lake as consisting of silty to coarse-grained sandstone with interbedded, varicoloured shale.

Pebble or cobble conglomerate commonly exhibit crude horizontal stratification. Large scale crossbedding, mainly of a trough character, is evident in many units but planar crossbedded units are not so common. Sandy lenses and channel structures are present throughout the sequence. The coarser conglomerates appear to be clast-supported although coarse- to fine-grained sand may be present as a matrix. A crude fining upward trend occurs in many units and may be better developed in some of the finer gravel to sand sequences. The sandstone units commonly have lenses and pods of pebbles and may grade upward into siltstone and silty mudstone. The finer grained sandstones are commonly ripple bedded to finely planar laminated.

PLATE 44

Dunvegan conglomerate, cliffs opposite Scatter River; section 65-17. GSC Photo 128519.

The Dunvegan sandstones vary from very fine-grained to conglomeratic. The basal sandstone is generally fine- to coarse-grained with little or no conglomerate. Conglomerate dominates the overlying beds. The sand grains appear angular to rounded but much of the angularity may be related to development of secondary overgrowths of silica.

The Dunvegan sandstones vary in composition, with quartz dominating the finer-grained units, and chert being more abundant in the coarser sandstones and conglomerates. Lithic grains rarely exceed 10 per cent. Minor constituents include feldspar, mica, carbonaceous fragments, some opaque to brown iron oxide and carbonate cement. Carbonaceous fragments are almost ubiquitous within the sandstones. Glauconite occurs in the basal sandstone.

The quartz of the Dunvegan is generally clear, with only a few grains showing undulose extinction. Composite grains of typical quartzite are rare but composite grains with gneissic texture are more common. The quartz is subrounded to angular, with some indication of secondary overgrowths modifying the original grain shapes. Boundaries tend to be more commonly straight than sutured, but the presence or absence of matrix has some bearing on the nature of the contacts.

Chert is a common constituent of the Dunvegan sandstones and conglomerates, appearing to dominate in the medium grained to conglomeratic sandstones. Several types of chert were noted, with that having fine microaggregate texture appearing to be most abundant. Coarse aggregate chert is common. The grains exhibit numerous small structures, possibly representing silicified fossil fragments. The colour of the chert also varies, from very dark to light.

Lithic grains appear to consist of very fine siliceous argillaceous fragments and, possibly, volcanic fragments. These commonly have undergone some sericitization.

The thin sections examined did not contain large quantities of matrix but many of the sections were of coarser sandstone. In the finer sandstone, the matrix content increases and in some samples, surrounds the sand grains.

Age and correlation. The various age assignments and proposed correlations of the Dunvegan Formation were summarized by McLearn and Kindle (1950, p. 99):

> *...The age of the Dunvegan, proposed by various authors, has varied from earliest Upper Cretaceous (Cenomanian) to Belly River (Campanian). It was dated Niobrara or late Coloradoan by Dawson (1881); Belly River by McConnell (1893); Belly River by Dowling (1915); Coloradoan by McLearn (1918); probably early Coloradoan by McLearn (1926); Upper Cretaceous, about Cenomanian, by McLearn (1932); late Cenomanian or rather early Turonian by Williams and Bocock (1932); on the advice of W.A. Bell; Cenomanian or very early Turonian by McLearn (1937); Cenomanian by Warren and Stelck (1940); and probably Cenomanian (early Upper Cretaceous) by Hage (1944); on the advice of W.A. Bell.... Today, however, all students of Canadian Cretaceous fauna will accept an early Upper Cretaceous age for the Dunvegan Formation and, tentatively at least, a Cenomanian date in terms of European chronology...*

McLearn (1945) discussed the invertebrate fauna known to occur in the Dunvegan Formation. He considered the following nonmarine species to be diagnostic of the Dunvegan: **Unio (Pleurobema) dowlingi, Unio sulfuriensis,** and **Melania**? sp. McLearn indicated that **Corbula pyriformis** var. **dunveganensis** may record a nonmarine or brackish water habitat and that **Corbula** cf. **C. nematophora** occurs with marine fossils. McLearn also listed the following marine fossils: **Inoceramus dunveganensis, Inoceramus dunveganensis** var. **mcconnelli, Inoceramus rutherfordi, Inoceramus athabaskensis, Barbatia micronema, Ostrea anomioides, Brachydontes multilinigera, Ostrea soleniscus**?, and **Modiolus silentiensis.** McLearn followed Warren and Stelck (1940) by indicating the presence of **Dunveganoceras poucecoupense,** in the Pouce Coupé sandstone "at the top of the formation". The Pouce Coupé sandstone is regarded now as part of the overlying Kaskapau Formation, as stated by Warren and Stelck (1955), Stelck and Wall (1955), Stelck (1962), and Stott (1967c).

Stelck and Wall (1955, p. 17, 19) outlined the intertonguing relationships of marine shale and deltaic sand of Cenomanian age. They indicated that the sequence of the Howard, Pouce Coupé and Doe Creek sands separated by marine shale and included in the Kaskapau Formation in the Dunvegan-Spirit River area, becomes progressively less marine westward and is eventually included in the upper part of the Dunvegan Formation. They listed the following fossil forms as occurring in the Dunvegan Formation of the Dunvegan-Spirit River area: **Unio dowlingi** McLearn, **Psammosolen dunveganensis** Warren, **Brachidontes** cf. **tenuisculpta** (Whiteaves), **Brachidontes** cf. **fulpensis** Stephenson, **Callista** cf. **orbiculata** (H. and M.), **Mactra** sp., **Inoceramus rutherfordi** Warren, **Ostrea dunveganensis** Warren, **Ostrea** sp., **Rhytophorus**? **caurinus** McLearn. They assumed that, although precise stratigraphic data was lacking, the following fossils also came from the Dunvegan: **Inoceramus dunveganensis** McLearn, **Ostrea anomioides** Meek, **Inoceramus athabaskensis** McLearn, **Modiolus silentiensis** McLearn. Warren and Stelck then listed those species that they assigned to post-Dunvegan strata of the eastern region, but which had been stated to occur in Dunvegan beds by Rutherford (1930), Warren and Stelck (1940), McLearn (1945) and Gleddie (1954): **Barbatia micronema** (Meek), **Ostrea soleniscus** Meek, **Parmicorbula dunveganensis** (McLearn), **Unio sulfuriensis** McLearn, **Melania** sp., **Ostrea aurea** (Warren and Stelck), **Inoceramus corpulentus** McLearn, **Dunveganoceras** spp.

A tentative zonation for the early Turonian and late Cenomanian sequence was given to Stelck and Wall (op. cit., p. 16).

> **Inoceramus dunveganensis** and **Inoceramus athabascense**
> **Inoceramus rutherfordi** and **Ostrea dunveganensis**
> **Brachidontes** cf. **fulpensis**
> **Brachidontes** cf. **tenuisculptus**

They stated also (op. cit., p. 19) that **Inoceramus athabascense** which occurs in Dunvegan strata,

> *...acts as a partial link indirectly with the Cenomanian zones. On the Athabasca River I.* ***athabaskensis*** *is reported (McLearn, 1945) to occur in association with* ***Acanthoceras athabascense*** *Warren and Stelck, n. sp. This* ***Acanthoceras*** *is very closely related to* ***Euomphaloceras euomphalum*** *(Sharpe) (****A. cunningtoni*** *Sharpe) of the Cenomanian stage of England...*

Subsequently, Jeletzky (1968) recognized the **Inoceramus dunveganensis** zone above **Acanthoceras,** and suggested that "**Acanthoceras athabascense** zone may be a faunal facies of the restricted zones of **Inoceramus rutherfordi** and **Inoceramus dunveganensis**". Therefore, the Dunvegan Formation can be correlated with beds in the La Biche shale of northeastern Alberta which contain **Acanthoceras athabascense** (see also Stelck and Wall, 1955).

Bell (1963) gave his final conclusions on the age of the Dunvegan flora and its relationship to fossil floras of similar age in the United States. Bell listed sixty-six species and concluded:

> *. . .It may be seen from the above record of species of the Dunvegan flora and its distribution in Cretaceous floras of the United States, exclusive of Alaska, that the largest number of common species occur in floras of the Dakota, Woodbine, Tuscaloosa, Raritan, and Magothy. The Woodbine is most important for correlation with the European chronology, for its age is established as Cenomanian on the basis of marine fossils present in underlying beds of the Washita Group. . .*

The Dunvegan flora was not previously reported from the more northerly part of the region. Two collections obtained from the Dunvegan during the course of the present study were identified by W.A. Bell. The first (GSC loc. 7466) was obtained southeast of the junction of Tetsa and Muskwa Rivers, at the headwater of Akue Creek and included: **Menispermites reniformis** Dawson, **Populites wickendeni** Bell, **Laurophyllum** sp. Bell, **Platanus newberryana** Heer, **Pseudoprotophyllum boreale** (Dawson) Hollick, **Pseudoaspidiophyllum latifolium** Hollick. Bell commented that "the above species with the exception of **Populites wickendeni** have been recorded previously from the Dunvegan, the species of **Pseudoprotophyllum** being restricted so far as known to Cenomanian floras". The second (GSC loc. 7467), collected on lower Dunedin River, contained: **Pseudocycus unjiga** (Dawson) Bell, **Ficus daphnogenoides** (Heer) Berry, **Ficus**? **lesquereuxi**? Knowlton, **Magnolia coalvillensis**? Knowlton, **Menispermites reniformis** Dawson, **Laurophyllum** sp. Bell, **Platanus williamsi**? Bell, **Platanus raynoldsii** Newberry, **Ampelophyllites** sp., **Pseudoprotophyllum boreale** (Dawson) Hollick. Bell stated that "the above assemblage is indicative of a Cenomanian age". The occurrence of this flora in the Peace River and Liard River regions permits the correlation of the coarse sandstone to conglomeratic succession for a distance of 500 miles (804.7 km).

A microfaunal zone of **Verneuilinoides perplexus** is defined by Caldwell et al. (1978) which lies immediately above the Dunvegan Formation in the Peace River district of northwestern Alberta and northeastern British Columbia. According to those authors, the **V. perplexus** Zone spans the **Acanthoceras athabascense** Zone and the **Dunveganoceras** cf. **conditum** and **D. albertense** Subzones of the **Dunveganoceras** Zone.

In 1921, Spieker gave the name "Sukunka member" to upper beds of the Dunvegan Formation which were composed of green shale, mudstone, some sandstone, and coal. Stelck and Wall (1955, Fig. 5) suggested in a diagram that the Sukunka member was equivalent to a part of the basal Kaskapau Formation. However, the beds of the Sukunka member dip beneath the Kaskapau Formation in the vicinity of Trapper Mountain just east of sections studied by Spieker (see Fig. 3), and therefore, are not equivalent to sandstones exposed on Elephant Ridge and Tuskoola Mountain.

The Dunvegan Formation can be traced southward almost to Athabasca River (Stott, 1960a, 1967c). Beyond there, equivalent beds occurring above the Fish-Scale marker horizon lie within the Sunkay Member of the Blackstone Formation of the central and southern Foothills.

Beds assigned to the Trevor Formation on Mountain River have yielded **Inoceramus** cf. **dunveganensis** (Aitken et. al., in press), indicating a Cenomanian age and correlation with the Dunvegan Formation. As indicated previously, the lower part of the Trevor Formation is of Late Albian age, and therefore, only part of the upper beds can be equated with the Dunvegan Formation. Even younger beds containing Turonian fossils are reported from Trevor sandstone on Hume River (Aitken et al., in press).

The Dunvegan Formation apparently correlates in part with the Floweree Member of the Marias River Shale of the Colorado Group of the Sweetgrass Arch region of Montana as described recently by Cobban et al. (1976, p. 39). According to them, the Floweree Member contains, in its upper part, **Dunveganoceras albertense** (Warren) which, in the Peace River region is found above the Dunvegan Formation, and the older ammonite **Calycoceras**? **canitaurinum** (Haas).

The unconformity at the top of the Dunvegan Formation north of Sikanni Chief River appears to represent all of Turonian and Coniacian time. The Cenomanian to Turonian Kaskapau shales are recognized above the Dunvegan in Alberta immediately to the east of Dawson Creek and Fort St. John. However, it is not known whether sediments of that age in areas farther north were deposited on the Dunvegan and subsequently eroded, or whether no deposition occurred in the region during that time.

PALEOGEOGRAPHY

Introduction

The paleogeological and paleogeographical setting of the Fort St. John Group is related to broad features of continental extent. Sediments derived from a western mountainous source were deposited in an asymmetric basin whose foredeep trough paralleled the eastern margin of the mountains. This trough trended northwesterly to northerly through present northeastern British Columbia, District of Mackenzie, and Yukon, and southeasterly along the eastern margin of the present Rocky Mountains. The trough was bordered on the west by the rising Omineca Geanticline. The basin extended east toward the low-lying Precambrian Shield and the embayment at times may have lapped onto Precambrian rocks. Throughout most of the Cretaceous period, this basin was the site of the Western Interior Cretaceous seaway. That seaway extended from the Arctic Ocean (boreal) region during latest Neocomian, Aptian, and Early Albian time and eventually joined in Middle to Late Albian time with a similar invasion extending northward from the Gulf of Mexico. In Cenomanian time, the southern embayment was dominant with restriction of the connection to the boreal sea.

In the region north of Peace River, only the marine part of the sequence is preserved. The deltaic deposits, characterized by coal beds formed in extensive swamps, are seen only from Peace River southward. To the north, the preserved shorelines are marked by thick and continuous sandstone sequences.

Environments of deposition

The sediments of the Fort St. John Group contain major sequences of fluvial, deltaic, and marine origin. The depositional model is similar to that outlined for the Recent Mississippi Delta by Scruton (1960; see also Fig. 23). Lateral progradation, following and in conjunction with subsidence, resulted in the development of a succession which grades laterally and vertically from mid-basin shales, through prodelta shales and siltstone to delta-front sandstone, and

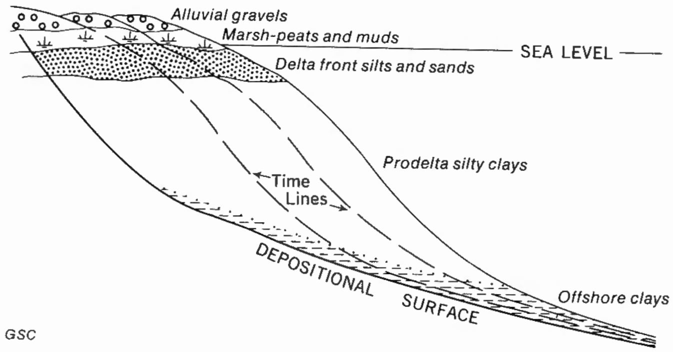


FIGURE 23. *Depositional model of prograding depositional environments.*

into delta-plain sandstones, coals, and mudstones. Four major repetitions are recognized. At the conclusion of the fourth sequence, the coarse conglomeratic sandstone and conglomerate of the Dunvegan Formation record the dominance of fluvial to piedmont alluvial environments. The main environments, within the stratigraphic model, are briefly summarized as follows.

Mid-basin (neritic) environment

Shales of the mid-basin environment can be recognized in the middle part of the Moosebar, Hasler, and Cruiser shales of the Peace River region, in the Buckinghorse and Sully Formations of Sikanni Chief region, in the Buckinghorse Formation of the Tetsa-Muskwa region, and in the Garbutt, Lepine and Sully Formations of the Scatter-Liard region, and also of the Liard Range. These shales lie on prodelta and shelf muds deposited during the initial phases of transgression and which are described in the following section.

This neritic facies is characterized by fissile to flaky, black to dark grey shales. The shales consist mostly of homogeneous, structureless clay and silty clay. The shales commonly contain pyrite and abundant, black organic material, indicating reducing conditions below the surface of deposition. They differ from shales of the prodeltaic environment in the lack of sideritic concretions. Laminations are not prominent but individual laminae of silt and fine sand are more abundant near the base and top of the sequence where it grades into sediments deposited at shallower depths. This facies is the result of slow accumulation of fine muds and is similar to the modern shelf sediments described by Moore and Scruton (1957) and Coleman and Gagliano (1965).

Prodelta and shelf environment

Shales or mudstones of the prodelta and shelf environment form the largest proportion of the Fort St. John sediments. These rocks typically occur at the base and in the upper part of the major shale formations and are present throughout the whole region. The lithology of this environment is dominantly grey to dark grey mudstone, laminated shale, and varying amounts of siltstone. Reddish weathering sideritic concretions are a characteristic feature.

In contrast to the mid-basin shales, silt is much more abundant and thin lenses and laminae of very fine-grained sandstone and siltstone are commonly present. Small carbonaceous fragments and mica occur along the bedding planes. Parallel laminations, small-scale crosslaminations, and ripple marks occur in most exposures. The siltstone and sandstone are commonly calcareous and weather grey to brown. Small slump structures or flow rolls, as well as some cut-and-fill structures are present. The sediments become siltier and thicker bedded as they grade into delta-front sediments. The thinly interbedded sequences of sandstone, siltstone, and mudstone, which characterize the uppermost part of the shale formations are typical of the uppr prodelta facies. These sediments are similar to modern prodelta sequences described by Fisk et al. (1954), Scruton (1960), Coleman and Gagliano (1964, 1965), Fisher et al. (1969), Allen (1965a, 1970), and Gould (1970).

Although the sediments of the Fort St. John Group are clearly associated with major deltas, penecontemporaneous deformation on a large scale was rarely noted. Structures comparable to the mudlumps of the Mississippi delta (Morgan et al., 1968) are rare. One of the best examples is found at the base of the type Scatter sandstone where argillaceous siltstone and mudstone are highly contorted and convoluted. The deformed layer is in the order of 25 to 30 feet (7.6-9.1 m) thick. A rare occurrence of crossbedded layers of silty shale with thin interbeds of siltstone was observed in the Garbutt Formation (Plate 19), although such occurrences in a constantly changing deltaic complex might be expected to be more common.

Further evidence of the marine nature of the shales is provided by their contained fossils. Microfauna, collected from the lower 65 feet (19.3 m) of the Buckinghorse Formation on Prophet River (Chamney in Stott, 1973, sec. 62-20) and including **Quadrimorphina** cf. Q. **albertensis** Mellon and Wall, **Gaudryina nanushukensis** Tappan, and **Conorbina norrisi** (Mellon and Wall), represent open marine conditions. Similarly, microfauna, including **Marginulinopsis collinsi** Mellon and Wall, **Saracenaria grandstandensis** Tappan, **Serovaina loetterlei** (Tappan), found within the Moosebar Formation in Monkman Pass region was reported by Wall (unpubl. report) to represent a normal marine environment of the inner to middle neritic zone. According to Stelck et al. (1956, p. 20), the **Haplophragmoides multiplum** zone, (recorded now in the Hulcross Formation on Peace River and Buckinghorse Formation on Petitot River), "suggests an epicontinental sea with restricted oceanic connections.... the assemblage of finely arenaceous foraminifera indicates normal salinity and probable depth in excess of 100 feet". Stelck (1975b, p. 265), in discussing the **Miliammina manitobensis** Zone, which occurs in the upper Buckinghorse shale in the Sikanni Chief region, suggested that:

> *...The depth of the water for the Buckinghorse-Sikanni succession seems to have ranged from about the outer-shelf depth of 600 feet (183 m) to the inner-shelf to estuarine depths of about 200 to 100 feet (60-30 m)...*

Wall (pers. comm., 1979) in commenting on the foraminifera at the Garbutt Formation stated:

> *The dominance of simple siliceous foraminifera and the absence of calcareous species normally associated with shelf tends to suggest either a relatively cold, deep water habitat or a shallow water sequence with rapid deposition.*

Delta-front and coastal shoreline environment

Modern-day delta front environments are characterized by a complex of sub-environments, including distal bar, distributary mouth bar, channel and subaqueous levee

(Coleman and Gagliano, 1965). Sediments at the terminous of a channel mouth are constantly subjected to reworking by stream currents and wave action, resulting in concentrations of sand and silt. Similar successions are encountered in the Gates, Boulder Creek and Goodrich sandstones of the Peace River region, the extensive Sikanni Formation, and the sandstones of the Scatter Formation.

The delta-front sandstones grade basinward into the prodeltaic mudstone, and as would be expected, the succession also grades vertically downward into prodeltaic sediments. Thin bedded, silty sandstones with interbeds of shale and siltstone which characterize the transition zone are similar to deposits of low energy, distal portions of distributary mouth base described by Coleman and Gagliano (1965). The thick bedded, well sorted, fine grained sandstones probably represent environments of higher energy. The extensive distribution of these sandstones along the margin of the marine embayment is suggestive of coastal shoreline deposits.

Sandstones of the Gates and Boulder Creek Formations can be traced laterally into coal-bearing beds of the delta-plain environment. They are therefore characteristic of typical delta-front sandstones. The sandstones within the Buckinghorse Formation at Muskwa River, and the Scatter sandstones appear to have been deposited in delta-front to epineritic environments. No well defined nor abrupt changes differentiate these deposits from those of the lower deltaic plain on one hand or from typical marine environments on the other. Structures that are characteristic of shoreline environments include uniform, parallel, and finely crossbedded laminae (Coleman and Gagliano, 1964, 1965; Fisher et al., 1969). The lack of abundant carbonaceous material and coal seams in both the sandstones at Muskwa River and Scatter sandstones suggests that delta plain deposits are not present. The abundant glauconite in the Scatter is strongly indicative of marine deposition, as the consensus is that glauconite forms only as an authigenic mineral during the early diagenesis of marine sediment (Odin, 1972; Bjerkli and Oestmo-Saeter, 1973; Porrenga, 1967).

The Sikanni sandstone, maintaining a fairly constant thickness over a distance of several hundred kilometres, without any major associated delta-plain sediments appears to be more representative of coastline deposits. The common vertical sequence of a prograding coastline is, in a descending direction, alluvium, marshes (peat and coal), tidal flat and lagoonal deposits, coastal sand, transition zone and shelf mud. In the Sikanni sequence only the latter three appear to be present. The shelf muds, similar to prodelta muds, contain abundant silt and sideritic concretions and the transition zone consists of mudstone and increasing quantities of siltstone and silty laminated sandstone. The main sand units of the Sikanni appear to be coastal sands and at no locality has a more landward facies been observed. These sandstones, in general fine grained, well-sorted and finely laminated, apparently represent sediments that were extensively winnowed and reworked by wave action along a linear coastline. These sediments are similar to the foreshore, upper shore-face and lower shore-face sands described by Bernard et al. (1962), Howard and Reineck (1972), Reineck and Singh (1973, p. 342).

The distribution and sedimentary structures of the Sikanni sandstones resemble those of the São Francisco delta described by Wright and Coleman (1973). The Sikanni Formation contains extensive thick sheet sands composed of clean, well-sorted quartzose sand. In the São Francisco delta, similar sheet sands are developed by high wave energy and low littoral currents. The lack of any extensive carbonaceous or coal deposits in the Sikanni might also be explained by comparison with the São Francisco where the interior delta plain is composed almost entirely of closely spaced beach ridges with only localized marsh-mangrove environments.

Structures similar to convolute laminations, "pillow" structures and "flow rolls" are encountered in many of these sections. Pillow structures are particularly well developed in the Sikanni sandstone (Plate 12) along the Trutch Escarpment and in the Gates sandstone on Peace River (Plate 4). The pillow structures, so evident at those localities, mark the outer delta platform to top of the prodelta slope (Hubert et al., 1972).

Delta-plain environment

Sediments of the delta-plain environment occur mainly in the Gates and Boulder Creek Formations south of Pine River and were described in some detail previously (Stott, 1968a). Terrestrial origin of parts of these formations is indicated by the abundance of carbonaceous material. Numerous coal beds south of Pine River provide evidence of widespread forests and swampy conditions associated with deltaic plain. The well preserved delicate flora, rootlets, fallen logs, and upright stumps are indicative of growth in place. Conglomerates associated with the carbonaceous facies were probably deposited in channels cutting through the delta. Other sediments, undoubtedly of fluviatile and interfluvial origin, include structureless or horizontally laminated, very fine sandstone and clay mudstone. These sediments are similar to the modern delta plain deposits described by Coleman and Gagliano (1965), Fisher et al. (1969) and Allen (1970).

Although some conglomerate occurs in the Sikanni Formation, and may represent channel deposits, carbonaceous sediments and coal beds are not recognized in the Fort St. John sandstone north of Peace River. If such delta-plain deposits were developed, they must have occurred west of the present outcrop belt of the Scatter and Sikanni sandstones.

Part of the Dunvegan Formation, particularly in the vicinity of Peace River, also contains sediments of the delta-plain environment. These sediments consist of carbonaceous siltstone and mudstone, silty sandstone, coarse grained to pebbly sandstone, and thin coals. Coal seams are best developed in the Dunvegan Formation in the vicinity of Pine River. A thin, but persistant seam appears above the basal Dunvegan sandstone along the Liard Escarpment. It presumably represents marsh deposits formed landward of the prograding shoreline.

Fluvial to piedmont alluvial environment

The conglomerate and coarse grained sandstone of the Dunvegan Formation formed in the fluvial to piedmont alluvial plain environment. The main locus of deposits occurs in the region between Tetsa and Kotaneelee Rivers, fanning out southeastward to southward, extending almost to Peace River. Eastward, the conglomerate grades into very fine-grained sandstone. Southward, the transition can be traced laterally from massive conglomerate into carbonaceous shale and sandstone of the deltaic plain, through cleaner sandstone of the deltaic-front environment, and finally into prodelta shale south of Wapiti River.

Most of the upper part of the Dunvegan Formation between Muskwa and Beaver Rivers consists of pebble and cobble conglomerates with associated coarse grained sandstone. The conglomeratic and coarse grained sandstone facies occur in thick units that commonly appear massive (Plates 37, 39). However, large-scale crossbedding, some of a festoon character, are evident at most localities. Tabular cross-stratification is not so common. Scour-and-fill structures are commonly present. The finer grained sandstones are commonly ripple-bedded to finely planar-laminated. These characteristics have been noted in recent braided streams by Ore (1965), Coleman (1969) and Smith (1970).

The sequence appears to resemble closely that described by Doeglas (1962) and to a lesser extent, that described by Williams and Rust (1969) from recent braided rivers. The lower part is composed of cobbles and pebbles with large-scale crossbedding, formed as a result of the lateral and downstream advance of the channel bar into an adjacent anabranch channel. These sediments grade into finer-grained sandstone deposited in low-water conditions. The constant migration of channels tends to remove the finer overbank silts and muds deposited under low energy conditions. The carbonaceous units of siltstone and mudstone that are preserved represent these associated overbank deposits.

Tectonic elements

Deposition of the Fort St. John Group was controlled by several structures which have a long history extending back through Mesozoic into Paleozoic time. The depositional basin was bordered on the west by the northwesterly trending Omineca Geanticline. Within the basin, structural features include the Alberta and Liard Troughs, the Peace River Arch, and the Bovie Lake Fault Zone (Fig. 24).

Omineca Geanticline

The Omineca Geanticline lies within the Columbian Orogen, the eastern belt of the Cordilleran Orogen, and became established in early Late Triassic time (Wheeler et al., 1972). Uplift continued in Early and Middle Jurassic when deformation culminated in the Omineca Geanticline, essentially the core zone of the Columbian Orogen, followed by emplacement of Middle Jurassic (165 m.y.) granitic plutons. The Omineca Crystalline Belt is dominated in the north by the elongate Cassiar batholith.

Price and Mountjoy (1970) concluded that the eastward migrating clastic wedges were derived in large part from thrust plates emplaced into the Main and Western Front Ranges of the Rocky Mountains. They considered the pulses of sedimentation reflected pulses of deformation. As outlined in the following discussion, the Blairmore-Fort St. John-Dunvegan sequence records four well-defined pulses within Albian to Cenomanian time.

Thick clastic wedge sequences were shed eastward into the foredeep and basins lying between the geanticline and craton. The first clastic wedge comprises the late Upper Jurassic shales of the Fernie Formation and sandstone and carbonaceous sediments of the Kootenay Formation and Minnes Group. The second major wedge consists of the dominantly nonmarine Blairmore clastic succession of the central and southern Foothills and the Fort St. John Group of the northern Foothills.

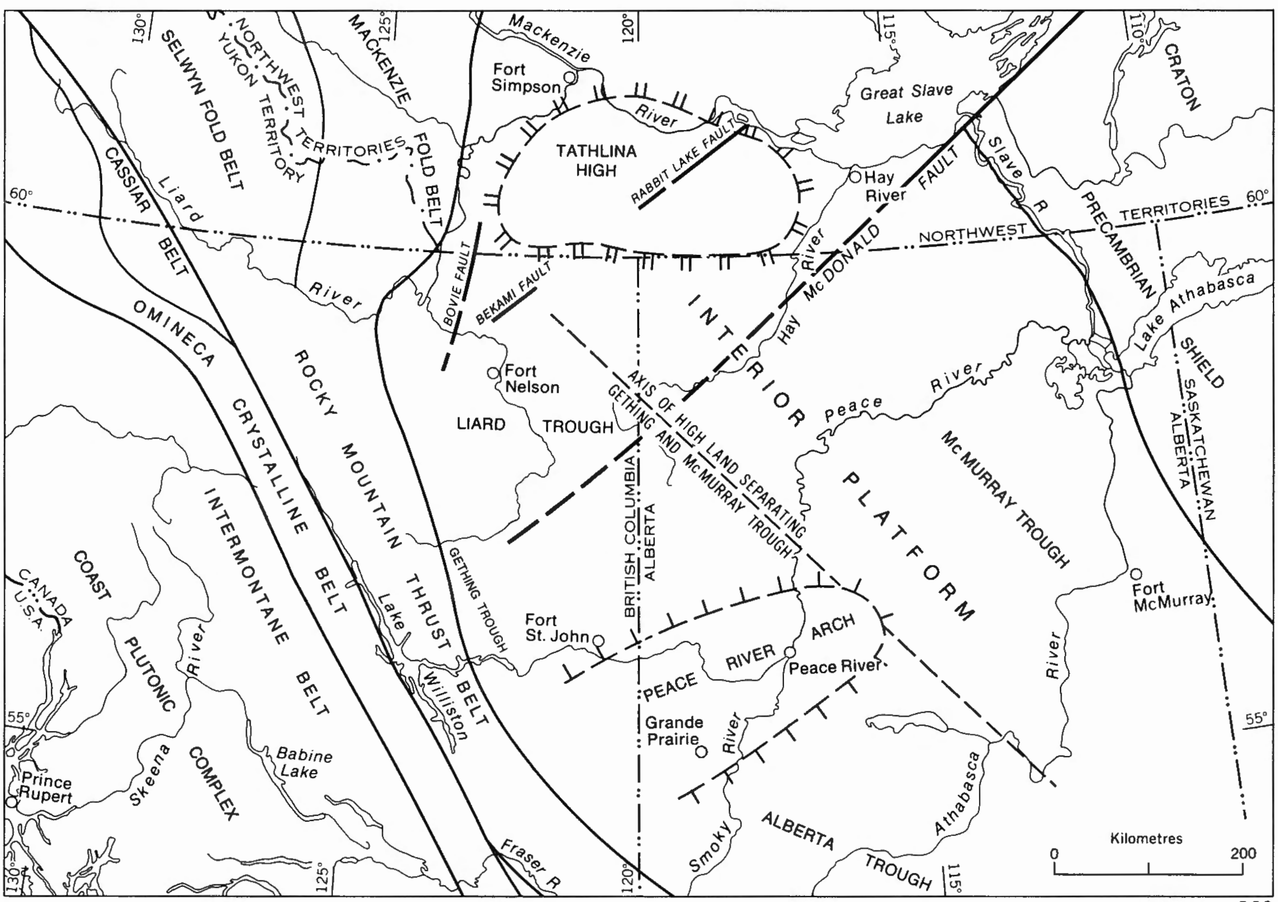


***FIGURE 24.** Principal tectonic elements controlling Cretaceous deposition.*

Peace River Arch

The Peace River Arch is a northeasterly trending structure, lying in the vicinity of Pine and Peace Rivers in British Columbia (Fig. 24). It is bounded on the south by the Alberta Trough and on the north by the Liard Trough. These troughs were strongly negative elements bordering the Interior Platform (see Douglas et al., 1970). The Alberta Trough was in existence in Cambrian time but the Liard Trough did not become prominent until the Late Devonian. The origins of the Peace River Arch may extend back into Cambrian time because Pugh (1975, p. 14) has shown that Cambrian sediments have trends that suggest some initial movement in the region. By Devonian time, the Peace River Arch was a major positive structure (Webb, 1951, 1954, 1964; Sikabonyi, 1975; de Mille, 1958; Belyea, 1964). During Mississippian time, the structure foundered (Lavoie, 1958; MacAuley et al., 1964) and remained as a negative component during Triassic and Jurassic time. As a result, the Liard and Alberta Troughs were linked during Carboniferous time, establishing a continuous belt of depression along the margin of the craton. The Peace River Arch was active during much of Albian time and its influence during deposition of the Cretaceous Bullhead Group and Fort St. John Group was outlined previously (Stott, 1968a, 1975; Stelck, 1975a).

The depositional trends of the Gates and Boulder Creek sandstones parallel the northeasterly trending Peace River Arch (Stott, 1968a, Fig. 17) which acted as a hinge, with thick marine deposits occurring north of it and delta-front to fluvial sediments lying in the south. The Peace River structural zone appears to have been relatively inactive during the development of the Goodrich-Sikanni sequence. The major trend of the sandstone, southeasterly to northwesterly, is more or less parallel to the later trends of the Laramide structures, suggesting that the Peace River Arch was exerting little or no influence during Late Albian time. The arch does mark a somewhat poorly defined boundary between the marine and nonmarine facies of the Dunvegan, with the nonmarine facies lying to the north.

Liard Trough

The Liard Trough, containing areas included in the Hay River Embayment (van Hees, 1964), the Hay River-Keg River Low (Stelck, 1975a), and extending west of the Elk Point Basin, is a large structural depression lying between the Peace River Arch to the south and the Liard or Tathlina High to the north. It is divided near its centre by the McDonald Fault. This fault, lying in the vicinity of the Great Slave Lake (Lang, 1961; Burwash et al., 1964) extends southwesterly and has been linked by various authors with the Hay River Fault (Sikabonyi and Rodgers, 1959). The McDonald Fault borders the East Arm Fold Belt of the Churchill Province in the Northwest Territories. According to Stockwell et al. (1970, p. 89):

> *. . .the McDonald (and other fault zones) . . .were initiated early, about 1700 to 1760 m.y. ago. . . Along a few faults such as the McDonald, there is evidence of movement in Paleozoic time. Most faults appear to be strike-slip types with left-hand displacement being more common than right-hand. However, some of the older faults with a long history of movement appear to have a considerable vertical component.*

Other northeasterly trending faults have been illustrated by Sikabonyi and Rodgers (1959), Douglas (1974), and Williams (1978, Fig. 7). The Tathlina High is a large basement feature within the Interior Plains, mainly in the District of Mackenzie. Belyea (1971) documented differential subsidence on the flanks of the Tathlina High during Middle Devonian time.

As shown previously (Stott, 1968a) and as noted by Stelck (1975a), a major lobe of the Fort St. John Group lies on the northwest, down-thrown side of the Peace River Arch at the southern end of the Liard Trough. The greatest thickness of the Fort St. John occurs at the northern end of the trough in the vicinity of the junction of Scatter and Liard Rivers. The total thickness there is almost one and a half times that in the Peace River region. The latter is readily recognized as a major deltaic lobe (Stott, 1968a) and although the coarser types of deposits are not seen at Scatter River, the thick sequence there must represent another very large deltaic system.

The McDonald Fault, lying south of Fort Nelson, was considered by Stelck (1975a) to mark the southern limit of the Scatter deltaic complex and also the main southern limit of the conglomeratic facies of the Dunvegan Formation. The main southern boundary of the Scatter deltaic complex, however, lies near the mouth of Toad River and would more closely coincide with a southwesterly extension of the Bekami Fault illustrated by Sikabonyi and Rodgers (1959). Also, no abrupt change occurs within the Dunvegan Formation, although the sediment becomes finer toward the Peace River Arch.

The Goodrich-Sikanni succession extends northwestward without any significant change across the McDonald Fault and the underlying Buckinghorse shale shows no marked variation in the vicinity of the fault. However, the main sand facies of the Sikanni Formation grades laterally within a short distance into silty shale north of the junction of Toad and Liard Rivers, in about the same region where the Scatter sandstone disappears southward. If the facies changes in the Scatter Formation and in the Sikanni Formation are a reflection of structural control, that element lies some distance north of the extension of the McDonald Fault. The latter does not appear to have played an important role during Albian deposition, although another northeasterly fault system, such as the Bekami, may be involved.

Bovie Lake Fault Zone

The Bovie Lake Fault Zone, extending from north of Petitot River (Douglas, 1976a) south to southeastward to the junction of Tetsa and Muskwa Rivers (Taylor and Stott, 1968a), has played an important role in the deposition of sediments from early Paleozoic time onward, but its influence has not been documented in detail. Very little information has been published on the Bovie Lake structure although Richards (1969) referred to the "Bekami Lake-Bovie Lake-Liard River structural hinge". He implied that it was active throughout Cambrian, Ordovician and Silurian time. According to G.K. Williams (unpubl. report):

> *. . .The Bovie hinge line (so named because it coincides with the Bovie anticline) divides the shelf from the western basin. This hinge is an ancient flexure, down in the west, which was active throughout much of Paleozoic and Mesozoic time. The hinge continues south of the map-area, where its trend changes to south-southeast. The Bovie hinge line marks the eastern limit, except for thin and discontinuous patches of Pennsylvanian, Permian, and Triassic rocks. . .*

Williams's study has shown marked thickening of the Mississippian and Triassic rocks to the west of the Bovie hinge line, indicating substantial subsidence during those periods.

The Bovie Lake fault controlled the deposition of the lower Fort St. John Group, and probably was active during deposition of the Cretaceous sediments. The eastern margin of the Garbutt shales lies against the Bovie Lake Fault Zone and does not extend eastward. The Garbutt succession thickens westward away from the zone (Figs. 18, 20), suggestive of subsidence during deposition and movement on the fault. The main Scatter delta was controlled by the fault zone, with only a relatively thin succession of sandstone, largely equivalent to the upper member, extending eastward beyond its trace. The whole upper Fort St. John Group appears to be controlled to some extent, thinning eastward beyond the fault.

In the region between Fort St. John and Sikanni Chief River, an elevated land area somewhat comparable to the eastern up-thrown side of the Bovie Lake structure is encountered. Evidence of pre-Cretaceous faults is meagre. A zone of faults, sub-parallel to the present escarpments formed by Sikanni Formation between Halfway and Muskwa Rivers, is shown in a recent series of structural maps released in 1975 by the British Columbia Department of Mines and Petroleum Resources. The faults, having a northwesterly trend, intersect the Bovie Fault Zone north of Kledo Creek. Presumably these thrust faults are of Laramide origin and therefore are much younger than the Fort St. John Group. However, they may mark an older zone of weakness or hinge line that affected deposition of the Lower Cretaceous sediments. The postulated hinge line coincides, more or less, with the eastern margin of the Gething sediments which lie beneath the Fort St. John Group (see Stott, 1973).

The eastern margin of the Gething Formation lies along a positive or high area which occurred as an island lying between the Gething and McMurray Troughs (Stott, 1973). Infilling by Gething and McMurray sediments resulted in the island being inundated by the following transgression and covered by the basal deposits of the Fort St. John Group. Unlike the deposits in the Bovie Fault region, where the oldest Fort St. John shales do not extend eastward, the lower shales in the region of Sikanni Chief River extend with relatively uniform thickness across the whole region (Fig. 14). This relationship suggests that the western edge of the island was stable throughout Early and Middle Albian time. However, that boundary approximates the facies change from Sikanni sandstone to shale in an eastward direction. If such a relationship does exist, and some type of hinge was present, then movement occurred in Late Albian time.

Cretaceous tectonic activity

The Fort St. John Group in the Rocky Mountain Foothills records a period of recurrent pulses of mountain building in the Cordillera region to the west. These pulses are part of the mid-Columbian Orogeny (Wheeler, 1966; Wheeler et al., 1972). Uplift associated with the preceding pulse of the orogeny resulted in the deposition of the widespread, coarse clastic Bullhead Group that underlies the Fort St. John Group (Stott, 1973). Renewed subsidence within the Liard-Alberta Trough and along the Interior Platform during Early Albian time permitted the gradual expansion of the boreal marine invasion that extended toward Peace River and eventually joined in the latest Middle Albian time with the northward expanding invasion from the Gulf of Mexico (Stelck et al., 1956, p. 6, 9; Stelck, 1958, p. 3, 6; Jeletzky, 1971a, p. 45).

Evidence within the Lower Cretaceous succession suggests that uplifts and possible deformation occurred periodically and extended throughout Early Cretaceous time and into Late Cretaceous.

The trends of maximum accumulation of the Gates and Boulder Creek sandstones parallel the major structural trend related to the Peace River Arch. The latter structure was active during much of Albian time, directly influencing the depositional basin by subsidence along its northern flank. During Late Albian and earliest Cenomanian time, the Peace River structure was apparently inactive, exerting little or no influence on sedimentation within the basin.

The development of other major deltas along the western margin of the Lower Cretaceous embayment is similar to the major deltas developed along the Peace River Fault Zone. It seems possible that other fault lineaments may have controlled the position and development of the deltas in the Muskwa-Tetsa region and also at Scatter River. One cannot but be impressed by the coincidence of ancient deltas with the present location of major drainage systems. It seems quite probable that the major drainage systems have existed at least since earliest Cretaceous time in the vicinity of Peace River, Muskwa and Tetsa Rivers, and Liard-Scatter Rivers. The persistence of such long-lived drainage patterns may reflect control by fault lineaments.

Another major depositional trend recognized within the Cretaceous sequence has a north-south to northwesterly-southeasterly component. As demonstrated previously (Stott, 1973) the eastern margin of the Barremian?-to Early Albian Bullhead Embayment was controlled by the edge of a broad low island whose western edge trends northwesterly from about Sikanni Chief River to Muskwa River. The trend is paralleled by the outer limits of the Late Albian Sikanni sandstone. Farther north, the eastern limit of the Early Albian Garbutt shale is controlled by the north-trending Bovie fault which also played an influential role in the deposition of the younger Scatter sandstone and is to some extent reflected in the deposition of the Sikanni sandstone.

Source

The source of Cretaceous sediments has been attributed by many earlier geologists to the area west of the Rocky Mountains (Dawson, 1881, p. 114B; Dowling, 1915; Schuchert, 1923; McLearn, 1932). Later geologists (Price and Mountjoy, 1970) concluded that much of the clastic material was of sedimentary origin and probably derived from the rising western Rocky Mountains. The writer (Stott, 1973, p. 83) considered that the Gething sediments, immediately beneath the Fort St. John Group, were derived from two principal areas, the low-lying island separating the Gething and McMurray-Clearwater Troughs and the western borderland. The central core of the latter was formed by the Omineca Geanticline in the north and the Nelson uplift to the south. Stott stated (1973, p. 83):

> *...The main source of the Gething sediments therefore, appears to have been a dominantly sedimentary terrain lying to the west, consisting mainly of latest Precambrian, Cambrian, and younger Paleozoic rocks uplifted during early and middle phases of the Columbian Orogeny.... In addition, the large island which formed the eastern margin of the Gething trough was probably contributing detritus from older Mesozoic and possibly Paleozoic rocks...*

The configuration of the embayment succeeding Gething deposition was considerably modified as the interior of the continent became inundated. The large island was reduced in size although its northern end was still prominent, marked by the Bovie Lake Fault system. With gradual infilling and greater transgression, the islands disappeared and the embayment extended eastward toward and perhaps lapped onto the Precambrian Shield. The contribution of sediments derived from an eastern source was reduced to a minimum for the western Plains and Foothills region dealt with in this report.

The main source of sediments of the Fort St. John Group north of Peace River was the western borderland. Wheeler (1966, p. 37) pointed out that the Columbia orogeny began in the southern part of the Omineca Geanticline in Late Jurassic time and culminated in mid-Tertiary as a late Laramide episode. It becomes evident that the wedges of Fort St. John coarse clastic sediments, thickening westward, record the periodic movement of the geanticline and the associated development of the early stages of the Rocky Mountain thrust belt.

The basal Cretaceous sandstone at Jackfish Gap, assigned to the Garbutt Formation, contains, according to Braman (1976) and Braman and Hills (1977), a reworked palynoflora. The assemblage includes representatives of Famennian, Strunian, Tournaisian and Viséan age, indicating that the sandstone was derived, at least in part, from sedimentary rocks of Early Devonian to Mississippian age. After the Aptian-Early Albian movement that resulted in the deposition of the Bullhead Group (Stott, 1973), the next major phases of uplift is documented within the Gates Formation and Lower Scatter sandstone (**Arcthoplites** - early Albian time), followed by the Boulder Creek Formation and upper Scatter (**Gastroplites** - Middle Albian time). The Gates sandstone, with its dominant constituents of chert and quartz, with varying quantities of carbonate detritus, rock fragments of schists, slates and sedimentary quartzites, and feldspar appears to be derived from a dominantly sedimentary to metamorphic terrain. The feldspar could be derived either from volcanic, metamorphic or igneous rocks. The decrease in carbonate detritus in the younger Boulder Creek sandstone might be attributable to previous stripping of the main Paleozoic carbonate beds in the source area and erosion of siliceous beds that occur in the Lower Paleozoic succession. Or it may only represent more reworking of the sediments.

The Sikanni Formation (**Neogastroplites** - Late Albian time) records a third pulse. The Sikanni sandstones appear to contain more quartz and less chert than some of the older Cretaceous formations. The Goodrich sandstones, south of Peace River, contain more chert and lithic grains and some detrital carbonate grains. Feldspar is rare within these sandstones, although the fine-grain size and marine environment would not favour its preservation. Nevertheless, the general composition is indicative of a sedimentary to metamorphic terrain source, not greatly different to that of the preceding Middle Albian sandstones. According to Anan-Yorke and Stelck (1978, p. 482), the upper Buckinghorse and lower Sully shales at Sikanni Chief River contain recycled elements from Paleozoic and Lower Mesozoic microflora - a somewhat similar occurrence to that reported by Braman and Hills (1977) from the basal Cretaceous sandstone. Anan-Yorke and Stelck reported Late Devonian miospores, Carboniferous elements, Permo-Triassic pollen and phytoplanktonic species of probable Jurassic age. They considered that the microflora, showing no thermal alteration, was derived from unmetamorphosed sedimentary rocks, and suggested the region of the Mackenzie Mountains as a possible source.

The combined mineralogical and chemical data of the Fort St. John clays were interpreted by Foscolos and Stott (1975) to indicate that the formations studied could be divided into three groups, each with different source characteristics.

The chemistry of the Cruiser, Hasler, Hulcross and Moosebar shales at Peace River was found to differ substantially from that of the Fort St. John sequences farther north. The relationship indicates that the sediments in the region near Peace River were derived from a different source area.

The Gething Formation and the lowermost Buckinghorse Formation at Tetsa River differ from the succession at Peace River and that found on Liard River, and from the overlying shale. That difference may be attributed to erosion of different rocks in a western source area or possibly to a completely different source area. The Gething Formation does not extend far eastward (Stott, 1973) and these basal sediments could have been derived, at least in part, from an eastern, rather than a western source.

The Lepine, Sully, and Sikanni shales of the Scatter-Liard region were probably derived from the same source terrain. Foscolos and Stott concluded (op. cit., p. 24):

> *...Sediments which comprise the shale of middle and upper Buckinghorse Formation at Tetsa River, the Buckinghorse at Muskwa River, Scatter and Garbutt Formation also may have been derived from the same area that supplied the sediments of the Lepine, Sikanni and Sully Formations...*

In summary, the Gething-basal Buckinghorse of the Prophet-Muskwa region may have been derived totally or in part from an eastern source. The Fort St. John shales of the Peace River region were derived from a different source than the sequence between Muskwa and Tetsa River. The development of large deltaic complexes in each of those areas is further confirmation of probably three major drainage systems; one in the vicinity of Pine-Peace Rivers region, one in the Muskwa-Tetsa region, and another in the Liard region.

The Dunvegan Formation, with its high arkose content in the Peace River region (Tater, 1964) indicates that gneiss or granite within the Omineca Geanticline had been unroofed by Late Cenomanian time.

Depositional history

Most of the earlier interpretations of the paleogeography of the Fort St. John seas were made by F.H. McLearn (1932, 1940, 1944a, 1944b; McLearn and Kindle, 1950) who showed remarkable insight into the development of the sedimentary sequence. McLearn suspected that the Gething sediments were marginal to an early phase of the later marine transgression, as was subsequently documented by Stott (1973). McLearn (1932, 1944a; McLearn and Kindle, 1950) recognized that the marine invasions came from the Arctic region, spread across the present site of the Foothills and Plains of northeastern British Columbia, central Alberta, and extended southward to southern Alberta and Saskatchewan.

The outlines of the deltas associated with the deposition of Fort St. John sediments were shown on paleogeographic maps by McLearn in 1932 and later revised in 1944b. The easterly trend of some of the delta fronts, particularly in the Peace River region were commented upon by McLearn and Kindle (1950) who acknowledged the earlier recognition by McLearn (1932, 1944a), Wickenden and Shaw (1943), and Nauss (1945) of north-south replacement of marine by nonmarine strata.

The development of the Cretaceous seaway was outlined in a series of maps by Ziegler (1967, 1969). He recognized the major deltaic lobes of the "Scatter Delta" and "Paddy Delta", showing them as part of a larger deltaic complex which he called the "Bullhead-Blairmore Delta". However, the sediments of the Bullhead and Fort St. John Groups were not shown separately and the paleogeographic map is generalized for all of Aptian-Albian time. A second map showed the major trends of the "Dunvegan Delta" with two major sources, one in the vicinity of Peace River and one in the area of Liard River.

The Cretaceous paleogeography of western and Arctic Canada was discussed by Jeletzky (1971a). He showed the inferred maximum extent of the seas in late Early Albian (**Arcthoplites**) and Late Albian (**Neogastroplites**) and Late Cenomanian time. He did not describe the major Albian deltas and their positions in detail, although he discussed the development of the Cenomanian Dunvegan delta.

The paleogeography of North America was reviewed by Jeletzky (1971a, p. 43) and by Williams and Stelck (1975). They showed that the latest Early Albian (**Subarcthoplites**) sea extended southward to about latitude 50°. Further, they suggested that the embayments from the Arctic and Gulf of Mexico were joined during early Late Albian time, but that in Late Albian (**Neogastroplites**) time, the connection of the Gulf of Mexico was closed.

Barremian-Aptian(?)

The initial phase of the great boreal transgression, that was to spread southward and eventually join with the expanding embayment extending northward from the Gulf of Mexico, occurred during Barremian-Aptian(?) to Early Albian time when the Bullhead Group was deposited (Stott, 1973). That phase was limited to a narrow trough which was separated by a broad, low positive area from the McMurray Trough to the east (Fig. 25). Marine shales associated with this first transgression in the Muskwa-Tetsa region and the southern limit of the embayment is marked by alluvial-deltaic sediments between Peace and Pine River. Subsequently, subsidence throughout the interior basin resulted in marine conditions extending over a much greater area.

The suggestion that the initial transgression began in Barremian-Aptian time is at variance with a recent interpretation by Jeletzky (1971a) who considered that the Aptian seas were apparently narrowly restricted and did not extend into the western interior region of Canada.

Albian

The boreal seaway was well established by Early Albian time (Stelck et al., 1956; Stott, 1968a; Jeletzky, 1971a). Four major transgressive-regressive sequences are recognized in the Fort St. John Group and overlying Dunvegan Formation. Each sequence begins with a thick succession of non-calcareous, concretionary marine shale and ends with a gradation upward into epineritic to deltaic and alluvial deposits. No major hiatus is known within this sequence although minor disconformities may occur at the base of each succeeding transgressive shale. Toward the centre of the basin, the marine Fort St. John shale was deposited with little or no hiatus. The four regressions are reasonably well dated; the first occurred at or near the end of the Early Albian **Arcthoplites** time; the second, during the Middle Albian **Gastroplites** time; the third, near the end of the Late Albian **Neogastroplites** time; and the fourth in late Cenomanian time.

The sediments of the Fort St. John Group represent deposits of a shallow epicontinental sea bordered by relatively low plains. Subsidence in the order of a few tens or few hundreds of feet (metres) resulted in shoreline movements of tens to hundreds of miles (kilometres). The positions of most of the shorelines are not well documented because the western limit of the outcrop belt is formed by the thrusted Paleozoic rocks of the Rocky Mountains and the western margin of the embayment is not preserved. However, general trends are indicated by isopach maps and by major regressive sediments.

In the Peace River region, the Fort St. John strata were deposited along an axis of maximum accumulation that trends northeasterly. A well developed nonmarine facies in that region appears to be controlled by a northeast trending hinge line that is more or less parallel to the axis of the ancient Peace River Arch. Farther north, shoreline sandstones along the western margin of the embayment are recognized near Muskwa and Tetsa Rivers. At Liard River, the site of the maximum accumulation of Fort St. John sediments, the shoreline trends appear to be northerly to northwesterly and a major deltaic lobe is centred in the vicinity of Scatter River.

The first transgression, which began in the earliest Albian time of **Pachygrycia** and continued through the later early Albian time of **Arcthoplites** spp. and which is recorded in the Moosebar, Buckinghorse and Garbutt Formations, extended southward beyond Athabasca River at least as far as Cadomin (Mellon and Wall, 1961; Mellon et al., 1963). Deposition of these lower Fort St. John shales occurred in water which ranged from normal marine salinity to somewhat more brackish, as indicated by the microfauna. This facies of alternating siltstone, mudstone, and clay shale is similar to that of delta-front deposits and apparently formed in fairly shallow water. Pyritic, flaky to fissile, non-concretionary shales represent deposition in an environment farther from shore. Those black shales with much organic material reflect reducing conditions below the surface of deposition. The reappearance of sideritic mudstone marks the beginning of the regressive phase.

The transgressive shale grades vertically and laterally southward beyond Peace River into nearshore, deltaic and floodplain sediments included in the Gates Formation. As subsidence within the basin was exceeded by sedimentation, the shoreline prograded basinward; the widespread sandstone of the basal Gates was deposited in the Peace River region (Fig. 26). In that area, the axis of maximum sedimentation and the hinge line controlling the lateral facies change were along the northeasterly trending Peace River Arch. In the Muskwa-Tetsa region, only a slight indication of the regressive phase is found in argillaceous to sandy siltstone. Farther north in the vicinity of Liard River, glauconitic sandstone of the Scatter Formation is part of another major delta whose history parallels that of the Gates. Unlike the Gates sequence, which includes alluvial-deltaic sediments, only marine sandstone is present in the Scatter and sediments of the alluvial-deltaic environment apparently are not preserved in that region.

The several lobes of sandstone, included in the Scatter, middle Buckinghorse or Muskwa-Tetsa region, Gates and Boulder Creek Commotion Formations of Peace River region are suggestive of coalescing fans, spreading eastward to form a low-lying deltaic plain along the western margin of the embayment.

The second transgression occurred within the time of generalized **Gastroplites** and it appears to have been more restricted than the previous one. The embayment did not extend as far southwesterly as the Moosebar sea; its southwestern margin lies near Belcourt Creek south of Pine River. This transgression was of short duration compared with the earlier one and the thickness of shale deposited is significantly less. The shale grades vertically and laterally into well-sorted marine sandstone included in the basal Boulder Creek Formation of the Pine River region. That sandstone is strikingly similar to the Cardium sandstone, interpreted as part of a barrier bar sequence (Stott, 1967c), and it seems likely that the Boulder Creek sandstone formed in a similar environment. Overlying beds, including a thick conglomerate and carbonaceous unit represent fluvial to deltaic conditions. The presence of an old coastal swamp or delta-front, related to the Boulder Creek succession in the region between Peace and Pine Rivers, was recognized by McLearn and Kindle (1950). Maximum accumulation and the facies trends parallel the ancient Peace River Arch. The upper sandstone wedge of the Boulder Creek Formation disappears at Peace River and northward beyond there the sequence is represented by a continuous succession of marine shale included in the Buckinghorse Formation, although some sandstone appears at Muskwa River (Fig. 27). Farther north in the vicinity of Liard River, the upper cycle, formed by the middle Scatter shale and upper Scatter sandstone, is part of a major deltaic wedge that occurs along a main shoreline that appears to have a north to northwesterly component.

The third major transgression, inundation and regression lasted from the Middle Albian time of **Gastroplites allani** to almost the end of **Neogastroplites** time. In the District of Mackenzie, the invasion is recorded in the upper Buckinghorse (Stott, 1960b), in the Liard region in the Lepine Formation; and in the Sikanni Chief region in the middle Buckinghorse, and in the Peace River region, in the Hasler Formation. These sediments consist predominantly of rubbly

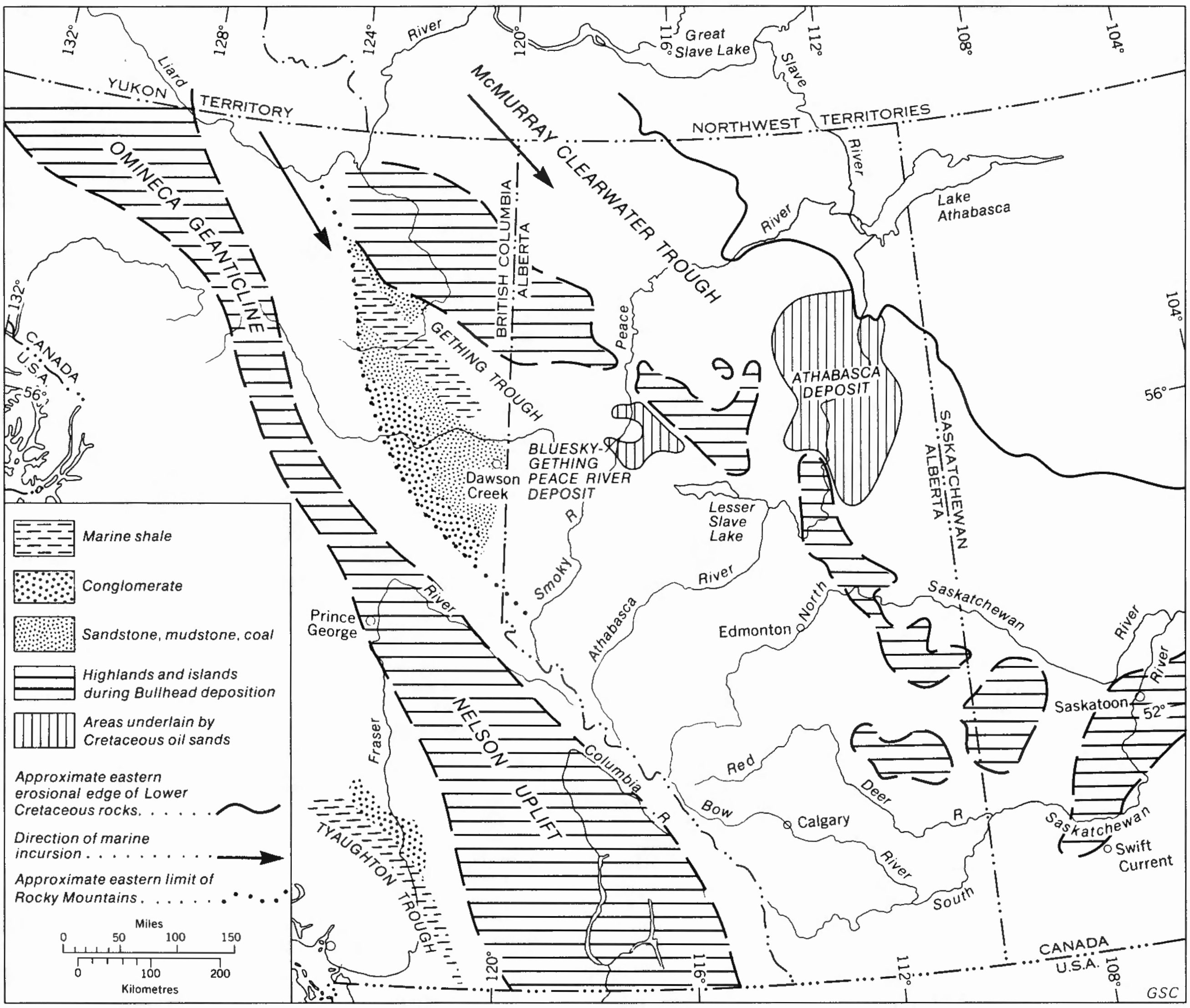


***FIGURE 25.** Paleogeographic map of Bullhead Group (Late Neocomian-Early Albian). Modified after Rudkin, 1964.*

to blocky, silty mudstone with sideritic concretions. The base of these transgressive deposits, perhaps slightly older at Scatter River than at Peace River becomes markedly diachronous farther south, lying within the **Neogastroplites** Zone at Smoky River, only slightly below the "Fish Scale" marker or Lower Cretaceous-Upper Cretaceous boundary at North Saskatchewan River and being as young as Turonian in the Crowsnest Pass area of southwestern Alberta.

A inundative facies of fissile, non-concretionary shale occurs about 300 feet (91.4 m) above the base of the Lepine Formation at Scatter River and in the Muskwa-Tetsa region but this deeper water facies does not appear to occur in the Peace River region. An extremely thick succession of sideritic mudstone, marking the initiation of regression, developed in the Scatter-Liard region. Its thickness is almost double that found at Peace River, indicating a major depocentre in the north.

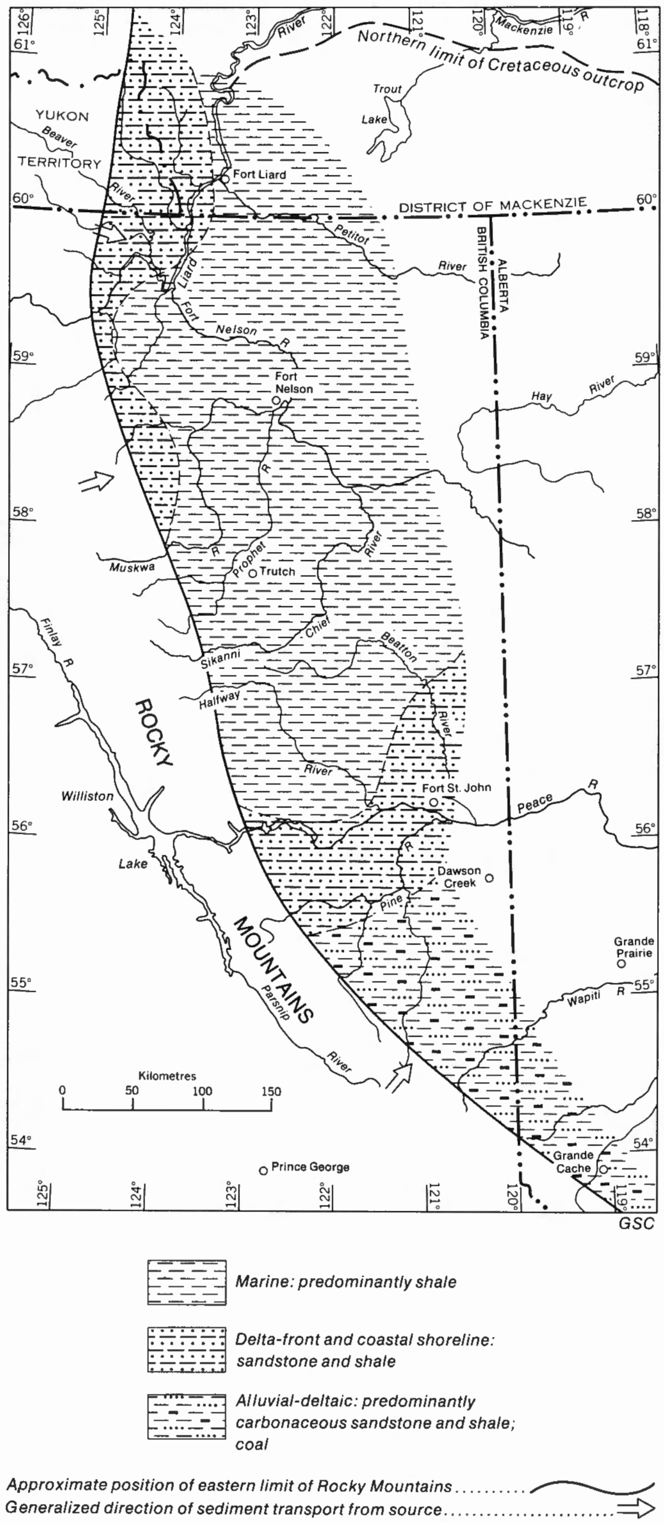


FIGURE 26. *Paleogeographic map of Gates-Bulwell sandstone (Early to Middle Albian).*

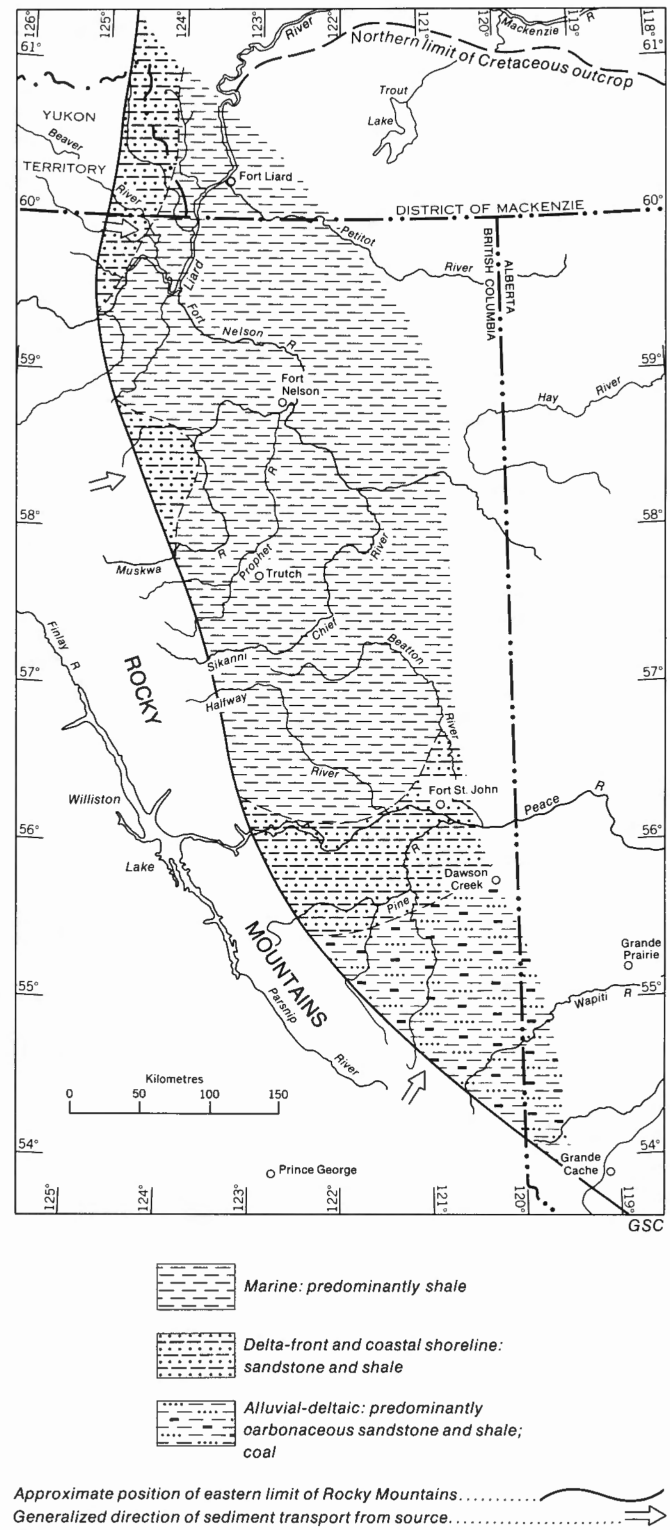


FIGURE 27. *Paleogeographic map of Boulder Creek-Tussock sandstones (Middle Albian).*

The regressive, sideritic facies grades upward into epineritic Goodrich and Sikanni sandstones (Fig. 28). These sandstones represent nearshore to delta-front deposits formed during Late Albian (**Neogastroplites**) time. The northwesterly trend of these coastal sandstones contrasts markedly with the northeasterly trend of the earlier nearshore sediments in the vicinity of Peace River. This change in basin margin configuration reflects a change in the tectonic pattern. The general parallelism of the deposits with present structural trends of the Rocky Mountains suggests that movements related to the later Laramide Orogeny were already affecting the region. The sandstones grade rapidly eastward into shale, and only a silty facies extends much beyond the Alaska Highway between Dawson Creek and Fort Nelson. As a result, the beds between the Boulder Creek and Dunvegan Formations in the Peace River region merge into a continuous shale sequence included in the Shaftesbury Formation (Fig. 8; McLearn and Henderson, 1944).

It was during this time that the boreal embayment spread southward and became linked with the embayment extending from the Gulf of Mexico (Reeside, 1957, p. 516-518; Stelck et al., 1956; Stelck, 1958; Jeletzky, 1971a).

The last transgression of Early Cretaceous time is recorded in Cruiser and Sully shale which grade transitionally upward into Cenomanian (earliest Late Cretaceous) alluvial and deltaic conglomeratic sandstone of the Dunvegan Formation (Fig. 29). The rusty-weathering sideritic shales and siltstone of the Cruiser, Shaftesbury, and Sully Formations were deposited under nearshore mildly oxidizing marine conditions in a shallow epicontinental sea. The uniform thin bedding and repeated alternations of silt and shale are typical of the environment from wavebase downward.

In the type region of the Sully Formation, at Scatter River and also at Sikanni Chief River, the middle part of the succession consists of pyritic, fissile, soft shale. These indicate an open marine, reducing environment in which the alkalinity of normal sea water was maintained. These sediments were deposited in the deeper part of the basin, below the zone of wave action.

As the basin filled and the depositional surface again lay within a slightly oxidizing environment, conditions favouring the precipitation of siderite once again developed. As the shoreline associated with the development of the Dunvegan deltaic plain prograded basinward, silt and sand became more abundant within the mudstone and thin beds of siltstone and sandstone developed, forming a gradational sequence with the succeeding massive sandstone of the Dunvegan Formation. The deltaic and fluvial environments finally advanced well into the middle of the basin bringing to an end the deposition of marine sediments in the present Foothills region of northeastern British Columbia.

Cenomanian

The coarse clastic sediments of the Dunvegan Formation in the Foothills and Plains indicate tectonism along the Omineca Geanticline before the time of the late Cenomanian **Dunveganoceras** Zone. Cycles comprising massive conglomerate, coarse grained sandstone, carbonaceous mudstone, and coal are indicative of major alluvial-deltaic conditions that covered the region north of Sikanni Chief River. In most of the northern region, the upper surface of the Dunvegan lies immediately below Pleistocene glacial deposits and some of the uppermost beds probably have been removed by erosion. In the Peace River Plains and farther south in the Smoky River region, the formation contains mainly marine sandstone and shales of the prodeltaic facies. Apparently, the Dunvegan beds of northeastern British Columbia lie at the northwestern margin of a marine embayment centred in the western interior.

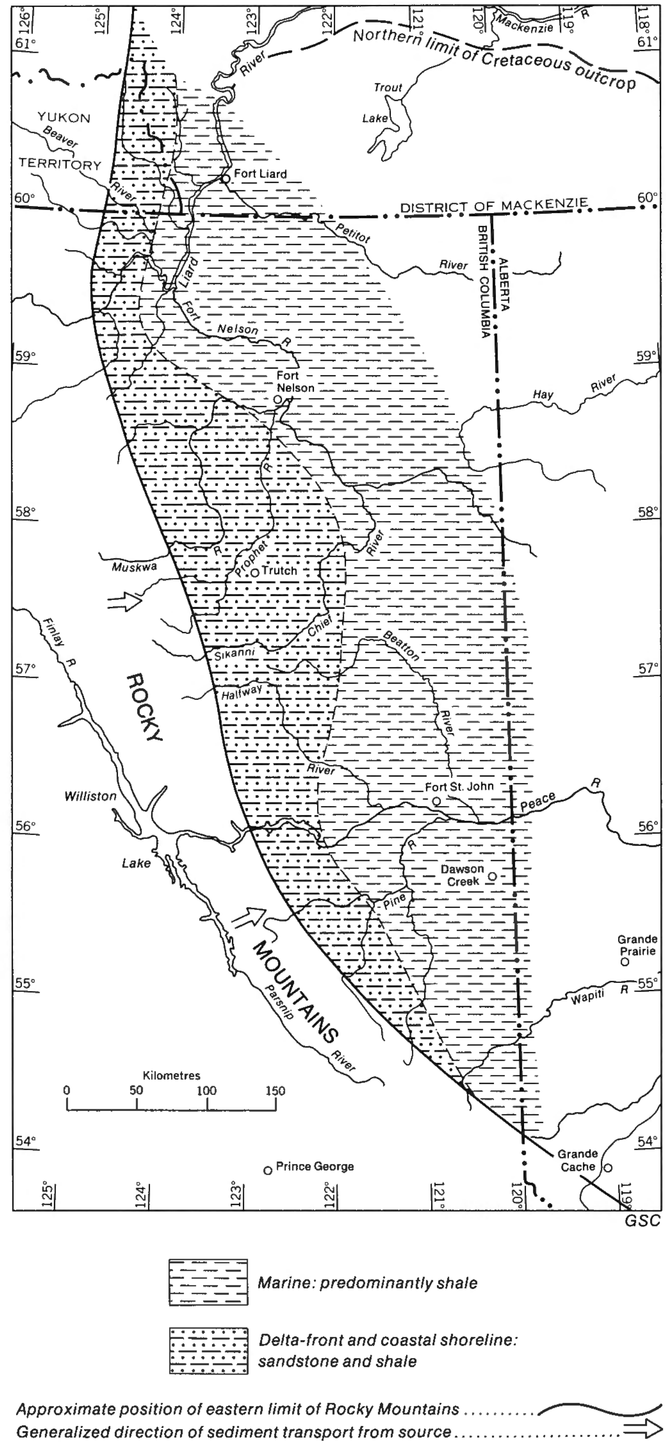


FIGURE 28. *Paleogeographic map of Goodrich-Sikanni Formations (Late Albian).*

The major alluvial-deltaic Dunvegan succession of northeastern British Columbia extends eastward into Alberta (Fig. 29). The relationship of marine beds (Trevor Formation) to the north of the Liard region with the marine Cenomanian succession in the Foothills south of Peace River is not fully understood. If a marine connection did exist, it must have been along some eastern seaway lying in the region of the presently exposed Precambrian Shield. The Dunvegan is present in the upper slopes of the Caribou Mountains and along the northern margin of the Birch Mountains, near the eastern limit of Cretaceous exposures bordering the Precambrian Shield (Green et al., 1970). According to the descriptive notes that accompany the map:

> *...Exposures are generally poor and discontinuous, consisting mainly of friable, pale grey, fine-grained, feldspathic sandstone with scattered hard calcareous beds, laminated carbonaceous siltstone and dark grey silty shale. Although fossil remains are scarce, the beds appear to be of deltaic origin. The unit thins from 500 feet in the southwest to less than 200 feet in the Caribou and Birch Mountains, grading laterally into marine shale of the La Biche Formation in the southeast part of the map-area...*

Jeletzky (1971b, p. 48) showed a rather narrow marine connection through northern Alberta. However, the occurrence of deltaic Dunvegan sediments in that region suggests that such a connection must have been still farther east. The Dunvegan delta was built into a broad embayment, centred to the south (Williams and Burk, 1964), which was dominated by the influence of the major invasion from the Gulf of Mexico.

Summary

The Fort St. John Group records four major regressions that are related to tectonic movement, mainly along the Omineca Geanticline. The main pulses of deformation coincide with the major regressive deposits. The first occurred in Early to Middle Albian (**Arcthoplites**) time, and was followed by a second in Middle Albian (**Gastroplites**) time. The third pulse is recorded in Late Albian (**Neogastroplites**) and the final one, which terminated the Fort St. John episode, occurred in the Late Cretaceous Cenomanian stage.

ECONOMIC GEOLOGY

Coal geology

The coal deposits of northeastern British Columbia, occurring mainly within the Gething Formation of the Bullhead Group and the Gates Formation of Fort St. John Group, were outlined in previous reports (Stott, 1968a, 1973, 1974). In the region between Smoky and Wapiti Rivers, the major deposits occur within the Gates Formation. No significant coal seams are known in Fort St. John Group north of Peace River. Although coal is present in the Dunvegan Formation throughout the region, the potential for major coal deposits does not appear to be great.

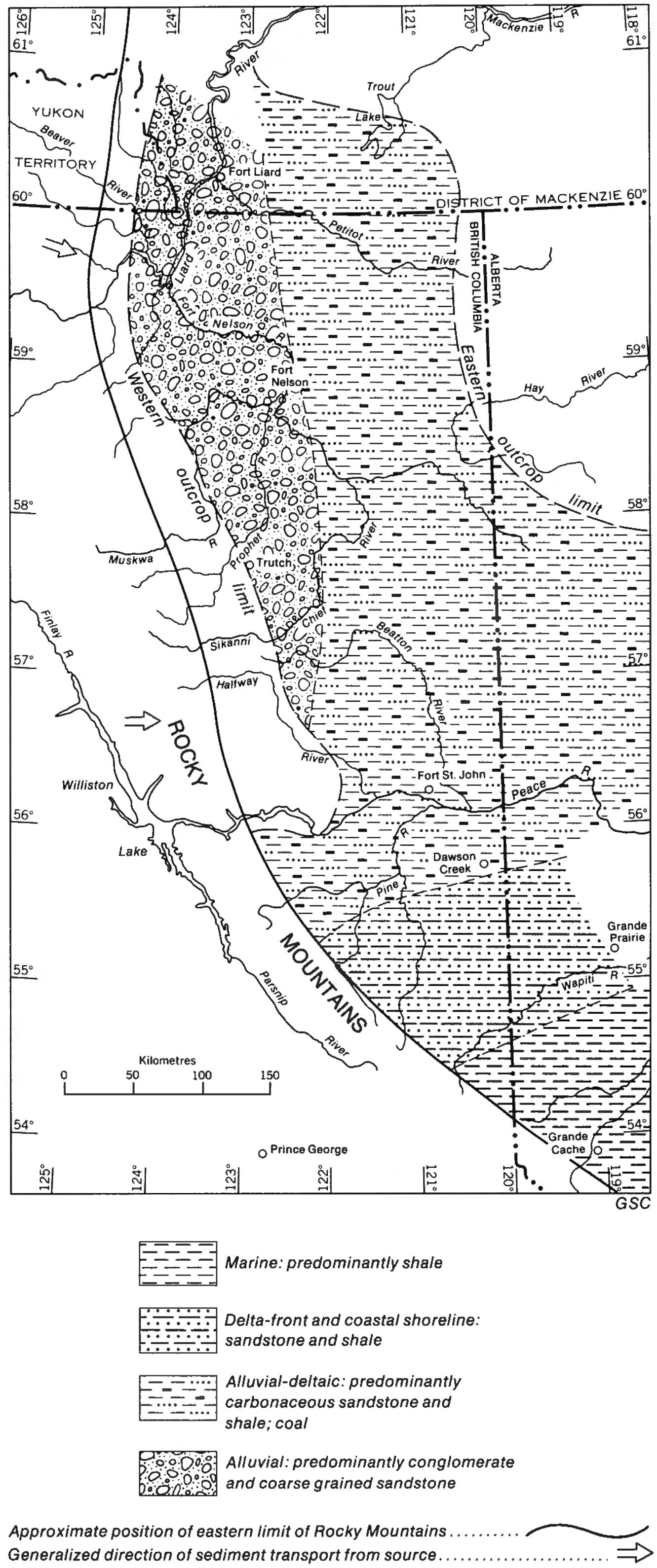


FIGURE 29. Paleogeographic map of Dunvegan Formation (Cenomanian).

Fort St. John Group

Coal resources of northeastern British Columbia (including both Gething and Gates Formations) were reported by B.A. Latour[1] (pers. comm., July, 1979) in the following categories:

	Megatons	Short Tons (millions)
Measured	996	1098
Indicated	462	510
Inferred	7719	8509

The total inferred resource of 7719 megatons is the same as that reported in a recent review of coal resources in northeastern British Columbia by a Resource Sub-Committee on Northeast Development, Ministry of Mines and Petroleum Resources, British Columbia. In its report, entitled the Northeast Coal Study (1977), the Sub-Committee indicated that the Gates Formation alone contains an estimated 5350 megatons of metallurgical coal. The coal has superior coking quality, is low in ash and sulphur content, and has high fluidity.

The Northeast Coal Study briefly summarizes the geology, exploration activity, reserves and resources, and mineability of coal deposits of various parts of the region. From south to north, the coal deposits of the Gates Formation are outlined for the areas of Saxon Creek, Monkman-Belcourt, Belcourt, Quintette, and Mount Spieker, with thick coal seams reported from many parts of the region. At Saxon Creek, five seams have a total thickness of 59 feet (18 m). In the vicinity of Mount Belcourt, the Gates contains three seams over 5 feet (1.5 m), and totalling 46 feet (14 m) of coal, whereas north of Wapiti River, there are six seams over 5 feet (1.5 m), having a total of 59 feet (18 m) of coal. Between Ptarmigan Mountain and Little Prairie Creek east of Mount Belcourt, the Gates is reported to contain 151 feet (46 m) of coal in eleven seams with one seam having a thickness of 33 feet (10 m). In the Quintette-Babcock area, six seams are of mineable thickness, with three seams being in excess of 10 feet (3 m) thick. Aggregate thickness is in the order of 39 to 59 feet (12-18 m). A recent press statement suggests that the Quintette property, covering 100 000 acres (40 000 hectares) has "an estimated 2.8 billion tons (2.5 billion tonnes) of potentially mineable metallurgical coal in places". At Mount Spieker south of Bullhead Mountain, four distinct seams, having individual thicknesses of as much as 16 feet (5.1 m), have an aggregate thickness of 39 feet (12 m).

To date, exploration for coal within the Fort St. John Group has centred on the Gates Formation. Four main zones that appear relatively extensive were recognized in the region between Kakwa River and Bullmoose Mountain (Stott, 1974). Although more recent data has been provided by the British Columbia Ministry, regional correlations are still not well documented, and detailed correlations of coal seams regionally have not been published.

The lower zone includes the coal that occurs above the basal fine-grained sandstone of the Gates between Smoky River and Mount Belcourt (Fig. 30). This zone occupies the interval that lies between 300 and 400 feet (91-122 m) above the base of the Moosebar Formation. It includes No. 3 and No. 4 seams at Grande Cache which have maximum thicknesses in the order of 13 and 36 feet (3.9-10.9 m) respectively. Major seams are recognizable in the Kakwa River region, in the vicinity of Horn Ridge, at Saxon Ridge and at Mount Belcourt. The main sandstone underlying this zone apparently disappears beyond Wapiti River, grading laterally into Moosebar shale. The coal sequence apparently grades into a sandstone which in turn forms the base of the Gates Member from Monkman Pass to Wolverine River.

The second coal zone, occupying the interval between 500 to 600 feet (152-183 m) above the base of the Moosebar shale, is extensively developed between Kinuseo Creek and Quintette Mountain, including the areas of Five Cabins and Babcock Creeks (Fig. 30). The number of seams within this zone varies considerably, with as many as eight or more coals within an interval of 75 feet (22.8 m). The occurrence of these coals bears a great similarity to the lower zone, because they lie above a thick unit of fine grained sandstone that is considered to mark the base of the Gates Member. However, the sandstone of the Quintette-Babcock region appears to be stratigraphically higher than the basal sandstone of the Smoky-Kakwa region. The coals of the second zone appear to grade laterally northward into sandstone and conglomerate in the Wolverine region.

A third zone of coal occurs in the interval between 800 and 1000 feet (244-305 m) above the base of the Moosebar, and is best developed in the Quintette-Babcock area (Fig. 30). Thicknesses of the main seam are in the order of 10 feet (3.0 m) or less. The zone appears to extend as far or farther north than the second zone and may correlate with a zone in a somewhat similar stratigraphic position in the Wolverine area north of Murray River. The zone disappears northward at Bullmoose Mountain, being replaced there by thick sandstone and conglomerate. To the south in the Kakwa River region, a major seam occurs at about the same stratigraphic postion.

A fourth zone of coal occurs near the top of the Gates in the vicinity of Babcock Creek and Quintette Mountain and also at Bullmoose Mountain (Fig. 30). Rapid facies changes occur in the Gates on Bullhead Mountain with mudstone and carbonaceous sediments occurring at some localities and more massive sandstone and conglomerate becoming dominant at others.

Although the upper part of the Boulder Creek Member contains a relatively thick carbonaceous unit and some coal, no major seams were noted nor have any been reported[1].

The similar relationships of the main coal zones from one region to another are a striking feature of the deposits. Each zone overlies a sandy sequence, but it is evident that different sandstone units are involved from one local area to another (Fig. 30). The relationships suggest that environments favourable for the development of coal existed on the lower deltaic plain landward of marine sandstone, and that as a result of progradation, coal swamps advanced basinward, covering the older marine sediments. Possibly pods of coal, relatively thick and perhaps of considerable extent, developed on the upper deltaic plain and that type of accumulation would be represented most likely in the upper Gates in the more southerly region.

The northern limit of major coal deposition within the Gates Member is closely related to the Peace River Arch. That structure acted as a hinge line, where shoreline sandstone developed along the southern or southwestern margin of the boreal embayment. The alluvial-deltaic environments in which coal formed lay landward to the south and southwest.

Dunvegan Formation

Thick coal seams have not been recognized in the Dunvegan Formation. To the south in the Smoky River region, the formation comprises mainly marine sandstone and shale of the prodeltaic and delta-front facies in which coal

[1] Recent exploration indicates substantial coal deposits in the Boulder Creek Formation near Hasler Creek.

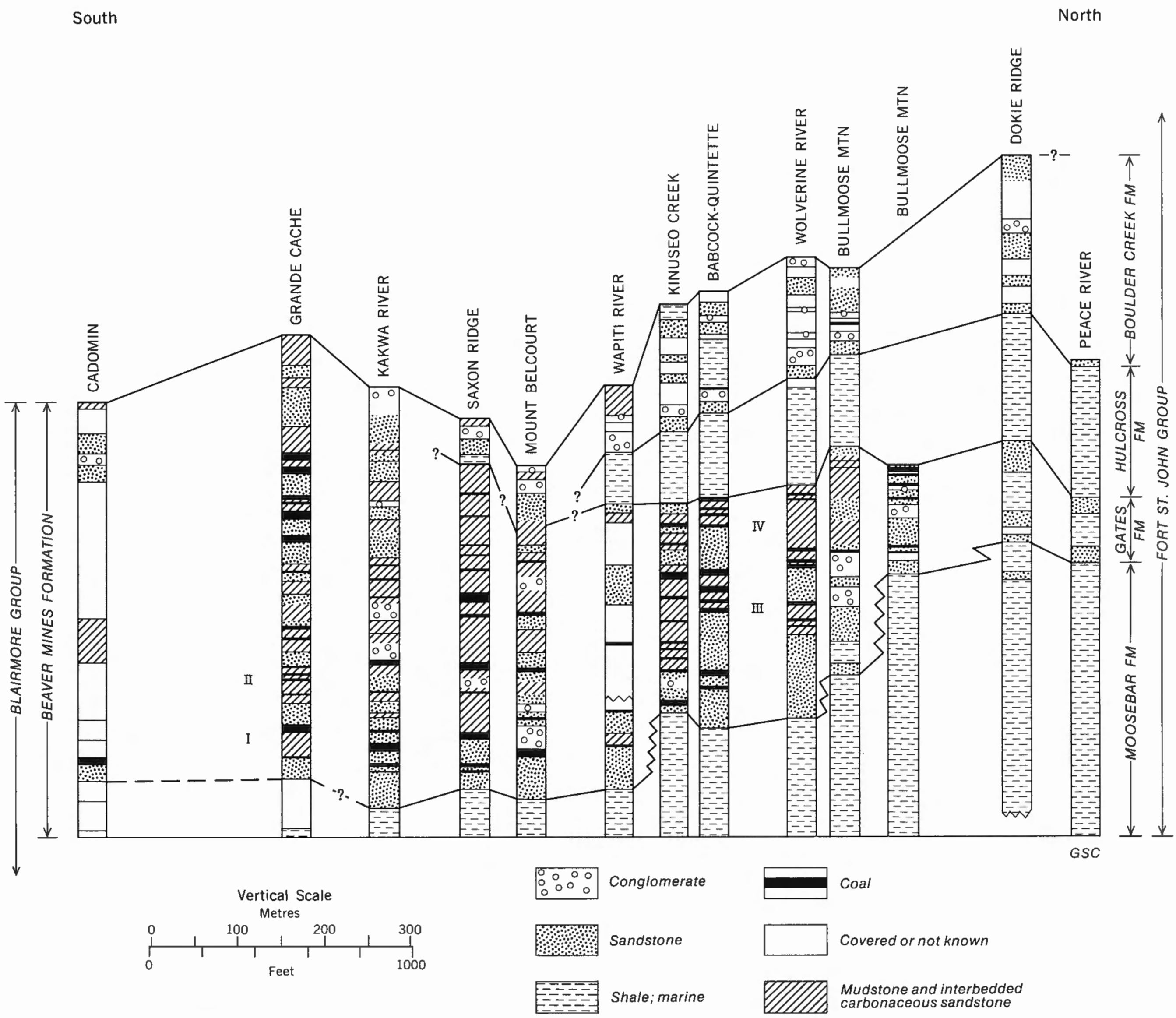


FIGURE 30. *Schematic diagram showing coal seam distribution between Cadomin and Peace River.*

does not commonly occur. The region between Murray and Pine Rivers presumably contains sediments of the lower deltaic plain which is most favourable for coal development. From Prophet River northward, most of the Dunvegan sediments were deposited in the upper deltaic or alluvial plain environment where conditions probably did not favour the development of thick coal deposits. A thin coal seam occurs above the basal sandstone in the Scatter-Liard region.

Petroleum and natural gas

Cretaceous rocks of British Columbia are currently of great interest although in the past they contained a minor portion of the proven oil and gas reserves of the province. Cretaceous sediments of the Fort St. John Group, with only minimal recoverable crude oil, until recently were considered to contain only a very small percentage of the known marketable gas.

The Fort St. John Group, comprising a thick succession of marine and deltaic clastic sediments, would normally be considered favourable for both source and reservoir rocks. Many of the sand bodies are enclosed by shales, thereby forming stratigraphic traps. In addition, the succession is deformed along the Foothills where structural traps might exist. However, despite these favourable factors, no major accumulation of petroleum or natural gas had been discovered by drilling prior to 1975. Many wells have been drilled in the Plains region of northeastern British Columbia and adjacent Alberta, penetrating the Cretaceous succession before obtaining production from Triassic, Mississippian, and Devonian strata.

Reservoirs have been known for many years in sandstones at several different stratigraphic positions within the Fort St. John Group. Three older fields in Alberta and 14 fields in British Columbia obtain production of natural gas from the Bluesky Formation, a sandstone unit at the base of the Fort St. John Group in the Peace River Plains. In past years, production was obtained from the Notikewin (Gates) sandstone at the Gordondale field in Alberta, and from the Peace River Formation (Boulder Creek equivalent) at two fields - Sunrise and Dawson Creek in British Columbia, and five fields in Alberta, Pouce Coupé, Pouce Coupé South, Braeburn, Gordondale, and Heart River.

Recent discoveries of natural gas in the Alberta Syncline of Alberta and British Columbia suggest that significant gas accumulations may exist in that region. According to published reports (Masters, 1979), tests have flowed gas from the Dunvegan, Paddy, Cadotte, and Falher sands as well as other Cretaceous and Triassic Formations. The main Cretaceous reservoir in the Elmworth-Wapiti area of northwestern Alberta is the Falher Member of the Spirit River Formation, equivalent to much of the Gates Formation of the Foothills. Conglomerates and underlying sandstones are the prime target within the Falher.

The Falher sandstones until recently, have been considered to be of relatively poor reservoir quality, similar to other Cretaceous sandstones with porosities in the order of ten per cent and permeabilities in the order of 0.5 millidarcies. Much of the current production at Elmworth is from conglomerates having good reservoir quality. Fair to good porosity and permeability is present in the conglomerate beds, with permeabililities that range from 50 millidarcies to several darcies (Masters, 1979, p. 161).

One company, Canadian Hunter, drilled 36 wells in northwestern Alberta in 1976 and 1977, of which 30 were successfully completed. Flow rates range up to 15 cf/d, and averaged 4 mmcf per day (Master, 1979, p. 178). Since then, many more successful gas wells have been drilled in Alberta and more recently in British Columbia.

Much of the gas is apparently stratigraphically trapped by decreased porosity, with the trap occurring at a gas-water interface and with water occurring up-dip. The sandstones in the deeper part of the basin are less porous and permeable than those on the Alberta Shelf to the east, owing to increased cementation, greater amount of clay matrix and compaction. Other traps may be pinch-outs of major sandstone or conglomerate units. The older fields in the Pouce Coupé area, to the north of Elmworth-Wapiti are located on anticlines.

The potential natural gas resources of the region have been estimated by Masters (1979) to be very large, but whether these indicated gas accumulations in northwestern Alberta and northeastern British Columbia can be produced economically remains to be demonstrated. Unlike the gas at Elmworth, much of which is recoverable using conventional techniques, most of the gas in the region apparently is trapped in sandstone having very low porosity and permeability. Production from such sandstone requires costly recovery methods such as hydraulic fracturing.

All of the producing fields are located in the vicinity of the Peace River Arch where the Gates and Boulder Creek and equivalent Notikewin and Cadotte sandstones are well developed. Although these well sorted sandstones are widely distributed, siliceous cementation has reduced their porosity and permeability. Porosity decreases in a westward direction and appears to be a major factor in controlling development of suitable reservoirs. The northernmost limit of potential production from these sandstones occurs along a northeasterly trend between Peace and Sikanni Chief Rivers where the sandstones grade laterally into shale (Figs. 10, 11).

The Goodrich and Sikanni sandstones are siltier and finer grained than the producing sandstone and have very low porosity and permeability. These sandstones do not extend far eastward, grading laterally into shales (Figs. 8, 14, 15). Further, these rocks, in general, are exposed at the surface for great distances, thereby allowing any accumulations of oil or natural gas to have escaped. Although these rocks are widely distributed and do have some potential, they are unlikely to be productive.

The Scatter sandstone has considerable potential as a reservoir rock but it has been breached throughout much of the more favourable area. The sandstone is best developed from Garbutt Creek northward to Fantasque Lake and west of the Bovie Lake Fault. In the immediate vicinity of the fault, the Scatter succession is extremely silty and porosity is low.

The shales of the Fort St. John Group must be considered as potential source rocks for petroleum and natural gas. Indeed, they may have contributed to the tremendous accumulation of hydrocarbons now present in the Athabasca oil sands and heavy oils of eastern Alberta.

The diagenetic studies of clays by Foscolos (Foscolos and Stott, 1975) and other studies of extractive hydrocarbons and of vitrinite reflectance (Foscolos et al., 1976) all point to a diagenetic stage of some of the Fort St. John shales in which hydrocarbons could be generated.

The diagenesis of the Fort St. John shales was outlined by Foscolos and Stott (1975, p. 22-24) and Foscolos and Kodama (1974). The stage of diagenesis was determined from the crystallinity index, sharpness ratio, per cent 2M illite polymorphs, per cent illite in the illite - 2:1 expandable random mixed layers, presence or absence of discrete expandable silicates and regular inter-stratified layer silicates with diagenetic stages. Three stages of diagenesis were recognized - early, middle and late. Based on this scheme, the lowermost shales of the Buckinghorse Formation at Tetsa River are classified as being in the late stages of diagenesis. The remainder of the Buckinghorse in the Muskwa Tetsa region is assigned to the intermediate middle stage of diagenesis. The same stage of diagenesis was found in shales of the Moosebar, Commotion, Hasler and Cruiser Formations of the Peace River region. The shales of the Lepine, Sikanni and Sully Formations of the Liard region are allocated to the early middle stage of diagenesis.

The diageneses of the shales have a direct bearing on the generation and migration of hydrocarbons. Studies by Tissot et al. (1971) and Tissot et al. (1974) have shown that when a sediment is heated to 60°C, its organic components form petroleum products at the expense of hydrogen. During early stages of diagenesis, hydrocarbons may be generated; as the process of transformation continues, and under suitable conditions of temperature and pressure, primary oil migration may occur (Colombo, 1967; Andreev et al., 1968; Kartsev et al., 1971; and Yerofeyev, 1972; Deroo et al., 1977; Foscolos and Powell, in press).

In current studies, Foscolos, Powell and Gunther (1976) indicate that the Sully-Lepine sequence lies within the early stages of mesodiagenesis. They consider that "hydrocarbon generation commences in early mesodiagenesis by thermal cracking of hydrocarbons from kerogen and resins". Their study suggests that the peak of hydrocarbon generation has not been reached in the Sully-Lepine sediments. In contrast, the Buckinghorse Formation in the region of Tetsa-Muskwa region lies within the late mesodiagenesis to telodiagenesis zones where cracking of the liquid hydrocarbons formed during early mesodiagenesis occurs. In the study of clay minerals (Foscolos and Stott, 1975), the shales of the Fort St. John Group at Peace River, the Buckinghorse Formation in the Tetsa-Muskwa region, and the Garbutt shales are considered to fall within the more advanced stages of diagenesis, indicating hydrocarbons could have been generated. The Fort St. John shales, having undergone various stages of diagenesis, and being organic rich, were a likely source of major volumes of hydrocarbons.

REFERENCES

Aitken, J.D., Cook, D.G. and Yorath, C.J.
in press: Upper Ramparts River (106G) and Sans Sault (106H) map-areas, District of Mackenzie; Geological Survey of Canada, Memoir 388.

Alberta Society of Petroleum Geologists
1954: Lexicon of Geologic Names in Alberta and adjacent portions of British Columbia and Northwest Territories.

Alberta Study Group
1954: Lower Cretaceous of the Peace River Region; in Western Canada Sedimentary Basin, Rutherford Memorial Volume, Clark, L.M., ed.; American Association of Petroleum Geologists, Tulsa, Oklahoma, p. 268-278.

Allan, J.A. and Stelck, C.R.
1940: Subsurface formations of the Pouce Coupé River District, Alberta; Royal Society of Canada, Transactions, 3rd ser., v. 34, sec. 4, p. 15-20.

Allen, J.R.L.
1965a: Late Quaternary Niger delta, and adjacent areas: Sedimentary environments and lithofacies; American Association of Petroleum Geologists, Bulletin, v. 49, no. 5, p. 547-600.

1965b: A review of the origin and characteristics of recent alluvial sediments; Sedimentology, v. 5, no. 1, p. 89-191.

1970: Physical processes of sedimentation. An Introduction; London, G. Allen & Unwin, 248 p.

Anan-Yorke, Rowland and Stelck, C.R.
1978: Microfloras from Upper Albian **Neogastroplites** Zone, Sikanni Chief River, northeastern British Columbia; in Western and Arctic Canadian Biostratigraphy, Stelck, C.R. and Chatterton, B.D.E., eds.; Geological Association of Canada, Special Paper 18, p. 473-493 (1979).

Andreev, P.V., Bogomolov, A.I., Dobyanskü, A.F. and Kantsev, A.A.
1968: Transformation of Petroleum in Nature; Oxford, Pergamon Press, 466 p.

Badgley, P.C.
1952: Notes on the subsurface stratigraphy and oil and gas geology of the Lower Cretaceous Series in central Alberta; Geological Survey of Canada, Paper 52-11, 12 p.

Beach, H.H. and Spivak, J.
1944: Dunlevy-Portage Mountain map-area, British Columbia; Geological Survey of Canada, Paper 44-19, 13 p.

Bell, W.A.
1956: Lower Cretaceous floras of western Canada; Geological Survey of Canada, Memoir 285, 331 p.

1963: Upper Cretaceous floras of the Dunvegan, Bad Heart, and Milk River Formations of western Canada; Geological Survey of Canada, Bulletin 94, 76 p.

Belyea, H.R.
1964: Upper Devonian: in Geological History of Western Canada; Chapter 6, Part II; McCrossan, R.G. and Glaister, R.P., eds.; Alberta Society of Petroleum Geologists, Calgary, p. 66-88.

1971: Middle Devonian tectonic history of the Tathlina uplift, southern District of Mackenzie and northern Alberta, Canada; Geological Survey of Canada, Paper 70-14, 38 p.

Bjerkli, K. and Oestmo-Saeter, J.S.
1973: Formation of glauconite in foraminiferal shells on the continental shelf off Norway; Marine Geology, v. 14, p. 169-178.

Bernard, H.A., LeBlanc, R.J. and Major, C.F.
1962: Recent and Pleistocene geology of southeast Texas, Field excursion no. 3, in Geology of the Gulf Coast and central Texas and guidebook of excursions, Geological Society of America, 1962 Annual Meeting; Houston, Texas, Houston Geological Society, p. 175-224.

Bostock, H.S.
1946: Physiography of the Canadian Cordillera, with special reference to the area north of the fifty-fifth parallel; Geological Survey of Canada, Memoir 247, 106 p.

1970: Physiographic subdivisions of Canada; in Geology and Economic Minerals of Canada, Chapter I; Douglas, R.J.W., ed.; Geological Survey of Canada, Economic Geology Report no. 1, p. 10-30.

Braman, D.R.
1976: Palynology and paleoecology of the Mattson Formation, northwest Canada; unpublished M.Sc. thesis, Department of Geology, University of Calgary.

Braman, D.R., and Hills, L.V.
1977: Source of Lower Cretaceous sandstone, Jackfish Gap, N.W.T.; Bulletin of Canadian Petroleum Geology, v. 25, no. 3, p. 631-634.

Burk, C.F., Jr.
1962: Upper Cretaceous structural development of the southern flank of the Peace River Arch; Journal of the Alberta Society of Petroleum Geologists, v. 10, no. 5, p. 223-227.

1963: Structure, isopach and facies maps of Upper Cretaceous marine successions, west-central Alberta and adjacent British Columbia; Geological Survey of Canada, Paper 62-31, 10 p.

Burst, J.F.
1969: Diagenesis of Gulf Coast clayey sediments and its possible relation to petroleum migration; American Association of Petroleum Geologists, Bulletin, v. 53, no. 1, p. 73-93.

Burwash, R.A., Baadsgaard, H., Peterman, Z.E. and Hunt, G.H.
1964: Precambrian; in Geological History of Western Canada, Chapter 2; McCrossan, R.G. and Glaister, R.P., eds.; Alberta Society of Petroleum Geologists, p. 14-19.

Caldwell, W.G.E., North, B.R., Stelck, C.R. and Wall, J.H.
1978: A foraminiferal zonal scheme for the Cretaceous System in the Interior Plains of Canada; in Western and Arctic Canadian Biostratigraphy; Stelck, C.R. and Chatterton, B.D.E., eds.; Geological Association of Canada, Special Paper 18, p. 495-575 [1979].

Camsell, C. and Malcolm, W.
1921: The Mackenzie River Basin (rev. ed.); Geological Survey of Canada, Memoir 108, 151 p.

Chamney, T.P.
1964a: Albian foraminifera of the Peel River area, District of Mackenzie; Geological Survey of Canada, Paper 64-2, p. 5.

1964b: Foraminiferal evidence for the Moosebar Formation equivalent in the central Foothills and Rocky Mountains; Summary of Activities; Office and Laboratory, 1963; Compiled by Peter Harker; Geological Survey of Canada, Paper 64-2, p. 5-6.

1967: Preliminary report on some significant species of Albian Foraminifera from western Canada; in Report of Activities; Geological Survey of Canada, Paper 67-1, pt. B, p. 64-66.

1973a: Microfauna of Gething Formation; in Lower Cretaceous Bullhead Group between Bullmoose Mountain and Tetsa River, Rocky Mountain Foothills, northeastern British Columbia; Geological Survey of Canada, Bulletin 219, p. 67-71.

1973b: Micropaleontological correlation of the boreal Lower Cretaceous; in The Boreal Lower Cretaceous; Casey, R. and Rawson, P.F., eds.; Geological Journal, Special Issue No. 5, p. 19-40.

1978: Albian Foraminifera of the Yukon; Geological Survey of Canada, Bulletin 253, 62 p.

Cobban, W.A., Erdman, C.E., Lemke, R.W. and Maughan, E.K.
1976: Type sections and stratigraphy of the members of the Blackleaf and Marias River Formations (Cretaceous) of the Sweetgrass Arch, Montana; U.S. Geological Survey, Professional Paper 974, 65 p.

Coleman, J.M.
1969: Brahmaputra River: Channel processes and sedimentation; Sedimentary Geology, v. 3, p. 129-239.

Coleman, J.M. and Gagliano, S.M.
1964: Cyclic sedimentation in the Mississippi River Deltaic Plain; Gulf Coast Association of Geological Societies, Transactions, v. XIV, p. 67-80.

1965: Sedimentary structures; Mississippi River deltaic plain: in Primary sedimentary structures and their hydrodynamic interpretation; Middleton, G.V., ed.; Society of Economic Paleontologists and Minerologists, Special Publication 12, p. 133-148.

Colombo, V.
1967: Origin and evolution of petroleum; in Fundamental aspects of Petroleum Geochemistry; Nagy, G. and Colombo, V., eds.; p. 321-336, Elsevier, New York, 388 p.

Crickmay, C.H.
1944: Preliminary map, Pouce-Coupé-Peace River, Alberta and British Columbia; Geological Survey of Canada, Paper 44-31.

Dawson, G.M.
1881: Report on an exploration from Port Simpson on the Pacific Coast, to Edmonton, on the Saskatchewan, embracing a portion of the northern part of British Columbia and the Peace River country; Geological and National History Survey of Canada, Report of Progress 1879-80, pt. B, p. 1-177.

de Mille, G.
1958: Pre-Mississippian history of the Peace River Arch; Alberta Society of Petroleum Geologists, Journal, v. 6, no. 3, p. 61-68.

Deroo, G., Powell, T.G., Tissot, B., McCrossan, R.G. and Hacquebard, P.A.
1977: Origin and migration of petroleum in the Western Canadian Sedimentary Basin, Alberta; a geochemical and thermal maturation study; Geological Survey of Canada, Bulletin 262, 136 p.

Doeglas, D.J.
1962: The structure of sedimentary deposits of braided rivers; Sedimentology 1, p. 167-190.

Douglas, R.J.W.
1959: Great Slave and Trout River map-areas, Northwest Territories; Geological Survey of Canada, Paper 58-11, 57 p.

1974: Trout River, District of Mackenzie; Geological Survey of Canada, Map 1371A.

1976a: Fort Liard, District of Mackenzie; Geological Survey of Canada, Map 1379A.

1976b: La Biche River, District of Mackenzie (sic.); Geological Survey of Canada, Map 1380A.

Douglas, R.J.W., Gabrielse, H., Wheeler, J.O., Stott, D.F. and Belyea, H.R.
1970: Geology of western Canada; in Geology and Economic Minerals of Canada; Douglas, R.J.W., ed.; Geological Survey of Canada, Economic Geology Report No. 1, Chapter VIII, p. 367-488.

Douglas, R.J.W. and Norris, D.K.
1959: Fort Liard and La Biche map-areas, Northwest Territories and Yukon; Geological Survey of Canada, Paper 59-6, 23 p.

Dowling, D.B.
1915: The Cretaceous Sea in Alberta; Royal Society of Canada, Transactions, 3rd ser., v. 9, sec. 4, p. 27-42.

Fisher, W.L., Brown, L.R., Scott, A.J. and McGowen, J.H.
1969: Delta systems in the exploration for oil and gas; University of Texas Bureau of Economic Geology, 78 p.

Fisk, H.N., McFarlan, E., Jr., Kolb, C.R. and Wilbert, L.J., Jr.
1954: Sedimentary framework of the modern Mississippi delta; Journal of Sedimentary Petrology, v. 24, no. 2, p. 76-99.

Folinsbee, R.E., Baadsgaard, N. and Cummings, G.L.
1963: Dating of volcanic ash beds (bentonites) by the K-Ar method; Nuclear Geophysics, National Academy of Sciences - National Research Council, Publication 1075, p. 70-82.

Foscolos, A.E. and Kodama, H.
1974: Diagenesis of clay minerals from Lower Cretaceous shales of northeastern British Columbia; Clays and Clay Minerals, v. 22, p. 319-335.

Foscolos, A.E. and Powell, T.G.
in press: Mineralogical and geochemical transformation of clays during catagenesis and their relation to oil generation; in Society of Petroleum Geologists 50th Anniversary Volume, Facts and Principles of World Oil Occurrence; Miall, A.D., ed.

Foscolos, A.E., Powell, T.G. and Gunther, P.R.
1976: The use of clay minerals and inorganic and organic geochemical indicators for evaluating the degree of diagenesis and oil generating potential of shales; Geochimica et Cosmochimica Acta, v. 40, p. 953-966.

Foscolos, A.E. and Stott, D.F.
1975: Degree of diagenesis, stratigraphic correlations and potential sediment sources of Lower Cretaceous shale of northeastern British Columbia; Geological Survey of Canada, Bulletin 250, 46 p.

Glaister, P.
1959: Lower Cretaceous of southern Alberta and adjoining areas; American Association of Petroleum Geologists, Bulletin, v. 43, no. 3, p. 590-640.

Gleddie, Joseph
1954: Upper Cretaceous in western Peace River Plains, Alberta; in Western Canada Sedimentary Basin, Symposium; Clark, L.M., ed.; American Association of Petroleum Geologists, p. 486-509.

Gould, H.R.
1970: The Mississippi delta complex; in Deltaic sedimentation modern and ancient; Morgan, J.P., ed.; Society of Economic Paleontologists and Mineralogists, Special Publication, v. 15, p. 3-47.

Green, R., Mellon, G.B. and Carrigy, M.A.
1970: Bedrock geology of northern Alberta; west and east halfs (2 sheets); Research Council of Alberta.

Greiner, H.R.
1955: Two Lakes, Alberta; Geological Survey of Canada, Paper 55-14, 9 p.

Hage, C.O.
1944: Geology adjacent to the Alaska Highway between Fort St. John and Fort Nelson, British Columbia; Geological Survey of Canada, Paper 44-30, 22 p.

1945: Geological reconnaissance along lower Liard River, British Columbia, Yukon and Northwest Territories; Geological Survey of Canada, Paper 45-22, 33 p.

Henderson, W.R.S.
1954: Cretaceous and some Triassic beds of northeastern Bristish Columbia, Canada; American Association of Petroleum Geologists, Bulletin, v. 38, no. 11, p. 2269-2289.

Holland, S.S.
1964: Landforms of British Columbia, a physiographic outline; British Columbia Department of Mines and Petroleum Resources, Bulletin 48, 138 p.

Howard, J.D. and Reineck, H.E.
1972: Georgia coastal region, Sapelo Island, U.S.A.; Sedimentology and biology, VIII Conclusions; Senckenbergiana Maritima, v. 4, p. 217-222.

Hubert, J.F., Butera, J.G. and River, R.F.
1972: Sedimentology of Upper Cretaceous Cody-Parkman Delta, Southwestern Powder River Basin, Wyoming; Geological Society of America, Bulletin, v. 83, no. 6, p. 1649-1670.

Hughes, J.E.
1967: Geology of the Pine Valley, Mount Wabi to Solitude Mountain, northeastern British Columbia; British Columbia Department of Mines and Petroleum Resources, Bulletin 52, 137 p.

Hume, G.S.
1923: Geology of the Norman Oil Fields and a reconnaissance of a part of Liard River; Geological Survey of Canada, Summary Report 1922, pt. B, p. 47-64.

1954: The lower Mackenzie River area, Northwest Territories and Yukon; Geological Survey of Canada, Memoir 273, 118 p.

Irish, E.J.W.
1954: Copton Creek map-area, Alberta; Geological Survey of Canada, Paper 52-7, 30 p.

1955a: Copton Creek, Alberta, Geological Survey of Canada, Map 1041A.

1955b: Adam's Lookout (west half), Alberta; Geological Survey of Canada, Paper 54-19, map with marginal notes.

1958: Charlie Lake, British Columbia; Geological Survey of Canada, Map 17-1958.

1961: Halfway River, British Columbia; Geological Survey of Canada, Map 37-1961.

1963: Halfway River, British Columbia; Geological Survey of Canada; Map 22-1963.

1965: Geology of the Rocky Mountain Foothills, Alberta; Geological Survey of Canada, Memoir 334, 241 p.

1970: Halfway River, British Columbia; Geological Survey of Canada, Paper 69-11, 154 p.

Jeletzky, J.A.
1964: Illustrations of Canadian Fossils, Lower Cretaceous marine index fossils of western and Arctic Canada; Geological Survey of Canada, Paper 64-11, 101 p.

Jeletzky, J.A. (cont'd)
1968: Macrofossil zones of the marine Cretaceous of the Western Interior of Canada and their correlation with the zones and stages of Europe and the Western Interior of the United States; Geological Survey of Canada, Paper 67-72, 66 p.

1971a: Marine Cretaceous biotic provinces and paleogeography of western and arctic Canada; Illustrated by a detailed study of ammonites; Geological Survey of Canada, Paper 70-22, 92 p.

1971b: Marine Cretaceous biotic provinces of Western and Arctic Canada; Proceedings of the North American Paleontological Convention, September, 1969, pt. L, p. 1638-1659, Allen Press, Inc., Kansas.

1980: New or formerly poorly known, biochronologically and paleo-biogeographically important gastroplitinid and cleoniceratinid (Ammonitida) taxa from middle Albian rocks of mid-western and Arctic Canada; Geological Survey of Canada, Paper 79-22, 63 p.

Jones, J.F.
1968: Geology and groundwater resources, of the Peace River District, Northwestern Alberta; Alberta Research Council, Bulletin 16, 143 p.

Kartsev, A.A., Vassoevich, N.B., Geodekian, A.A., Neruchev, S.G. and Sokolov, V.A.
1971: The principal stage in the formation of petroleum; Proceedings of the 8th World Petroleum Congress (preprint) Panel Discussion No. 1, p. 1-17, Elsevier, New York.

Kindle, E.D.
1944: Geological reconnaissance along Fort Nelson, Liard and Beaver Rivers, northeastern British Columbia and southeastern Yukon; Geological Survey of Canada, Paper 44-16, 19 p.

Kubler, B.
1966: La Cristallinité d'illite et les zones tout à fait supérieure du métamorphisme; in Colloque sur les étages tectoniques à la Baconnière; Neuchatel, p. 105-122.

Lang, A.H.
1961: A preliminary study of Canadian metallogenic provinces; Geological Survey of Canada, Paper 60-33, 54 p.

Lavoie, D.H.
1958: The Peace River Arch during Mississippian and Permo-Pennsylvanian time; Alberta Society of Petroleum Geologists, Journal, v. 6, no. 3, p. 69-74.

Loranger, D.M.
1951: Useful Blairmore microfossil zone in central and southern Alberta, Canada; American Association of Petroleum Geologists, Bulletin, v. 35, p. 2348-2367. Reprinted 1954, in Western Canada Sedimentary Basin, Rutherford Memorial Volume; Clark, L.M., ed.; American Association of Petroleum Geologists, p. 279-296.

Masters, J.A.
1979: Deep Basin Gas Trap, Western Canada; Bulletin American Association of Petroleum Geologists, v. 63, No. 2, p. 152-181.

McAuley, G., Penner, D.G., Procter, R.M. and Tisdall, W.H.
1964: Carboniferous; Chapter 7; Geological History of Western Canada; Alberta Society of Petroleum Geologists, Calgary, p. 89-102.

McConnell, R.G.
1890: Report on an Exploration in the Yukon and Mackenzie Basins; Geological Survey of Canada, Annual Report 1888-89, v. IV, pt. D, 163 p.

1893: On a portion of the District of Athabaska comprising the country between Peace River and Athabaska River; Geological Survey of Canada, Annual Report 1890-91, v. 5, pt. D, 67 p.

McLearn, F.H.
1918: Peace River section, Alberta; Geological Survey of Canada, Summary Report 1917, pt. C, p. 14-21.

1919a: New species of pelecypods from the Cretaceous of northern Alberta; Geological Survey of Canada, Museum Bulletin 29.

1919b: The Cretaceous of Peace and Athabaska valleys (Alberta); Geological Survey of Canada, Memoir 116, p. 25-33.

1921: Mesozoic of upper Peace River, British Columbia; Geological Survey of Canada, Summary Report 1920, pt B, p. 1-6.

1923: Peace River Canyon coal area, British Columbia; Geological Survey of Canada, Summary Report 1922, pt. B, p. 1-46.

1926: New species from the Coloradoan of Lower Smoky and Lower Peace Rivers, Alberta; Geological Survey of Canada, Bulletin 42, p. 117-126.

1931: The **Gastroplites** and other Lower Cretaceous faunas of the northern Great Plains; Transactions of the Royal Society of Canada, 3rd ser., v. 25, sec. 4, p. 1-8.

1932: Problems of the Lower Cretaceous of the Canadian Interior; Royal Society of Canada, Transactions, 3rd ser., v. 26, sec. 4, p. 157-175.

1933: The Ammonoid Genera **Gastroplites** and **Neogastroplites**; Royal Society of Canada, Transactions, 3rd ser., v. 27, sec. 4, p. 13-26.

1937: The Fossil Zones of the Upper Cretaceous Alberta Shale; Royal Society of Canada, Transactions, 3rd ser. v. XXVII, sec. 14, p. 13-26.

1944a: Revision of the Lower Cretaceous of the Western Interior of Canada; Geological Survey of Canada, Paper 44-17, 2nd ed., 1945, 14 p.

1944b: Revision of the palaeogeography of the Lower Cretaceous of the western interior of Canada; Geological Survey of Canada, Paper 44-32, 11 p.

1944c: The occurrence of starfish in the Lower Cretaceous of the Peace River Valley; Canadian Field Naturalist, v. 58, p. 132-134.

1945: The Upper Cretaceous Dunvegan Formation of northwestern Alberta and northeastern British Columbia; Geological Survey of Canada, Paper 45-27, 5 p.

McLearn, F.H. and Henderson, J.F.
1944: Geology and oil prospects of Lone Mountain area, British Columbia; Geological Survey of Canada, Paper 44-2, p. 5.

McLearn, F.H. and Kindle, E.D.
1950: Geology of northeastern British Columbia; Geological Survey of Canada, Memoir 259, 236 p.

Mathews, W.H.
1946: Geology and Coal Resources of the Carbon Creek - Mount Bickford map-area; British Columbia Department of Mines, Bulletin No. 24, 27 p.

Mellon, G.B.
1967: Stratigraphy and petrology of the Lower Cretaceous Blairmore and Mannville Groups, Alberta Foothills and Plains; Alberta Research Council, Bulletin 21, 270 p.

Mellon, G.B. and Wall, J.H.
1961: Correlation of the Blairmore Group and equivalent strata; Edmonton Geological Society, Quarterly, v. 5, no. 1, p. 1-11. Reprinted 1963, Canadian Petroleum Geologists, Bulletin, v. 11, no. 4, p. 396-409.

1956: Geology of the McMurray Formation, Part I; Foraminifera of the Upper McMurray and basal Clearwater Formation; Research Council of Alberta, Report No. 72, p. 5-29.

Mellon, G.B., Wall, J.H. and Stelck, C.R.
1963: Lower Cretaceous section, Mount Belcourt, northeastern British Columbia; Canadian Petroleum Geologists, Bulletin, v. 11, no. 1, p. 64-72.

Moore, D.G. and Scruton, P.C.
1957: Minor internal structures of some recent unconsolidated sediments; American Association of Petroleum Geologists, Bulletin, v. 41, no. 12, p. 2723-2751.

Morgan, J.P., Coleman, J.M. and Gagliano, S.M.
1968: Mud lumps: Diapiric structures in Mississippi delta sediments; in Diapirism and diapirs, a symposium; Braunstein, J., O'Brien, G.D., eds.; American Association of Petroleum Geologists, Memoir 8, p. 145-161.

Mountjoy, E.W. and Chamney, T.P.
1969: Lower Cretaceous (Albian) of the Yukon: Stratigraphy and foraminiferal subdivisions, Snake and Peel Rivers; Geological Survey of Canada, Paper 68-26, 71 p.

Muller, J.E.
1961: Pine Pass, British Columbia; Geological Survey of Canada, Map 11-1961.

Nauss, A.W.
1945: Cretaceous stratigraphy of Vermilion area, Alberta, Canada; American Association of Petroleum Geologists, Bulletin, v. 29, no. 11, p. 1605-1629.

1947: Cretaceous microfossils of the Vermilion area, Alberta; Journal of Paleontology, v. 21, p. 329-343.

Obradovitch, J.D. and Cobban, W.A.
1975: A time-scale for the Late Cretaceous of the Western Interior of North America; in The Cretaceous System in the Western Interior of North America, W.G.E. Caldwell, ed.; Geological Association of Canada, Special Paper 13, p. 31-54.

Odin, G.S.
1972: Observations on the structure of the glauconite vermicular pellets: A description of the genesis of these granules by neoformation; Sedimentology, v. 19, p. 285-294.

Ogilvie, William
1893: Peace River region; Report of the Department of the Interior, 1892, pt. VII, p.

Ore, H.T.
1965: Characteristics of rapidly aggrading stream; in Sedimentation of Late Cretaceous and Tertiary outcrops; Wyoming Geological Association Guidebook, 19th Field Conference, p. 195-201.

Pelletier, B.R. and Stott, D.F.
1963: Trutch map-area, British Columbia; Geological Survey of Canada, Paper 63-10, 12 p.

Perry, E. and Hower, J.
1972: Late stage dehydration in deeply buried pelitic sediments; American Association of Petroleum Geologists, Bulletin, v. 56, no. 10, p. 2013-2021.

Porrenga, D.H.
1967: Glauconite and chamosite as depth indicators in the marine environment; Marine Geology, v. 5, p. 495-501.

Price, L.C.
1973: Solubility of hydrocarbons and petroleum in water as supplied to primary migration of petroleum; unpublished Ph.D. thesis, University of California, Riverside.

Price, L.L.
1963: Structure Contours on Fish Scales Marker Horizon northeastern British Columbia, and adjoining Alberta and Northwest Territories; Geological Survey of Canada, Map 57-1963.

Price, R.A. and Mountjoy, E.
1970: Geologic structure of the Canadian Rocky Mountains between Bow and Athabasca Rivers - A progress report; Geological Association of Canada, Special Paper No. 6, p. 7-25.

Pugh, D.C.
1975: Cambrian stratigraphy from western Alberta to northeastern British Columbia; Geological Survey of Canada, Paper 74-37, 31 p.

Reeside, J.B., Jr.
1957: Paleoecology of the Cretaceous seas of the western interior; Treatise on Marine Ecology and Paleoecology; Geological Society of America, Memoir 67, p. 505-542.

Reeside, J.B., Jr. and Cobban, W.A.
1960: Studies of the Mowry shale (Cretaceous) and contemporary formations in the United States and Canada; U.S. Geological Survey, Professional Paper 355, 126 p.

Reineck, H.E. and Singh, I.B.
1973: Depositional sedimentary environments with reference to terrigenous clastics; New York, Springer-Verlag, 439 p.

Richards, W.B.
1969: A summary of the geology and exploration history of the "Liard Fold Belt"; Guidebook, Field Conference, Edmonton Geological Society, p. 30-45.

Rudkin, R.A.
1964: Lower Cretaceous; in Geological History of Western Canada; Chapter 11; McCrossan, R.G. and Glaister, R.P., eds.; Alberta Society of Petroleum Geologists, Calgary, Alberta, p. 156-168.

Russell, L.S.
1943: Sexsmith-Bison Lake, preliminary map; Geological Survey of Canada, internal report.

Rutherford, R.L.
1930: Geology and water resources in parts of the Peace River and Grand Prairie Districts, Alberta; Alberta Research Council, Report 21, 68 p.

Schuchert, Charles
1923: Sites and nature of the North American geosynclines; Geological Society of America, Bulletin, v. 34, p. 151-229.

Scruton, P.C.
1955: Sediments of the eastern Mississippi delta, in Finding Ancient Shorelines; Society of Economic Paleontologists and Mineralogists, Special Publication no. 3, p. 21-49.

1960: Delta building and the deltaic sequence; in Recent Sediments, northwest Gulf of Mexico; Shepard, F.P. et al., ed.; American Association of Petroleum Geologists, p. 82-100.

Selwyn, A.R.C.
1877: Report on exploration in British Columbia in 1875; Geological Survey of Canada, Report of Progress 1875-76, p. 28-86.

Shepard, F.P.
1960: Mississippi delta; Marginal Environments, sediments and growth; in Recent sediments; northwest Gulf of Mexico; Tulsa, Oklahoma, American Association of Petroleum Geologists, p. 56-81.

Shepard, F.P. and Moore, D.G.
1955: Sediment zones bordering the barrier islands of central Texas Coast; in Finding Ancient Shorelines; Society of Economic Paleontologists and Mineralogists, Special Publication No. 3, p. 78-96.

Sikabonyi, L.A.
1957: Major Tectonic trends in the Prairie region of Canada; Alberta Society of Petroleum Geologists, Journal, v. 5, no. 2, p. 23-28.

Sikabonyi, L.A. and Rodgers, W.J.
1959: Paleozoic tectonics and sedimentation in the northern half of the west Canadian basin; Alberta Society of Petroleum Geologists, Journal, v. 7, no. 9, p. 193-216.

Singh, C.
1971: Lower Cretaceous microfloras of the Peace River area, northwestern Alberta; Alberta Research Council, Bulletin 28, 542 p.

1976: Stratigraphic significance of early angiosperm pollen in the mid-Cretaceous strata of Alberta; in The Cretaceous System in the Western Interior of North America; Caldwell, W.G.E., ed; Geological Association Canada, Special Paper no. 13, p. 365-388.

Smith, N.D.
1970: The braided stream depositional environment; comparison of the Platte River with some Silurian clastic rocks, north-central Appalachians; Geological Society of America, Bulletin, v. 81, no. 10, p. 2993-3014.

Spieker, E.M.
1921: The geology and oil resources of the Foothills south of Peace River in northeastern British Columbia, in Report of oil surveys in the Peace River district, 1920, by John A. Dresser and Edmund M. Spieker; British Columbia Department of Lands, 21 p.

Stelck, C.R.
1958: Stratigraphic position of the Viking Sand; Alberta Society of Petroleum Geologists, Journal, v. 6, no. 1, p. 2-7.

1962: Upper Cretaceous, Peace River area, British Columbia; Edmonton Geological Society, Fourth Annual Field Trip, Guidebook, p. 10-21.

1975a: Basement control of Cretaceous sand sequences in western Canada; in The Cretaceous System in the Western Interior of North America; Caldwell, W.G.E., ed.; Geological Association of Canada, Special Paper no. 13, p. 427-440.

1975b: The Upper Albian Miliammina manitobensis zone in northeastern British Columbia; in The Cretaceous System in the Western Interior of North America; Caldwell, W.G.E., ed.; Geological Association of Canada, Special Paper no. 13, p. 253-275.

Stelck, C.R. and Wall, J.H.
1955: Foraminifera of the Cenomanian Dunveganoceras zone from Peace River area of western Canada; Alberta Research Council, Report no. 70, p 1-62.

Stelck, C.R., Wall, J.H., Baham, W.G. and Martin, L.J.
1956: Middle Albian Foraminifera from Athabasca and Peace River drainage areas of western Canada; Alberta Research Council, Report no. 75, 60 p.

Stelck, C.R., Wall, J.H. and Wetter, R.E.
1958: Lower Cenomanian Foraminifera from Peace River area, western Canada; Alberta Research Council, Bulletin 2, pt. I, p. 1-35.

Stockwell, C.H., et al.
1970: Geology of the Canadian Shield: in Geology and Economic Minerals of Canada; Douglas, R.J.W., ed.; Geological Survey of Canada, Economic Geology Report, no. 1, Chapter IV, p. 44-226.

Stott, D.F.
1960a: Cretaceous rocks between Smoky and Pine Rivers, Rocky Mountain Foothills, Alberta and British Columbia; Geological Survey of Canada, Paper 60-16, 52 p.

Stott, D.F. (cont'd)
1960b: Cretaceous rocks in the region of Liard and Mackenzie Rivers, Northwest Territories; Geological Survey of Canada, Bulletin 63, 36 p.

1961a: Dawson Creek map-area, British Columbia; Geological Survey of Canada, Paper 61-10, 32 p.

1961b: Type sections of some formations of the Lower Cretaceous Fort St. John Group near Pine River, British Columbia; Geological Survey of Canada, Paper 61-11, 61 p.

1963: Stratigraphy of the Lower Cretaceous Fort St. John Group, Gething and Cadomin Formations, Foothills of northern Alberta and British Columbia; Geological Survey of Canada, Paper 62-39, 48 p.

1967a: The Fernie and Minnes strata north of Peace River, foothills of northeastern British Columbia; Geological Survey of Canada, Paper 67-19A, 58 p.

1967b: Jurassic and Cretaceous stratigraphy between Peace and Tetsa Rivers, northeastern British Columbia; Geological Survey of Canada, Paper 66-7, 73 p.

1967c: The Cretaceous Smoky Group, Rocky Mountain Foothills, Alberta and British Columbia; Geological Survey of Canada, Bulletin 132, 133 p.

1968a: Lower Cretaceous Bullhead and Fort St. John Groups, between Smoky and Peace Rivers, Rocky Mountain Foothills, Alberta and British Columbia; Geological Survey of Canada, Bulletin 152, 279 p.

1968b: Cretaceous stratigraphy between Tetsa and La Biche Rivers, northeastern British Columbia; Geological Survey of Canada, Paper 68-14, 41 p.

1969: The Fernie and Minnes strata north of Peace River, Foothills of northeastern British Columbia; Geological Survey of Canada, Paper 67-19B, 132 p.

1973: Lower Cretaceous Bullhead Group between Bullmoose Mountain and Tetsa River, Rocky Mountain Foothills, Northeastern British Columbia; Geological Survey of Canada, Bulletin 219, 228 p.

1974: Lower Cretaceous Coal Measures of the Foothills of west-central Alberta and northeastern British Columbia; Canadian Mining and Metallurgical Bulletin, v. 67, no. 749, p. 87-101.

1975a: The Cretaceous System in northeastern British Columbia; in The Cretaceous System in the Western Interior of North America; Caldwell, W.G.E., ed.; Geological Association of Canada, Special Paper no. 13, p. 441-467.

1975b: Dawson Creek map-area, British Columbia; Geological Survey of Canada, Open File 286.

1975c: Monkman Pass map-area, British Columbia; Geological Survey of Canada, Open File Report 286.

1975d: Wapiti map-area, Alberta; Geological Survey of Canada, Open File Report 286.

Stott, D.F. (cont'd)
1975e: Pine Pass map-area, British Columbia; Geological Survey of Canada, Open File Report 286.

Sutherland, C.D. and Stelck, C.R.
1972: Foraminifera from the Cretaceous Neogastroplites zone, Moberly Lake, British Columbia; Canadian Petroleum Geologists, Bulletin, v. 20, no. 3, p. 549-582.

Tappan, Helen
1951: Northern Alaska, index Foraminifera; Cushman Foundation for Foraminiferal Research, Contribution, v. 2, pt. 1, p. 1-8.

Tater, J.M.
1964: The Dunvegan Sandstone of the type area; unpublished M.Sc. thesis, University of Alberta, 58 p.

Taylor, G.C. and Stott D.F.
1968a: Maxhamish Lake, British Columbia; Geological Survey of Canada, Paper 68-12, 23 p.

1968b: Fort Nelson, British Columbia, Geological Survey of Canada, Paper 68-13, 23 p.

1973: Tuchodi Lakes, British Columbia, Geological Survey of Canada, Memoir 373, 37 p.

1979: Trutch (96G) and Ware East Half (94F, E½) map-areas, Northeastern British Columbia; Geological Survey of Canada, Open File Report 606.

1980: Toad River map-area, British Columbia (NTS 94W); Geological Survey of Canada, Open File Report 673.

Thompson, R.I.
1977: Geology of Beatton River (94H), Fontas River (94I) and Petitot River (94P) map-areas, northeastern British Columbia; Geological Survey of Canada, Paper 75-11, 8 p.

Thorsteinsson, R.
1952: Grande Cache map-area, Alberta, Geological Survey of Canada, Paper 52-26, 44 p.

Tissot, B., Califet-Delyser, Y., Deroo, G. and Oudin, J.L.
1971: Origin and evolution of hydrocarbons in early Toarcian shales, Paris basin, France; American Association of Petroleum Geologists, Bulletin, v. 55, no. 12, p. 2177-2193.

Tissot, B., Durand, B., Espitalic, J. and Combaz, A.
1974: Influence of nature and diagenesis of organic matter in formation of petroleum; American Association of Petroleum Geologists, Bulletin, v. 58, no. 3, p. 499-506.

van Hees, H.
1964: Cambrian, Part 1 - Plains; in Geological History of western Canada; Chapter 3; McCrossan, R.G. and Glaister, R.P., eds.; Alberta Society of Petroleum Geologists, Calgary, p. 20-28.

Warren, P.S. and Stelck, C.R.
1940: Cenomanian and Turonian faunas in the Pouce Coupé District, Alberta and British Columbia; Royal Society of Canada, Transactions, 3rd. ser., sec. IV, v. XXXIV, p. 143-153.

Warren, P.S. and Stelck, C.R. (cont'd)
1955: New Cenomanian ammonites from Alberta; Alberta Research Council, Report No. 70, Appendix, p. 63-80.

1958a: The Nikanassin-Luscar Hiatus in the Canadian Rockies; Royal Society of Canada, Transactions, 3rd ser. v. 52, sec. 4, p. 55-62.

1958b: Lower Cenomanian Ammonoidea and Pelecypoda from Peace River area, western Canada; Alberta Research Council, Geological Division, Bulletin 2, pt. 2, p. 36-51.

1969: Early **Neogastroplites**, Fort St. John Group, western Canada; Bulletin of Canadian Petroleum Geologists, v. 17, no. 4, p. 529-547.

Weaver, C.E.
1961: Minerals of the Ouachita structural belt and adjacent foreland; in The Ouachita System P.T. Flawn, et al., eds.; University of Texas, Bureau of Economic Geology, Publication 6120, p. 147-162.

Webb, J.B.
1951: Geological history of the plains of western Canada; American Association of Petroleum Geologists, Bulletin, v. 35, no. 11, p. 2291-2315; Reprinted 1954, Western Canada Sedimentary Basin, Rutherford Memorial Volume, American Association of Petroleum Geologists, p. 3-27.

1964: Historical Summary: in The Geological History of Western Canada; Chapter 16; McCrossan, R.G. and Glaister, R.P., eds.; Alberta Society of Petroleum Geologists, Calgary, p. 218-232.

Wheeler, J.O.
1966: Eastern tectonic belt of western Cordillera in British Columbia; in Tectonic History and Mineral deposits of the western Cordillera; Canadian Institute of Mining and Metallurgy, Special Volume 8, p. 24-45.

Wheeler, J.O. et. al.
1972: The Cordilleran Structural Province; in Variations in Tectonic styles in Canada, R.A. Price and R.J.W. Douglas, eds.; Geological Association of Canada, Special Paper 11, p. 1-81.

Whiteaves, J.F.
1885: Description of a new species of ammonite from the Cretaceous rocks of Fort St. John on the Peace River; Royal Society of Canada, Proceedings and Transactions, v. 2, sec. 4, p. 239-240.

1893: Notes on the ammonites of the Cretaceous rocks of the district of Athabaska, with descriptions of four new species; Royal Society of Canada, Proceedings and Transactions, v. 10, sec. 4, p. 111-121.

Wickenden, R.T.D.
1949: Some Cretaceous sections along Athabaska River from the mouth of Calling River to below Grand Rapids, Alberta; Geological Survey of Canada, Paper 49-15, 31 p.

1951: Some Lower Cretaceous sections on Peace River below the mouth of Smoky River, Alberta; Geological Survey of Canada, Paper 51-16, 47 p.

Wickenden, R.T.D. and Shaw, G.
1943: Stratigraphy and structure in Mount Hulcross-Commotion Creek map-area, British Columbia; Geological Survey of Canada, Paper 43-13, 14 p.

Williams, G.D. and Burk, C.F.
1964: Upper Cretaceous: in McCrossan, R.G. and Glaister, R.P., eds.; The Geological History of Western Canada; Chapter 12; Alberta Society of Petroleum Geologists, p. 169-189.

Williams, G.D. and Stelck, C.R.
1974: Speculations on the Cretaceous paleogeography of North America; in The Cretaceous System in the Western Interior of North America; Caldwell, W.G.E., ed.; Geological Association of Canada, Special Paper 13, p. 1-20.

Williams, G.K.
1979: An update of subsurface information, Cretaceous rocks, Trout Lake area, southern Northwest Territories; Scientific and Technical Notes in Current Research, Part A; Geological Survey of Canada, Paper 78-1A, p. 545-553.

Williams, M.Y.
1923: Reconnaissance across northeastern British Columbia and the Geology of northern extension of Franklin Mountains, N.W.T.; Geological Survey of Canada, Summary Report 1922, pt. B, p. 65-66.

1944: Geological investigations along the Alaska Highway from Fort Nelson, British Columbia, to Watson Lake, Yukon; Geological Survey of Canada, Paper 44-28, 33 p.

Williams, M.Y. and Bocock, J.B.
1932: Stratigraphy and palaeontology of the Peace River valley of British Columbia; Royal Society of Canada, Transactions, 3rd ser.; v. 26, sec. 4, p. 197-224.

Williams, P.F. and Rust, B.R.
1969: The sedimentology of a braided river; Journal of Sedimentary Petrology v. 39, p. 649-679.

Wright, L.D. and Coleman, J.M.
1973: Variations in morphology of major river deltas as functions of ocean wave and river discharge regimes; American Association Petroleum Geologists, Bulletin, v. 57, no. 2, p. 370-398.

Yerofeyev, V.F.
1972: Geothermal activity at depth and distribution of deposits of hydrocarbons; International Geology Review, v. 14, p. 49-53.

Young, F.G., Myhr, D.W. and Yorath, C.F.
1977: Geology of the Beaufort-Mackenzie basin; Geological Survey of Canada, Paper 76-11, 65 p.

Ziegler, P.A.
1967: Canadian Cordillera Field Trip; Guidebook, International Symposium on the Devonian System; Alberta Society of Petroleum Geologists, Calgary, Canada, 72 p.

1969: The development of sedimentary basins in western and Arctic Canada; Alberta Society of Petroleum Geologists, 89 p.

APPENDIX

Lithological Sections

Section 58-9. Shaftesbury and Dunvegan formations: on ridge east of Deadhorse Meadows, between Kakwa and Torrens rivers, Alberta, 54°09'N, 119°52'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
	Immediately overlying beds not exposed. Next outcrop downstream is Kaskapau shale.				
	DUNVEGAN FORMATION				
44	Sandstone, with conglomerate lenses	23	(7.0)	544	(165.8)
43	Covered	8	(2.4)	521	(158.8)
42	Sandstone	15	(4.6)	513	(156.4)
41	Covered	45	(13.7)	498	(151.8)
40	Sandstone, fine grained, argillaceous; thick bedded	11	(3.3)	453	(138.1)
39	Mudstone and siltstone	7	(2.1)	442	(134.7)
38	Covered (approximately)	75	(22.8)	435	(132.6)
37	Sandstone, fine to medium grained, grey, laminated; massive at base but thin bedded at top	7	(2.1)	360	(109.7)
36	Mudstone, silty, olive-brown, carbonaceous; very silty at top	3	(0.9)	353	(107.6)
35	Sandstone, fine grained, laminated, silty, argillaceous, grey, brown weathering; medium bedded	8	(2.4)	350	(106.7)
34	Mudstone to siltstone, carbonaceous, blocky	10	(3.0)	342	(104.2)
33	Siltstone, sandy, argillaceous, carbonaceous; beds 6 inches to 1 foot (152 mm-305 m); some mudstone	7	(2.1)	332	(101.2)
32	Covered	45	(13.7)	325	(99.0)
31	Sandstone, medium grained, brownish grey, brown weathering, laminated; thick bedded	4	(1.2)	280	(85.3)
30	Mudstone, silty, grey, brown weathering	5	(1.5)	276	(84.1)
29	Sandstone, medium grained, grey to brown; thick bedded; brown weathering; becomes finer-grained and platy towards top	1	(0.3)	271	(82.6)
28	Mudstone, silty, grey, brown weathering	9	(2.7)	270	(82.3)
27	Sandstone, medium grained, grey to brown; thick bedded; brown weathering; becomes finer-grained and platy towards top	19	(5.8)	261	(79.5)
26	Sandstone, coarse grained, grey thick bedded	6	(1.8)	242	(73.7)
25	Sandstone, fine grained, grey to greenish grey, laminated; massive; becomes coarser grained at base	6	(1.8)	236	(71.9)
24	Mudstone, silty, carbonaceous; some siltstone	6	(1.8)	230	(70.1)
23	Sandstone, fine grained, brownish grey, laminated; crossbedded; carbonaceous	2	(0.6)	224	(68.3)
22	Mudstone, olive-brown to grey, rubbly to blocky; carbonaceous fragments	8	(2.4)	222	(67.7)
21	Sandstone, fine grained, brownish grey laminated, brown weathering; masssive	3	(0.9)	214	(65.2)
20	Mudstone, very silty, olive-brown, rubbly to blocky; some siltstone	12	(3.6)	211	(64.3)
19	Sandstone, fine grained, grey, carbonaceous, laminated; massive	7	(2.1)	199	(60.6)
18	Mudstone, olive-brown, rubbly	9	(2.7)	192	(58.5)
17	Sandstone, silty, brownish grey; thick bedded; very argillaceous at base, upper 3 feet (0.9 m) very silty	10	(3.0)	183	(55.8)
16	Covered	28	(8.5)	173	(52.7)
15	Sandstone, fine grained, laminated brown; thin bedded	3	(0.9)	145	(44.2)
14	Covered	15	(4.6)	142	(43.3)
13	Sandstone, medium grained, laminated, grey to brownish grey, brown-weathering; crossbedded, thick bedded; carbonaceous	7	(2.1)	127	(38.8)
12	Covered	8	(2.4)	120	(36.6)
11	Sandstone, fine grained, laminated, brown, brown weathering; carbonaceous	11	(3.3)	112	(34.1)
10	Covered	5	(1.5)	101	(30.7)
9	Sandstone to siltstone, argillaceous, light brown, laminated; thick bedded	3	(0.9)	96	(29.3)
8	Covered	46	(14.0)	93	(28.3)
7	Sandstone, fine grained, laminated, grey, brown weathering; crossbedded, flaggy; trace of carbonaceous fragments	6	(1.8)	47	(14.3)
6	Sandstone and shale, thinly interbedded; crossbedded, platy, grades into sandstone downslope	5	(1.5)	41	(12.5)
5	Sandstone, fine grained, laminated, platy to flaggy, greenish-brown weathering; crossbedded	3	(0.9)	36	(11.0)
4	Sandstone and shale interbedded; 2 to 8 inches (51-2.3 mm)	15	(4.6)	33	(10.0)
3	Sandstone, fine grained, laminated, brownish grey, brown-weathering; crossbedded; massive appearance	4	(1.2)	18	(5.5)
2	Shale, silty, and sandstone, thinly interbedded	6	(1.8)	14	(4.3)
1	Sandstone, fine grained, grey, platy to flaggy, brown-weathering	8	(2.4)	8	(2.4)
	SHAFTESBURY FORMATION				
39	Shale, dark grey, rusty weathering, platy; some sandstone	14	(4.2)	982	(299.3)
38	Sandstone, 4 to 6 inches (102-152 mm) beds, and shale (25%)	5	(4.6)	968	(295.0)
37	Sandstone and shale, interbedded	10	(3.0)	963	(293.5)
36	Covered. Some shale	100	(30.4)	953	(290.5)
35	Shale, rubbly; large reddish brown concretions	10	(3.0)	853	(260.0)
34	Siltstone and shale interbedded, dark grey; rust to brown weathering; platy	54	(16.4)	843	(256.9)
33	Covered	50	(15.2)	793	(241.7)
32	Shale, platy, as above	10	(3.0)	743	(226.5)
31	Shale, rubbly to flaky, dark grey, rust-weathering; some thin siltstone	65	(19.3)	733	(223.4)
30	Shale, platy, dark grey, rust to brown weathering; siltier at top	37	(11.3)	668	(203.6)
29	Covered	20	(6.1)	631	(192.3)
28	Siltstone and shale, dark grey, brown weathering	21	(6.4)	611	(186.2)
27	Shale, flaky, dark grey	48	(14.6)	590	(182.6)
26	Shale, flaky to platy; siltier in upper part; mostly talus-covered	28	(8.5)	542	(165.2)
25	Covered	15	(4.6)	514	(156.7)
24	Shale, fissile to flaky, dark grey to black, rusty weathering; few siltstone layers. (Small shear at base.)	46	(14.0)	499	(152.1)
23	Shale and siltstone, platy, dark grey, rust to brown weathering; fish scales	19	(5.8)	453	(138.0)
22	Shale, much as above	25	(7.6)	434	(132.3)
21	Shale, rubbly, dark grey to black, rust to brown weathering; 3 inches (76 mm) of siltstone at top; fish scales	43	(13.1)	409	(124.7)
20	Shale, platy, dark grey; few beds of siltstone in upper 5 feet (1.5 m)	40	(12.2)	366	(111.6)
19	Shale, rubbly, dark grey; few concretions; fish scales	10	(3.0)	326	(99.3)
18	Shale, silty, platy, dark grey; reddish brown sideritic concretions; fish scales	20	(6.1)	316	(96.3)
17	Shale, rubbly to blocky, dark grey; sideritic concretions	22	(6.7)	296	(90.2)
16	Shale, silty, platy, dark grey, rusty weathering; platy siltstone increases towards top; few fish scales	20	(6.1)	274	(83.5)
15	Shale, dark grey, rusty, silty; few sideritic concretions	23	(7.0)	254	(77.4)
14	Shale, silty, dark grey. (Small shear at top.)	13	(3.9)	231	(70.4)
13	Shale, flaky to rubbly, dark grey; siltier towards top; sideritic concretions; fish scales	52	(15.8)	218	(66.4)
12	Mudstone, blocky, dark grey, rusty weathering; siltier at top; some concretions; fish scales	25	(7.6)	166	(50.6)
11	Shale, rubbly, dark grey, rusty weathering; 4-inch sandy mudstone at top; rows of reddish-brown weathering sideritic concretions	19	(5.8)	141	(43.0)
10	Shale, flaky to rubbly, dark grey, rust-weathering; 2 inches (51 mm) of gritty siltstone at top	6	(1.8)	122	(37.1)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
9	Shale to mudstone; blocky at base; becoming siltier towards top; few pebbles in upper beds	17	(5.1)	116	(35.3)
8	Siltstone, argillaceous, laminated, and shale silty; few 1/4-inch (6.3 mm) pebbles and coarse sand in siltstone	4	(1.2)	99	(30.2)
7	Shale, rubbly, dark grey, rust weathering; becoming siltier at top; rare sideritic concretions	18	(5.4)	95	(28.9)
6	Shale, silty; minor siltstone beds, rusty-weathering	10	(3.0)	77	(23.5)
5	Shale, silty, dark grey, rusty weathering; platy siltstone	5	(1.5)	67	(20.4)
4	Shale, dark grey, rusty weathering	30	(9.1)	62	(18.9)
3	Covered	22	(6.7)	32	(9.7)
2	Shale, dark grey, rusty weathering, rubbly	4	(1.2)	10	(3.0)
1	Covered. Contact not visible	6	(1.8)	6	(1.8)
	BLAIRMORE GROUP				
3	Conglomerate, pebbles up to 1 inch (25.4 mm)	11	(3.3)	69	20.9
2	Covered (approximately)	50	(15.2)	58	17.6
1	Sandstone, coarse-grained, grey; thick bedded to massive; becomes finer grained towards top	8	(2.4)	8	2.4

Section 61-1. Sikanni Formation, on ridge north of junction of Halfway and Graham Rivers, Halfway River map-area, British Columbia, 56°32'N, 122°19'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Top of ridge, end of exposure.				
	Sikanni Formation				
3	Sandstone, fine grained, grey, laminated; thin bedded to platy; interbedded with shale, silty, and siltstone, carbonaceous, dark grey to brownish grey; weathers brown; grades into underlying unit	30	(9.1)	162	(49.4)
2	Mudstone, very silty, dark grey; blocky; rusty weathering; few concretions; very sandy in upper part	69	(21.0)	132	(40.2)
1	Sandstone, laminated; much as above; massive; weathers flaggy towards base; grades into shale and siltstone	63	(19.2)	63	(19.2)
	Buckinghorse Formation				
	Shale, and siltstone, dark grey				

Section 61-8. Sikanni Formation, north side of Sikanni Chief River, type locality near Alaska Highway, Trutch map-area, British Columbia, 57°14'N, 122°42'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Top of ridge.				
	Sikanni Formation				
	4th Sandstone				
24	Sandstone, fine grained, grey, laminated, crosslaminated; thick bedded; crossbedded; grey to light brown weathering	15	(4.6)	382.5	(116.6)
23	Sandstone, fine grained, laminated, grey; interbedded siltstone and shale; beds 3 to 4 inches (76-102 mm)	6	(1.8)	367.5	(112.0)
22	Sandstone, as below; thick bedded	3	(0.9)	361.5	(110.2)
21	Sandstone, fine grained, laminated, crosslaminated, grey; some crossbedding; shaly layers	8	(2.4)	358.5	(109.2)
	3rd Shale				
20	Sandstone, silty, laminated; interbedded with siltstone and shale	5	(1.5)	350.5	(106.8)
19	Shale, rubbly, dark grey; rusty weathering; few reddish brown weathering concretions	11	(3.3)	345.5	(105.3)
18	Shale, rubbly, dark grey; rusty weathering; becoming siltier and blocky towards top	30	(9.1)	334.5	(101.9)
17	Sandstone and shale interbedded	6	(1.8)	304.5	(92.8)
16	Partly covered. Shale	5	(1.5)	298.5	(91.0)
	3rd Sandstone				
15	Sandstone, silty, argillaceous, laminated, grey; shale, 40%; beds 3 inches to 1 foot (76-305 mm)	14	(4.3)	293.5	(89.4)
	2nd Shale				
14	Shale, rubbly, dark grey; siltier towards top with laminated siltstone	95	(28.9)	279.5	(85.2)
	2nd Sandstone				
13	Sandstone, fine grained, laminated, grey to light brown; massive; light brown weathering	8	(2.4)	184.5	(56.2)
12	Sandstone, as above, thick bedded to massive	17	(5.1)	176.5	(53.8)
11	Shale, silty, dark grey; platy	1	(0.3)	159.5	(48.6)
10	Sandstone, fine grained, laminated, grey; thick bedded; light brown to grey weathering	11	(3.3)	158.5	(48.3)
	1st Shale				
9	Sandstone, fine grained, laminated, silty; interbedded shale	36	(11.0)	147.5	(49.0)
8	Shale, dark grey, rubbly; grading upward into blocky shale and interbedded siltstone and shale	32	(9.7)	111.5	(33.9)
7	Shale, dark grey, rubbly; becoming siltier and blocky at top; some reddish brown weathering sideritic concretions	52	(15.8)	79.5	(24.2)
	1st Sandstone				
6	Sandstone, concretionary; lenses and layers of coarse grained sandstone, greenish grey, containing disseminated pebbles, ¼ to ½ inch (6.3-12.7 mm) chert	0.5	(0.15)	27.5	(8.4)
5	Sandstone, fine grained, laminated; shaly layers	2	(0.6)	27	(8.2)
4	Sandstone, fine grained, laminated, crosslaminated, grey; trough crossbedding; massive; yellowish grey weathering; some sideritic concretions, reddish brown weathering	11	(3.3)	25	(7.6)
3	Sandstone, fine grained, laminated, crosslaminated, massive; yellowish grey weathering; soft and porous	7	(2.1)	14	(4.3)
2	Sandstone, fine grained, laminated, grey, lenticular shale at base; some large scale crossbedding; few concretions	3	(0.9)	7	(2.1)
1	Sandstone, fine grained, laminated, crosslaminated, grey; beds 1 to 2 feet (0.3-0.6 m), somewhat lenticular; yellowish grey weathering.	4	(1.2)	4	(1.2)
	Buckinghorse Formation				
2	Siltstone to sandstone, grey, laminated, crosslaminated; beds 3 to 4 inches (6.3-12.7 mm); grey weathering; interbedded with shale and siltstones; reddish brown weathering concretions; grades into overlying unit	10.5	(3.2)	20	(6.1)
1	Siltstone, sandy, laminated, grey; beds 1 to 2 inches (25.4-50.8 mm); grey weathering; interbedded with shale, dark grey, silty, platy, grey weathering; few small sideritic concretions; grades into overlying unit	9.5	(2.9)	9.5	(2.9)
	End of exposure.				

Section 61-9. Sikanni Formation, roadcut along Alaska Highway, south side of Sikanni Chief River, Trutch map-area, British Columbia, 57°14'N, 122°43'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Sikanni Formation				
	Overlying beds not exposed.				
23	Sandstone, fine grained, laminated, crosslaminated, grey; beds 4 to 6 inches (102-152 mm); shaly layers; few concretions, reddish brown weathering	10	(3.0)	273.5	(83.3)
22	Siltstone and shale interbedded; some 2 to 3 inches (51-76 mm) sandstone beds	21	(0.4)	263.5	(80.2)
21	Sandstone and shale interbedded	2	(0.6)	242.5	(73.9)
20	Shale and siltstone interbedded; platy; banded appearance	5	(1.5)	240.5	(73.3)
19	Sandstone, fine grained, grey, laminated; one foot (0.3 m) of shale in middle	2	(0.6)	235.5	(71.8)
	2nd Shale				
18	Shale to mudstone, dark grey, rubbly; rusty weathering; some concretions, 6 to 8 inches (152-203 mm) reddish brown weathering	21	(6.4)	233.5	(71.1)
17	Mudstone, rubbly to blocky, dark grey; rusty weathering	12	(3.7)	212.5	(64.7)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
16	Shale, dark grey; rubbly; rusty weathering	10	(3.0)	200.5	(61.1)
15	Shale, rubbly to blocky; rusty weathering; few concretions, reddish brown weathering	8	(2.4)	190.5	(58.1)
14	Shale, dark grey; rubbly; rusty weathering; rare concretions	21	(6.4)	182.5	(55.6)
	<u>2nd Sandstone</u>				
13	Sandstone, fine grained, laminated, crosslaminated; massive; brown weathering	4.5	(1.30	161.5	(49.2)
12	Shale, rubbly; rusty weathering; some interbedded sandstone and siltstone; few concretions	4	(1.2)	157	(47.8)
11	Sandstone, fine grained, laminated, crosslaminated, grey; crossbedding; thick bedded to massive at top; light brown weathering; some concretions; pyritic nodules; few pebbles along bedding surfaces in upper one foot (0.3 m)	32	(9.7)	153	(46.6)
	<u>1st Shale</u>				
10	Sandstone, medium bedded; interbedded shale	4	(1.2)	121	(36.9)
9	Sandstone, fine grained, laminated, grey; beds 4 inches to one foot (101-305 mm); yellow grey weathering; interbedded shale in beds 3 to 6 inches (76-152 mm); one foot (0.3 m) of shale at top	15	(4.6)	117	(35.7)
8	Sandstone, fine grained, laminated, crosslaminated, grey; interbedded with silty shale and siltstones; beds 2 to 6 inches (51-152 mm)	6	(1.8)	102	(31.1)
7	Siltstone, sandy, laminated, grey; interbedded with shale, silty, rusty weathering; grades into overlying unit	14	(4.3)	96	(29.3)
6	Shale, silty, blocky; grades upward into blocky shale with 6 inches (152 mm) laminated siltstone at top; rusty weathering; few concretions, reddish brown weathering	12	(3.6)	82	(25.0)
5	Shale, dark grey; rubbly; rusty weathering; banded appearance	10	(3.0)	70	(21.3)
4	Shale, rubbly, dark grey; rusty weathering; grading upward into silty shale, blocky, with concretions	33	(10.0)	60	(18.3)
	<u>1st Sandstone</u>				
3	Sandstone, fine grained, laminated, grey	3	(0.9)	27	(8.2)
2	Mudstone, silty, blocky, dark grey; interbedded with sandstone	3	(0.9)	24	(7.3)
1	Sandstone, fine grained, laminated, crosslaminated, grey; some crossbedding; massive to thick bedded; light brownish grey weathering; some reddish brown weathering concretions	21	(6.4)	21	(6.4)
	Buckinghorse Formation				
9	Siltstone, sandy, laminated; some beds of sandstone and silty shale	6	(1.8)	64	(19.5)
8	Sandstone, fine grained, laminated, grey; brownish grey weathering	1	(0.3)	58	(17.7)
7	Siltstone and shale interbedded	8	(2.4)	57	(17.4)
6	Sandstone, fine grained, laminated, grey; light brown weathering	1	(0.3)	49	(14.9)
5	Siltstone, sandy laminated, grey; interbedded with silty mudstone; beds 2 to 4 inches (51-102 mm)	9	(2.7)	48	(14.6)
4	Siltstone, laminated, grey, argillaceous; interbedded with silty mudstone; banded appearance, few layers of concretions, reddish brown weathering; grades into overlying unit	9	(2.7)	39	(11.9)
3	Siltstone, sandy, laminated, crosslaminated, grey; 2 inches (51 mm) concretionary layer in middle	1	(0.3)	30	(9.1)
2	Shale, rubbly, dark grey; rusty weathering; grading upward into very silty shale with beds of siltstone; some concretions	21	(6.4)	29	(8.9)
1	Shale, rubbly, dark grey; rusty weathering; 2 to 3 inches (51-76 mm) layers of concretionary; pyritic nodules.	8	(2.4)	8	(2.4)

End of exposure.

Section 62-18. Sikanni Formation, roadcut on Alaska Highway, south of settlement of Trutch, Trutch map-area, British Columbia, 57°38'N, 122°58'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Sikanni Formation				
	Overlying beds not exposed.				
15	Mudstone, silty; platy; large sideritic concretions; some platy sandstone in upper part	8	(2.4)	229	(69.8)
14	Sandstone and shale interbedded; beds 2 to 4 inches (50.8-101.6 mm) sandstone, very fine grained, laminated, brown; flaggy to platy; more shale in upper 5 feet (1.5 m)	9	(2.7)	221	(67.4)
13	Sandstone, fine grained, laminated, brown; beds 2 inches to one foot (50.8-304.8 mm) interbedded shale, 40%, rusty weathering	10	(3.0)	212	(64.6)
12	Mudstone, dark grey, rubbly; becoming siltier at top with large sideritic concretions	26	(7.9)	202	(61.6)
11	Mostly covered; shale	10	(3.0)	176	(53.6)
10	Sandstone, fine grained, brown to grey laminated, crosslaminated; thick bedded	42	(12.8)	166	(50.6)
9	Sandstone, fine grained, brown to grey, laminated, crosslaminated; crossbedded; thick bedded; brown weathering; some lenticular beds and channel-fill	7	(2.1)	124	(37.8)
8	Siltstone, argillaceous, dark grey; flaggy; interbedded sandstone and shale, 30%, some sideritic concretions	13	(4.0)	117	(35.7)
7	Sandstone, fine grained, laminated, crosslaminated; crossbedded; brown; brown weathering; thick bedded; some thin beds of shale	22	(3.7)	104	(31.7)
6	Sandstone, fine grained, laminated; thin bedded to flaggy; some shale, silty, platy	10	(3.0)	82	(25.0)
	GSC Loc. 52208 **Pteria** cf. **P. camselli** McLearn **Inoceramus** sp. indet. **Pecten** sp. indet. **Aucellina**? sp. indet.				
5	Sandstone, fine grained, laminated, brown, thick bedded; few concretions	3	(0.9)	72	(21.9)
	<u>1st Shale</u>				
4	Mudstone, silty, dark grey to black; rusty weathering; becoming siltier at top with some small sideritic concretions at top; grades into overlying beds	42	(12.8)	69	(21.0)
3	Mudstone, silty, dark grey; rusty weathering; thin beds of siltstone; some thin sideritic concretions	12	(3.7)	27	(8.2)
	<u>1st Sandstone</u>				
2	Sandstone, argillaceous, laminated, very fine grained, brown; flaggy to platy; interbedded shale, 40%; beds 1 to 4 inches (25.4-101.6 mm)	12	(3.7)	15	(4.6)
1	Sandstone, fine grained, laminated, brown; thin bedded to flaggy; interbedded siltstone and shale, 40%, dark brownish grey, platy.	3	(0.9)	3	(0.9)
	Buckinghorse Formation				
2	Siltstone and shale, 20%; some beds of very fine grained sandstone; few sideritic concretions toward top	10	(3.0)	18	(5.5)
	GSC Loc. 52209 **Inoceramus** sp. indet. **Thracia**? sp. indet. Pelecypods, genus and species indet.				
1	Siltstone and shale, 40%; siltstone, argillaceous, laminated 1 to 2 inches (25.4-50.8 mm) beds, shale very silty, dark grey to black; rusty weathering.	8	(2.4)	8	(2.4)

Section 62-21. Sully Formation, Sikanni River, south side between Mistahae and Kettle Creeks; Trutch map-area, British Columbia, 57°17'N, 122°26'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
6	Sandstone, coarse grained, laminated; massive. Inaccessible	45	(13.7)	138	(42.1)
5	Sandstone, fine grained, laminated; massive	17	(5.3)	93	(28.3)
4	Shale	4	(1.2)	76	(26.2)
3	Sandstone, fine grained, laminated, brown; thick bedded	10	(3.0)	72	(21.9)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
2	Shale and siltstone, interbedded	17	(5.2)	62	(18.9)
1	Sandstone, fine grained, laminated, brown; thick bedded to massive, crossbedded; brown weathering.	45	(13.7)	45	(13.7)
	FORT ST. JOHN GROUP				
	Sully Formation				
19	Shale, silty	3	(0.9)	718	(218.8)
18	Sandstone, fine grained, laminated; thin bedded; lenticular; some shale	11	(3.3)	715	(217.9)
17	Shale, silty; some thin siltstone in upper part	30	(9.1)	704	(214.6)
16	Sandstone, fine grained, laminated, brown; thin bedded; brown weathering; interbedded platy shale, 40%	16	(4.9)	674	(205.4)
15	Mudstone, silty	4	(1.2)	658	(200.6)
14	Sandstone, very fine grained, silty, brownish grey; platy; some interbedded shale	3	(0.9)	654	(199.3)
13	Mudstone, silty, blocky; few sideritic layers; siltier at top	70	(21.3)	651	(198.4)
12	Mudstone, silty; blocky; rusty weathering; few concretionary layers	50	(15.2)	581	(177.1)
11	Covered	115	(32.0)	531	(161.8)
10	Mudstone, dark grey; yellow efflorescence; thin layer of bentonite; selenite	15	(4.6)	416	(126.8)
9	Covered	150	(45.7)	401	(122.2)
8	Mudstone, silty; platy; some siltstone	28	(8.5)	251	(76.5)
7	Partly covered. Mudstone, silty	14	(4.3)	223	(68.0)
6	Siltstone, argillaceous; platy; rusty weathering; fragmental fossils fragments in layer at top	4	(1.2)	209	(63.7)
5	Siltstone, very argillaceous; platy; concretionary sandy and bentonitic layers at top and base; fish fragments	2	(0.6)	205	(62.5)
4	Siltstone, very argillaceous; platy; interbedded mudstone; rusty weathering	18	(5.9)	203	(61.9)
3	Covered	115	(35.0)	185	(56.4)
2	Siltstone, argillaceous, and mudstone; platy; some concretions and platy siltstone at top	5	(1.5)	70	(21.3)
1	Mostly covered. Mudstone, rubbly, dark grey to black; sulphur stained.	65	(19.8)	65	(19.8)
	May be a gap of 20 to 30 feet (6.1-9.1 m) contact with Sikanni sandstone not exposed.				

Section 62-22. Sikanni Formation, Sikanni River below Barker Creek, Trutch map-area, British Columbia, 57°14'N, 122°34'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Top of ridge.				
	Sikanni Formation				
	4th Sandstone				
14	Sandstone, fine grained, grey, finely and uniformly laminated; festoon crossbedding; thick bedded; platy; light brownish grey weathering	14	(4.3)	351	(107.0)
	3rd Shale				
13	Siltstone, argillaceous, sandy, platy	4	(1.2)	337	(102.7)
12	Covered, recessive	60	(18.3)	333	(101.5)
	3rd Sandstone				
11	Sandstone, fine grained, laminated, brownish grey; shaly at base; some intervals of silty mudstone; few concretions	16	(4.9)	273	(83.2)
10	Sandstone, fine grained, laminated, brownish grey; interbedded sandy siltstone, 40%; some crossbedding; light brownish grey weathering	7	(2.1)	257	(78.3)
	2nd Shale				
9	Siltstone, argillaceous, sandy; blocky to flaggy; few concretions	7	(2.1)	250	(76.2)
8	Covered, recessive	85	(25.9)	243	(74.1)
	2nd Sandstone				
7	Sandstone, fine grained, laminated, brownish grey: argillaceous at base with some shaly layers; platy to thin bedded; pebbles on upper surface, chert, quartzite, well rounded, as much as one inch (25.4 mm)	8	(2.4)	158	(48.2)
6	Sandstone as above; thick bedded	9	(2.7)	150	(45.7)
5	Sandstone, fine grained, laminated, brownish grey; thin to thick bedded; weathers platy; some thin shale layers; crossbedded	25	(7.6)	141	(43.0)
	1st Shale				
4	Siltstone, sandy, argillaceous, flaggy to platy	3	(0.9)	116	(32.3)
3	Mostly covered, recessive	76	(23.2)	113	(31.4)
	1st Sandstone				
2	Sandstone, fine grained, laminated, brownish grey; thick bedded	28	(8.5)	37	(11.3)
1	Sandstone, fine grained, laminated, brownish grey; flaggy to thin bedded; crosslaminated; festoon crossbedding; few concretions.	9	(2.7)	9	(2.7)
	Buckinghorse Formation				
4	Partly covered. Mudstone in lower half; sandstone and interbedded shale in upper 5 feet (1.5 m)	42	(12.8)	103	(31.4)
3	Mudstone, silty, blocky; thin concretionary layers and concretions; siltier at top; few thin beds of laminated sandstone	29	(8.9)	61	(18.6)
2	Mudstone, silty; blocky; dark grey; small sideritic concretions	13	(3.9)	32	(9.7)
1	Shale, dark grey to black, blocky.	19	(5.8)	19	(5.8)
	River level				

Section 64-1. Basal Buckinghorse Formation, Mile 375, Alaska Highway, Tuchodi Lakes map-area, British Columbia, 58°40'N, 124°15'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Buckinghorse Formation				
	End of exposure.				
12	Shale, rubbly to splintery, soft, black; rusty weathering; yellow efflorescence; few sideritic concretions; thin seams of bentonite	45	(13.7)	242	(73.8)
11	Covered	29	(8.6)	197	(60.0)
10	Shale, black, rubbly; rusty weathering; few sideritic concretions; much yellow efflorescence	10	(3.0)	168	(51.2)
9	Shale, dark grey to black, rubbly to flaky; rusty weathering; sideritic concretions, reddish brown weathering	20	(6.1)	158	(48.2)
8	Mudstone, dark grey to black, rubbly to flaky; rusty weathering; few thin bentonitic seams; large sideritic concretions, 4 x 6 inches to 18 inches (101.6x152.4-452.2 mm), in rows but less continuous toward top of unit, reddish brown weathering	114	(3.7)	138	(42.1)
7	Mudstone, sandy, rubbly; greenish to rust weathering; glauconitic	2	(0.6)	24	(7.3)
6	Mudstone, silty, concretionary; orange to rust weathering; glauconitic; 2 inches (50.8 mm) pebble bed at base, 1/8 inch (3.1 mm) black chert pebbles in mudstone matrix; few disseminated pebbles in overlying mudstone	1	(0.3)	22	(6.7)
5	Siltstone, argillaceous, dark grey to black; blocky; rusty weathering	0.5	(0.1)	21	(6.4)
4	Shale, black, rubbly to flaky; rusty weathering; few small sideritic concretions	6	(1.8)	20.5	(6.2)
3	Shale and siltstone, interbedded; 2 to 6 inches (50.8-152.4 mm) beds of fine grained, silty, platy sandstone; shale, black, flaky to platy; rusty weathering	6	(1.8)	14.5	(4.4)
2	Sandstone, fine grained, non-calcareous, medium dark grey, silty, homogeneous; thick bedded; some large crossbeds and channel-fill; rusty weathering; few thin shale partings	5	(1.5)	8.5	(2.6)
1	Conglomerate; 1/8 to ½ inch (3.1-12.7 mm) black chert pebbles embedded in a sandy mudstone matrix; fills small depressions and cracks in 18-inch (457.2 mm) thick erosion remnant of underlying Triassic. Some channelling is evident in shales and sandy beds are not continuous. Upper 6 inches to one foot (152.4-304.8 mm) is carbonaceous with thin coal partings and lenticular fine grained sandstone.	3.5	(1.1)	3.5	(1.1)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Contact is abrupt, sharp, and parallel except for a small remnant of weathered calcareous sandy siltstone which is cut out upslope by channel-fill of conglomerate and sandy mudstone. Calcite veinlets extend from underlying beds into remnant but not into conglomeratic sediments.				
	TRIASSIC				
	Liard Formation				
2	Siltstone, dark grey, limy; thick bedded; orange to brown weathering; upper 2 feet (0.6 m) is sandy; thin veinlets of calcite	7	(2.1)	19	(5.8)
1	Siltstone, calcareous, dark to medium grey; thick bedded; grey to brownish grey weathering; few shaly layers; thin calcite veinlets perpendicular to bedding.	12	(3.7)	12	(3.7)

Section 64-2. Sully and Dunvegan Formations, south side of Steamboat Mountain, Fort Nelson map-area, British Columbia, 58°42'N, 123°49'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
	Top of ridge, end of exposure.				
8	Conglomerate, massive, brown to grey weathering; showing considerable planar crossbedding; pebbles range from ½ to 6 inches (12.7-152.4 mm); rounded, grey, blue, green, black, white, brown, pink, yellowish brown; quartz, chert, quartzite, quartzitic sandstone, argillite; some beds consist almost entirely of pebbles; some contain a sandstone matrix; well indurated	208	(63.4)	563	(171.6)
7	Mostly covered. Appears to be sandy shale and thin sandstones	24	(7.3)	355	(108.2)
6	Partly covered and mostly inaccessible. Sandstone, coarse grained, conglomeratic; massive; layers of conglomerate; some crossbedding	25	(7.6)	331	(100.1)
5	Conglomerate, grey; massive; grey to brown weathering; some sandy lenses; sandy matrix; shows some crossbedding but mainly massive; slightly finer conglomerate and more sandstone toward top	67	(20.4)	306	(93.3)
4	Sandstone, coarse grained, conglomeratic; crossbedding	3	(0.9)	239	(72.8)
3	Conglomerate, grey; massive; grey to brown weathering; some sandy lenses; some large crossbedding; pebbles, ⅛ to 3 inches (6.3-76.2 mm); chert, argillite, quartzite; black, white, green, blue, pink	40	(12.2)	236	(71.9)
2	Covered. Talus indicates that this interval is predominantly sandy shale with some thin, platy sandstone	125	(38.1)	196	(59.7)
1	Sandstone, fine grained, grey, laminated, non-calcareous; thick bedded to massive; brown to brownish grey weathering; some concretions, reddish brown weathering.	71	(21.6)	71	(21.6)
	FORT ST. JOHN GROUP				
	Sully Formation				
17	Shale, silty, brownish grey; platy	1	(0.3)	227	(69.2)
16	Sandstone, fine grained, laminated, brownish grey; platy	1	(0.3)	226	(68.9)
15	Shale, silty; rusty weathering	1	(0.3)	225	(68.6)
14	Sandstone as above	2	(0.6)	224	(68.3)
13	Shale, silty; platy	1	(0.3)	222	(67.7)
12	Sandstone, fine grained, laminated, brownish grey; platy	1	(0.3)	221	(67.4)
11	Mostly covered. Shale, rubbly, rusty weathering	31	(9.4)	220	(67.1)
10	Sandstone, fine grained, laminated, grey; platy to thick bedded	3	(0.9)	189	(57.6)
9	Mostly covered. Shale as above	17.5	(5.3)	186	(56.7)
8	Sandstone, fine grained, laminated, grey; platy; brownish grey weathering	2	(0.6)	168.5	(51.3)
7	Mostly talus covered. Shale, rubbly, rusty weathering; some orange weathering sideritic concretions	33	(10.1)	166.5	(50.7)
6	Sandstone, argillaceous, fine grained, laminated; platy; rusty grey weathering	1.5	(0.4)	133.5	(40.7)
5	Talus covered. Shale, silty, dark grey	17	(5.2)	132	(40.2)
4	Covered	30	(9.1)	115	(35.0)
3	Shale, rubbly, dark grey to black; mostly talus covered	20	(6.1)	85	(25.9)
2	Shale, rubbly, dark grey to black, rusty weathering; thin beds of argillaceous siltstone and sandstone; few small sideritic concretions	20	(6.1)	65	(19.3)
1	Shale, rubbly, dark grey to black; mostly talus covered.	45	(13.7)	45	(13.7)
	Contact with Sikanni Formation is not exposed but flat ledge at base is formed by resistant sandstones at top of Sikanni Formation. Probably less than 50 feet (15.2 m) covered at base of Sully Formation.				

Section 64-3. Buckinghorse Formation, south side of Tetsa River, west flank of anticline, opposite Mile 367 to 368, Alaska Highway, British Columbia, 58°40'N, 124°07'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Buckinghorse Formation				
	Axis of syncline, no higher exposures.				
80	Mudstone, rubbly; rusty weathering; few concretions. Inaccessible	100	(30.4)	2094	(638.2)
79	Mudstone, very silty; blocky; rusty weathering. Inaccessible	25	(7.6)	1994	(607.8)
78	Mudstone, very silty; blocky; rusty weathering; reddish brown weathering concretions	20	(6.1)	1969	(600.2)
77	Covered	12	(3.7)	1949	(594.1)
76	Mudstone, very silty; blocky to platy; some reddish brown weathering concretions	15	(4.6)	1937	(590.4)
75	Covered	35	(10.7)	1922	(585.8)
74	Shale, dark grey; rubbly; rusty weathering; slightly siltier and platy at top; few concretions	40	(12.2)	1887	(575.1)
73	Mudstone, blocky to platy; rusty weathering	6	(1.8)	1847	(562.9)
72	Covered by mud flow	200	(61.0)	1841	(561.1)
71	Siltstone and interbedded shale, platy; poorly exposed	5	(1.5)	1641	(500.2)
70	Shale, rubbly to platy; rusty weathering; striped appearance; few concretions	70	(21.3)	1636	(498.6)
69	Covered	20	(6.1)	1566	(477.3)
68	Shale, dark grey; rubbly at base, becoming siltier and platy toward top; rusty weathering; few sideritic concretions	48	(14.6)	1546	(471.2)
67	Shale, dark grey; rubbly at base, becoming silty and platy toward top	37	(11.3)	1498	(456.6)
66	Covered	20	(6.1)	1461	(445.7)
65	Mudstone and siltstone (60-40), as above, few concretionary layers	21	(6.4)	1441	(439.2)
64	Mudstone, silty, and siltstone, argillaceous, dark grey; platy; rusty weathering. Siltstone increases from 40% to 60% at top	55	(16.8)	1420	(432.8)
63	Shale, rubbly, rusty weathering	15	(4.6)	1365	(416.0)
62	Mudstone, silty, and siltstone, interbedded	5	(1.5)	1350	(411.5)
61	Covered	10	(3.0)	1345	(410.0)
60	Sandstone, fine grained, argillaceous, dark grey, laminated, crosslaminated; flaggy; greyish brown weathering; some concretions, orange weathering	4	(1.2)	1335	(406.9)
59	Covered	15	(4.6)	1331	(405.7)
58	Shale, dark grey to black; rubbly; rusty weathering	6	(1.8)	1316	(392.6)
57	Siltstone, argillaceous, dark grey; platy; few thin interbeds of rubbly shale	22	(6.7)	1310	(399.3)
56	Siltstone, dark grey, argillaceous; platy; rusty weathering; interbedded shale, 20%. Inaccessible	25	(7.6)	1288	392.6
55	Shale, dark grey to black; rubbly; rusty weathering; few large concretions	6	(1.8)	1263	(384.9)
54	Siltstone, argillaceous, laminated, platy, rusty weathering; some interbedded shale	5	(1.5)	1257	(383.1)
53	Shale, dark grey to black; rubbly; rusty weathering	6	(1.8)	1252	(381.1)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	drag fold				
52	Shale, dark grey to black; rubbly; rusty weathering	10	(3.0)	1246	(379.8)
51	Covered	50	(15.2)	1236	(376.8)
50	Shale, dark grey; rusty weathering; siltstone, argillaceous, platy, 50%	24	(7.3)	1186	(361.5)
49	Shale, silty, dark grey; platy; rusty weathering; platy siltstone	20	(6.1)	1162	(354.2)
48	Mudstone, silty; blocky; siltstone, argillaceous, platy, 50%; few small concretions	10	(3.0)	1142	(348.1)
47	Siltstone, dark grey, argillaceous; platy	5	(1.5)	1132	(345.0)
46	Sandstone, very fine grained, silty, laminated, grey; interbeds of shale, rusty weathering, 40%	3	(0.9)	1127	(343.5)
45	Siltstone, laminated; platy; rusty weathering	3	(0.9)	1124	(342.6)
44	Sandstone, very fine grained, silty; beds 2 to 3 inches (50.8-76.2 mm) thin interbeds of shale	2	(0.6)	1121	(341.7)
43	Siltstone, platy; thin interbeds of shale. Inaccessible	26	(7.9)	1119	(341.1)
42	Shale, rusty weathering; some interbedded platy siltstone. Inaccessible	75	(22.9)	1093	(333.1)
41	Siltstone, platy; some interbedded shale. Inaccessible	10	(3.0)	1018	(313.5)
40	Partly covered. Siltstone and shale interbedded. Inaccessible	20	(6.1)	1008	(307.2)
39	Shale, black, rubbly; some interbedded platy sandstone; few concretionary layers	20	(6.1)	988	(301.1)
	shear				
38	Shale, grading upward into interbedded siltstone and shale	15	(4.6)	968	(295.0)
37	Siltstone and shale interbedded; platy, flaggy	8	(2.4)	953	(290.5)
36	Covered	25	(7.6)	945	(288.0)
35	Shale, black, rubbly, rusty weathering; rare concretions	70	(21.3)	920	(280.4)
34	Shale, black, rubbly to splintery; rusty weathering	28	(8.5)	850	(259.1)
33	Covered	35	(10.7)	822	(250.5)
	shear				
32	Shale, black, rubbly to flaky; rusty weathering; few hard beds	25	(7.6)	787	(239.9)
31	Shale, rubbly to platy; few reddish brown weathering concretionary beds. Inaccessible. Estimated	60	(18.3)	762	(232.2)
30	Siltstone, argillaceous; platy; rusty weathering. Inaccessible	20	(6.1)	702	(214.0)
29	Shale, silty; rusty weathering; rubbly, becoming blocky at top; 3 inches (76.2 mm) bentonite with shale in middle at 20 feet (6.1 m) above base	25	(7.6)	682	(207.9)
28	Shale, black; flaky; rusty weathering; thin concretionary beds; 1 inch (25.4 mm) of bentonite at 12 feet (3.7 m) from base, ½ inch (12.7 mm) at 13 feet (4.0 m) and 15 feet (4.6 m) from base; 6 inches (132.4 mm) argillaceous sandstone at top	58	(17.7)	657	(200.2)
27	Shale, silty; platy to blocky; rusty weathering; few concretionary beds	6	(1.8)	599	(182.6)
26	Shale, black; rubbly; rusty weathering	10	(3.0)	593	(180.7)
25	Shale, rubbly; rusty weathering; numerous thin concretionary beds producing platy appearance	15	(4.5)	583	(177.7)
24	Shale, black; flaky; rusty weathering; few concretions; 3 inches (76.2 mm) of bentonite at 10 feet (3.1 m) and at 15 feet (4.6 m) above base	25	(7.6)	568	(173.1)
	small creek gully				
23	Shale, black; flaky to rubbly; rusty weathering; few concretions; bentonite 5 feet (1.5 m) below top	45	(13.7)	543	(165.5)
22	Shale, black; flaky; rusty weathering; thin hard dolomitic beds; few small concretions	22	(6.7)	498	(151.8)
21	Shale, rubbly to flaky; rusty weathering; small sideritic concretions; bentonite at base	23	(7.0)	476	(145.0)
20	Shale, rubbly to platy; rusty weathering. Inaccessible and partly covered	20	(6.1)	453	(138.1)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	shear				
19	Shale, rusty weathering; rubbly to platy. Inaccessible	25	(7.6)	433	(132.0)
18	Shale, rusty weathering; platy; numerous concretions; one foot (0.3 m) laminated yellowish grey platy bed at top. Inaccessible	60	(18.3)	408	(124.4)
17	Shale, rubbly to flaky; rusty weathering; numerous irregular sideritic concretions with pyritic centres	13	(3.9)	348	(106.0)
16	Shale, black; flaky to blocky; rusty weathering; small concretions; topped by 4 inches (101.6 mm) concretionary siltstone	22	(3.6)	335	(102.1)
15	Shale, black; flaky to blocky; very rusty weathering; yellow efflorescence; selenite; small sideritic concretions; small pyritic nodules	60	(18.2)	313	(95.4)
14	Shale, rubbly to flaky; rusty weathering	30	(9.1)	253	(77.1)
	small creek				
13	Partly covered, shale as below	11	(3.3)	223	(68.0)
12	Shale, black, very rubbly; soft; very rusty weathering; selenite; some large concretions	10	(3.0)	212	(64.6)
	shear				
11	Shale, black, flaky	5	(1.5)	202	(61.6)
	shear				
10	Shale, black, flaky; thin beds of dolomite, yellowish grey weathering; few large kettle concretions	7	(2.1)	197	(60.0)
9	Shale, rubbly; rusty weathering; selenite; large sideritic concretions	15	(4.5)	190	(57.9)
8	Shale, black; rubbly to flaky; rusty weathering; thin sideritic concretions; partly inaccessible	7	(2.1)	175	(53.3)
7	Shale, black; very rubbly; rusty weathering; much yellow efflorescence; selenite; some silty concretionary layers at top	13	(4.0)	168	(51.2)
	shear				
6	Shale, black; rusty weathering; rubbly; rare small sideritic concretions	20	(6.1)	155	(47.2)
5	Shale, silty; blocky; rusty weathering; large oval concretions	12	(3.7)	135	(41.1)
4	Shale to mudstone, black; rubbly to blocky; rusty weathering; some yellow efflorescence; rows of concretions, 4 to 6 inches (101.6-152.4 mm) thick, reddish brown weathering; some are septarian with well developed quartz crystals	40	(12.2)	123	(37.5)
	small creek				
3	Shale, black; rubbly; rusty weathering; large concretions in rows	40	(12.2)	83	(25.3)
2	Shale, black; rubbly; rusty weathering; rows of large sideritic concretions, reddish brown weathering	15	(4.6)	43	(13.1)
1	Mostly covered. Shale, black; rubbly; rusty weathering; scattered sideritic concretions.	28	(8.5)	28	(8.5)
	Contact with underlying Triassic sediments is not exposed but shales apparently lie directly on latter.				
	TRIASSIC				
	Toad Formation				
	Siltstone, calcareous, dark grey, platy to irregularly bedded	12	(3.7)		

Section 64-4. Sikanni, Sully, and Dunvegan Formations, ridge north of Steamboat Mountain, Fort Nelson map-area, British Columbia, 58°45'N, 123°59'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
	Top of ridge, end of exposure.				
11	Conglomerate; massive; grey weathering; crossbedded; pebbles, 1/8 to 3 inches (3.1-76.2 mm), quartz, chert quartzite, argillite, conglomerate, grey, blue, black, green, pink	95	(29.0)	440	(134.1)
10	Sandstone, coarse grained, conglomeratic; crossbedded; massive; brown weathering	9	(2.7)	345	(105.1)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
9	Conglomerate; massive; grey weathering; pebbles, 1/8 to 1½ inches (3.1-38.1 mm); sandstone matrix	10	(3.0)	336	(102.4)
8	Conglomerate; massive; grey weathering; pebbles, 1/8 to 3 inches (3.1-76.2 mm); sandstone matrix	27	(8.2)	326	(99.4)
7	Covered	29	(8.9)	299	(91.1)
6	Conglomerate; massive; grey weathering; pebbles, 1/8 to 3 inches (3.1-76.2 mm); some coarse grained sandstone matrix	60	(18.3)	270	(82.3)
5	Covered. Some fine grained sandstone at top	14	(4.3)	210	(64.0)
4	Conglomerate and coarse grained sandstone as above; massive; grey weathering; pebbles, 1/8 to 1 inch (3.1-25.4 mm)	33	(10.0)	196	(59.7)
3	Conglomerate and coarse grained sandstone, crosslaminated; crossbedded; massive; grey weathering; pebbles, 1/8 to 1 inch (3.1-25.4 mm)	54	(16.4)	163	(49.7)
2	Mostly talus covered. Mudstone and siltstone, argillaceous, dark grey; blocky to platy; some platy, fine grained sandstone	75	(22.9)	109	(33.2)
1	Sandstone, fine grained, grey to brown, laminated; thick bedded to massive; crossbedded.	34	(10.4)	34	(10.4)
	FORT ST. JOHN GROUP				
	Sully Formation				
7	Covered	45	(13.7)	1109	(338.0)
6	Mostly covered. Mudstone, silty, black; rusty weathering	40	(12.2)	1064	(324.3)
5	Shale and sandstone, interbedded; sandstone, fine grained, laminated; platy	5	(1.5)	1024	(312.1)
4	Mudstone, silty, black; siltstone layers, 20%; orange weathering concretions. Poorly exposed	20	(6.1)	1019	(310.6)
3	Mostly covered. Mudstone, as below	50	(15.2)	999	(304.5)
2	Mudstone, rubbly, dark grey to black; rusty weathering; partly talus covered	80	(24.4)	949	(289.3)
1	Covered.	50	(15.2)	869	(264.9)
	Section continues up dip-slope. Contact between Sully and Sikanni Formations is not exposed.				
	Sikanni Formation				
45	Covered. This interval forms uppermost resistant beds and presumably includes sandstones; assigned to Sikanni Formation	100	(30.4)	819	(249.6)
44	Sandstone, fine grained, laminated; crossbedded; platy; reddish brown weathering	5	(1.5)	719	(219.1)
43	Covered	45	(13.7)	714	(217.6)
	7th Sandstone				
42	Sandstone, fine grained, laminated, crosslaminated, grey; crossbedded, thick bedded; brown weathering; platy to flaggy weathering	69	(21.0)	669	(203.9)
	6th Shale				
41	Inaccessible. Mudstone, black; rubbly to blocky at base, becoming siltier and platy toward top; upper half consists of interbedded shale and siltstone with few thin beds of sandstone	35	(10.7)	600	(182.9)
	6th Sandstone				
40	Sandstone, fine grained, grey, laminated; massive to thick bedded; minor crossbedding; brown weathering; shaly at base	17	(5.2)	565	(172.2)
39	Sandstone, fine grained, grey, laminated; thick bedded to massive; brown weathering	21	(6.4)	548	(167.0)
38	Covered, recessive	3	(0.9)	527	(160.6)
37	Sandstone, fine grained, laminated, grey; thick bedded; brown weathering	13	(4.0)	524	(159.7)
	5th Shale				
36	Mostly covered. Some platy sandstone in 3 to 4 foot (0.9-1.2 m) units	38	(11.5)	511	(155.4)
35	Sandstone, argillaceous, laminated; platy; some shale	4	(1.2)	473	(144.2)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
34	Covered	4	(1.2)	469	(142.9)
33	Sandstone, argillaceous	3	(0.9)	465	(141.7)
32	Covered	9	(2.7)	462	(140.8)
31	Sandstone, fine grained, very argillaceous, dark grey; poorly bedded	3	(0.9)	453	(138.1)
30	Mostly covered. Some silty mudstone, blocky	8	(2.4)	450	(137.2)
	5th Sandstone				
29	Sandstone, fine grained, laminated, crosslaminated, grey; thin bedded; brown weathering; minor crossbedding	28	(8.5)	442	(134.7)
28	Sandstone, fine grained, laminated, grey; thin bedded; thin concretions	13	(4.0)	414	(126.2)
	4th Shale				
27	Mudstone, dark grey, silty; blocky to platy; some interbedded sandstone, 20%; sandier at top	19	(5.8)	401	(122.2)
26	Sandstone, fine grained, laminated, crosslaminated, grey; interbedded shale and siltstone, 40%; beds 2 to 6 inches (50.8-152.4 mm)	14	(4.3)	382	(116.4)
25	Mostly covered. Some mudstone, silty; concretions; near base	45	(13.7)	368	(112.2)
24	Siltstone, sandy, grey; massive; shaly interbeds	7	(2.1)	323	(98.4)
23	Covered. Some mudstone	19	(5.8)	316	(96.3)
22	Sandstone, fine grained, grey, mottled; partly silty	4.5	(1.4)	297	(90.5)
21	Covered	12	(3.7)	292.5	(89.1)
20	Sandstone, argillaceous, laminated, brownish grey; shaly at base	4	(1.2)	280.5	(85.5)
19	Covered	6	(1.8)	276.5	(54.3)
18	Sandstone, fine grained, laminated, brownish grey; flaggy to thin bedded; brown weathering	5	(1.5)	270.5	(82.4)
17	Sandstone and shale interbedded; platy; few concretions	3	(0.9)	265.5	(80.9)
16	Covered	19	(5.8)	262.5	(80.0)
	GSC Loc. 65926. Talus from above 4th sandstone. **Posidonia? nahwisi** (McLearn, 1931) f. typ. (rare) **Posidonia? nahwisi** (McLearn, 1931) var. **goodrichensis** (McLearn, 1943) **Posidonia? nahwisi** (McLearn, 1931) var. **moberliensis** (McLearn, 1943) (last two forms are about equally numerous)				
	4th Sandstone				
15	Sandstone, fine grained, laminated, grey; thick bedded, crossbedded; weathers slightly platy; brown weathering; becoming thin bedded at top	17	(5.2)	243.5	(74.2)
14	Sandstone, fine grained, laminated, grey; thick bedded with irregular bedding surfaces; mottled; brown weathering; some large concretions at base	18	(5.5)	226.5	(69.0)
	3rd Shale				
13	Covered	7	(2.1)	208.5	(63.5)
12	Sandstone, fine grained, grey; thick bedded; brown weathering	4	(1.2)	201.5	(61.4)
11	Covered	10	(3.0)	197.5	(60.2)
	3rd Sandstone				
10	Sandstone, fine grained, grey, laminated; thick bedded; brown weathering; some crossbedding	29	(8.9)	187.5	(57.1)
	2nd Shale				
9	Covered	25	(7.6)	158.5	(48.3)
	2nd Sandstone				
8	Sandstone, fine grained, grey, laminated; thick bedded; brownish grey weathering	21	(6.4)	133.5	(40.7)
7	Sandstone, fine grained, grey, laminated; platy to flaggy; some crossbedding; brown weathering	7	(2.1)	112.5	(34.3)
6	Sandstone, fine grained, laminated, grey; platy; some interbedded shale	3	(0.9)	105.5	(32.1)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	1st Shale				
5	Covered	77	(23.5)	102.5	(31.2)
	1st Sandstone				
4	Sandstone, fine grained, homogeneous, grey; massive; brownish grey weathering	7	(2.1)	25.5	(7.8)
3	Sandstone, fine grained, laminated, crosslaminated, grey; thick bedded; brownish grey weathering; some crossbedding	10.5	(3.2)	18.5	(5.6)
2	Partly covered. Sandstone, as below	3	(0.9)	8	(2.4)
1	Sandstone, fine grained, laminated, some crosslamination, grey; brownish grey weathering; medium- to thick-bedded.	5	(1.5)	5	(1.5)
	End of exposure; presumably underlain by shales of Buckinghorse Formation.				

Section 64-5. Dunvegan Formation, south of tributary of McClellan Creek, Tuchodi Lake map-area, British Columbia, 58°48'N, 124°04'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Top of ridge, end of exposure.				
	DUNVEGAN FORMATION				
6	Conglomerate, grey; massive; crossbedded; some beds with matrix of coarse grained sandstone; pebbles range from ½ to 5 inches (12.7-127.0 mm) average ½ to 1 inch (12.7-25.4 mm); rounded; chert, quartzite, argillite, conglomerate; red, pink, green, blue, white, black	145	(44.2)	384	(117.0)
5	Covered	80	(24.4)	239	(72.8)
4	Sandstone, coarse grained to conglomeratic; massive to thick bedded; weathers brown and platy at top; lenses and streaks of conglomerate	19	(5.8)	159	(48.4)
3	Conglomerate, massive; grey to brown weathering; matrix of coarse grained sandstone; pebbles range from 1/8 to 2 inches (3.1-50.8 mm) average about one inch (25.4 mm); chert, quartz, quartzite, argillite; grey, green, pink, blue, black, white; rounded; some alignment of pebbles; more sandstone at top	24	(7.3)	140	(42.7)
2	Covered	85	(25.9)	116	(35.4)
1	Sandstone, fine grained, laminated, grey, cross-laminated; thick bedded to massive; some minor crossbedding; brownish grey weathering.	31	(9.4)	31	(9.4)
	FORT ST. JOHN GROUP				
	Sully Formation				
1	Poorly exposed. Mudstone with thin beds of siltstone and few concretions toward top.	30	(9.1)	30	(9.1)
	End of exposure.				

Section 64-6. Sikanni Formation, south of tributary of McClellan Creek, Tuchodi Lake map-area, British Columbia, 58°48'N, 124°04'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Top of ridge, end of exposure.				
	Sikanni Formation				
62	Sandstone, fine grained, laminated, grey, crosslaminated; thick bedded to massive; few intervals of shale; blocks of conglomerate occur in talus below but position in section was not determined	115	(350.0)	909	(277.0)
61	Covered, recessive	3	(0.9)	794	(242.0)
60	Sandstone, fine grained, laminated, cross-laminated, grey; thick bedded; brown to rusty weathering	17	(5.2)	791	(241.1)
59	Sandstone, fine grained, laminated; thick bedded to irregularly bedded; mottled; brown weathering	19	(5.8)	774	(235.9)
58	Covered. Two units of sandstone, 10 to 15 feet (3.0-4.6 m) thick, are exposed along edge of gully to north	80	(24.4)	755	(230.1)
57	Sandstone, fine grained, laminated, grey; thick bedded to massive; few silty layers; few concretions	32	(9.7)	675	(205.7)
56	Covered	19	(5.8)	643	(196.0)
55	Sandstone, fine grained, laminated; platy; brownish grey weathering	2	(0.6)	624	(190.2)
54	Covered	5	(1.5)	622	(189.5)
53	Sandstone, fine grained, laminated; platy; brownish grey weathering	5	(1.5)	617	(188.0)
52	Covered	9	(2.7)	612	(186.5)
51	Sandstone, silty, laminated, grey; rusty weathering	4	(1.2)	603	(183.8)
50	Covered, recessive	13	(4.0)	599	(182.6)
49	Siltstone, sandy to argillaceous, dark grey; wavy bedding	10	(3.1)	586	(178.6)
48	Sandstone, very argillaceous, laminated, grey; wavy bedding; small concretions	8	(2.4)	576	(175.5)
47	Sandstone, fine grained, laminated, cross-laminated, grey; thick bedded to massive; brown weathering; some concretionary zones	31	(9.4)	568	(173.1)
46	Covered	14	(4.3)	537	(163.7)
45	Sandstone, fine grained, laminated; thick bedded; grey weathering	20	(6.1)	523	(159.4)
44	Mostly covered. Mudstone, black to dark grey; numerous small concretions	41	(12.5)	503	(153.3)
43	Sandstone, argillaceous, dark grey; poorly bedded; interbedded shale, 25%	4	(1.2)	462	(140.8)
42	Mudstone, silty, dark grey	9	(2.7)	458	(139.5)
41	Siltstone, very argillaceous, dark grey; rusty weathering	1	(0.3)	449	(136.8)
40	Mudstone, silty, black; few small orange-weathering concretions	5	(1.5)	448	(136.5)
39	Covered	40	(12.2)	443	(135.0)
38	Sandstone, argillaceous; rusty weathering; some shaly intervals	4	(1.2)	403	(122.8)
37	Covered	15	(4.6)	399	(121.6)
36	Sandstone, fine grained, laminated, grey; thick bedded to massive; brownish grey weathering	22	(6.7)	384	(117.0)
35	Covered, recessive	9	(2.7)	362	(110.3)
34	Sandstone, fine grained, laminated; massive to thick bedded; grey weathering	14	(4.3)	353	(107.6)
33	Mostly covered. Sandstone, argillaceous and platy shale	4	(1.2)	339	(103.3)
32	Sandstone, fine grained, laminated, grey; thick bedded	8	(2.4)	335	(102.1)
31	Covered, recessive	3	(0.9)	327	(99.7)
30	Sandstone, fine grained, laminated, grey; thick bedded; brownish grey weathering	9	(2.7)	324	(98.7)
29	Sandstone, fine grained, laminated; thick bedded	12	(3.7)	315	(95.0)
28	Sandstone and shale interbedded	3	(0.9)	303	(92.3)
27	Sandstone, fine grained, slightly argillaceous, laminated, crosslaminated, grey; platy to thick bedded	14	(4.3)	300	(91.4)
26	Covered	16	(4.9)	286	(87.2)
25	Sandstone, very argillaceous, dark grey; cross-bedded; platy; slightly cleaner at top; rusty weathering	7	(2.1)	270	(82.3)
24	Covered, recessive	57	(17.4)	263	(80.2)
23	Sandstone, fine grained, laminated, grey; thick bedded to massive	16	(4.9)	206	(67.8)
22	Covered. Some shaly sandstone at base	3	(0.9)	190	(57.9)
21	Sandstone, fine grained, laminated, grey; thick bedded; brown to grey weathering	18	(5.5)	187	(57.0)
20	Sandstone, fine grained, laminated, cross-laminated, grey; thick bedded	9	(2.7)	169	(51.5)
19	Sandstone, fine grained, silty, brownish grey; thin bedded	3	(0.9)	160	(48.8)
18	Covered	5	(1.5)	157	(47.8)
17	Sandstone, fine grained, laminated, cross-laminated; massive to thick bedded; brownish grey weathering	13	(4.0)	152	(46.3)
16	Sandstone, very fine grained, silty, laminated, crosslaminated; platy to thick bedded; brown weathering	11	(3.3)	139	(42.3)
15	Mudstone, silty; thin platy siltstone and some sandstone toward top; few small concretions	11	(3.3)	128	(39.0)
14	Mostly covered, recessive. Mudstone	40	(12.2)	117	(35.7)
13	Sandstone, fine grained, laminated, cross-laminated, grey; thick bedded; brownish grey weathering	11	(3.3)	77	(20.4)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
12	Covered	19	(5.8)	66	(20.1)
11	Sandstone, fine grained, grey; thick bedded	3	(0.9)	47	(14.3)
10	Covered, recessive	2	(0.6)	44	(13.4)
9	Sandstone, as below, massive	6	(1.8)	42	(12.8)
8	Covered, recessive	1	(0.3)	36	(11.0)
7	Sandstone, fine grained, laminated, cross-laminated, grey; thick bedded to platy; brownish grey weathering; minor crossbedding	8	(2.4)	35	(10.7)
6	Covered	7	(2.1)	27	(8.2)
5	Sandstone, fine grained, laminated	3	(0.9)	20	(6.1)
4	Sandstone, fine grained, laminated; interbedded platy shale	3	(0.9)	17	(5.2)
3	Sandstone, fine grained, laminated, cross-laminated, grey; thick bedded; weathers platy and greyish brown	4	(1.2)	14	(7.3)
2	Sandstone, fine grained, very silty; platy; some shaly layers	1	(0.3)	10	(3.0)
1	Sandstone, fine grained, silty, laminated, cross-laminated, grey; thin bedded; greyish brown weathering.	9	(2.7)	9	(2.7)
	Buckinghorse Formation				
	Mudstone, black, concretionary, exposed on slopes below.				

Section 64-25. Buckinghorse and Sikanni Formations, gully on east side of Muskwa River, opposite mouth of Chlotapecta Creek, Fort Nelson map-area, British Columbia, 58°33'N, 123°45'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Sikanni Formation				
	Top of ridge, end of exposures.				
	Most of formation is inaccessible, and thicknesses of individual units of sandstones and shale were estimated from measurements carried along covered slopes.				
	The following thicknesses are only approximate.				
14	Sandstone, with some interbedded mudstone. Partly covered	210	(64.0)	810	(243.8)
13	7th Sandstone	50	(15.2)	600	(182.9)
12	Mudstone	30	(9.1)	550	(167.6)
11	6th Sandstone	30	(9.1)	520	(158.5)
10	Mudstone	40	(12.2)	490	(149.4)
9	5th Sandstone	80	(24.4)	450	(137.2)
8	Mudstone	55	(16.8)	370	(112.8)
7	4th Sandstone	40	(12.2)	315	(96.0)
6	Mudstone	10	(3.0)	275	(83.8)
5	3rd Sandstone	35	(10.7)	265	(80.8)
4	Mudstone	135	(41.1)	230	(70.1)
3	2nd Sandstone	40	(12.2)	95	(29.0)
2	Mudstone	10	(3.0)	55	(16.8)
1	1st Sandstone, thin bedded at base, thick bedded at top.	45	(13.7)	45	(13.7)
	Buckinghorse Formation				
27	Mudstone, very silty; interbedded siltstone and platy sandstone; rusty weathering	20	(6.1)	2151	(655.6)
26	Mudstone, black, rubbly; rusty weathering; some thin sandstones and one foot (0.3 m) of sandstone at top; thin concretionary layers, reddish brown weathering	110	(33.5)	2131	(649.7)
25	Mudstone, black, blocky; rusty weathering; very silty with siltstone at top; well developed concretionary layers, reddish brown weathering	60	(18.3)	2021	(616.0)
24	Mudstone, black, rubbly; rusty weathering; rare thin bed of platy sandstone; reddish brown weathering concretionary layers	185	(56.4)	1961	(597.7)
23	Mudstone. Inaccessible. Approximately	150	(45.7)	1776	(541.3)
22	Mudstone, black, rubbly; thin lenticular siltstone, 10%	20	(6.1)	1626	(495.6)
21	Mudstone, black, rubbly; rusty weathering; sandstone bed at top; few concretionary layers	75	(23.0)	1606	(489.5)
20	Mudstone, black, rubbly; rusty weathering; platy sandstone, 1 to 3 inches (25.4-75.2 mm) beds, finely laminated and crosslaminated, 5-10%	65	(19.8)	1531	(466.6)
19	Mudstone, black, rubbly; rusty weathering; rare platy sandstone; poorly developed concretionary layers	135	(41.1)	1466	(446.8)
18	Mudstone, black, rubbly; rusty weathering; poorly developed concretionary layers; few separate concretions at top	102	(31.1)	1331	(404.6)
17	Mudstone, black, rubbly; rusty weathering; yellow efflorescence; 1 to 2 inches (25.4-50.8 mm) beds of platy sandstone at irregular intervals	100	(30.5)	1229	(374.5)
16	Mudstone, black, rubbly; rusty weathering; yellow efflorescence; poorly developed concretionary layers	130	(39.6)	1129	(344.1)
15	Mudstone, black, rubbly; rusty weathering; poorly developed concretionary layers; 1 inch (25.4 mm) bed of bentonite at top	50	(15.2)	999	(304.5)
14	Mudstone, black, rubbly to splintery; rusty weathering; poorly developed concretionary layers; few thin layers of bentonite; 1 to 2 inches (25.4-50.8 mm) platy sandstone at top	65	(19.8)	949	(289.3)
13	Mudstone, black, rubbly; rusty weathering; few thin beds of platy sandstone toward top	30	(9.1)	884	(269.4)
12	Mudstone, black, rubbly; rusty weathering; several beds 3 to 4 inches (76.2-101.6 mm) laminated silty platy sandstone toward top; few thin bentonite beds	80	(24.4)	854	(260.3)
11	Mudstone, black, rubbly; rusty weathering; few sandy concretionary beds, 1 to 2 inches (25.4-50.8 mm)	20	(6.1)	774	(235.9)
10	Covered. Approximately	75	(23.0)	754	(229.8)
9	Mudstone, black, rubbly to flaky; yellow efflorescence; rusty weathering; few thin beds of platy concretionary sandstone	25	(7.6)	679	(207.0)
8	Mudstone, as above; thin concretionary beds give striped appearance	60	(18.3)	654	(199.3)
7	Mudstone, black, rubbly to flaky; yellow efflorescence; rusty weathering; few concretionary layers	30	(9.1)	594	(181.1)
6	Mudstone, as above; topped by concretionary layers	15	(4.8)	564	(171.9)
5	Mudstone, black, flaky to rubbly; yellow efflorescence; rusty weathering	50	(15.2)	549	(167.3)
	Remainder of section was measured on cliff immediately above sandstones. Some gap may occur between these beds and overlying beds measured in main creek				
4	Mudstone, black, rubbly to splintery; rusty weathering; rare concretions, reddish brown weathering	125	(38.1)	499	(152.1)
3	Mudstone, black, rubbly; rusty weathering; few concretions, reddish brown weathering	50	(15.2)	374	(114.0)
2	Mudstone, black, rubbly to blocky; rusty weathering; siltier at top; some concretions, reddish brown weathering	75	(23.0)	324	(98.8)
1	Mudstone, black, rubbly to blocky; rusty weathering; some concretions, reddish brown weathering; topped by 6 inches (152.4 mm) of sandstone.	105	(32.0)	249	(75.9)
	(Scatter equivalent)				
13	Sandstone, fine grained, laminated	2	(0.6)	144	(43.9)
12	Mudstone, very silty, black; rusty weathering	4	(1.2)	142	(43.3)
11	Sandstone, fine grained, grey, siliceous, laminated, crosslaminated; crossbedded, thick bedded; brownish grey weathering	8	(2.4)	138	(42.1)
10	Mudstone, silty, black; rusty weathering; some beds of sandstone, very fine grained, platy to flaggy; rusty weathering	13	(4.0)	130	(39.6)
9	Sandstone, fine grained, grey, siliceous, laminated, crosslaminated; crossbedded, thick bedded; brownish grey weathering	6	(1.8)	117	(35.7)

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
8	Mudstone, silty, black; rusty weathering; grading upward into argillaceous siltstone, blocky; rusty weathering; some lenses of sandstone; rare concretions, reddish brown weathering	9.5	(3.0)	111	(33.8)
7	Sandstone, fine grained, siliceous, brownish grey, laminated; concretionary layer	1	(0.3)	101.5	(30.9)
6	Mudstone, black, rubbly; rusty weathering; becoming slightly siltier at top. Partly talus covered	29	(8.8)	100.5	(30.6)
5	Siltstone, argillaceous, black, blocky; rusty weathering; some silty mudstone at base	7	(2.1)	71.5	(21.8)
4	Sandstone, very fine grained, grey, siliceous, very finely laminated, crosslaminated; crossbedded, thick bedded to massive; brownish grey weathering; few concretionary zones; worm burrows and tracks	46	(14.0)	64.5	(19.7)
3	Mudstone, very silty, blocky; rusty weathering	3.5	(1.1)	18.5	(5.6)
2	Sandstone, fine grained, grey, siliceous, brownish grey; brownish grey weathering	1	(0.3)	15	(4.6)
1	Mudstone, very silty, to siltstone, argillaceous, blocky; black; rusty weathering; few sandy lenses; very silty to sandy at top.	14	(4.3)	14	(4.3)

Section 64-26. Upper beds of Buckinghorse Formation, gully on east side of Muskwa River, above mouth of Kluachesi River, Fort Nelson map-area, British Columbia, 58°08'N, 123°25'W. Measured in feet and converted to metres.

Buckinghorse Formation

End of exposure.

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
13	Mudstone, black, rubbly; rusty weathering; some concretions and concretionary beds	125	(38.1)	1210	(368.8)
12	Mudstone, black, rubbly; some large concretions and concretionary beds; reddish brown weathering	160	(48.8)	1085	(330.7)
11	Mudstone, black, rubbly; rusty weathering	120	(36.6)	925	(281.9)
10	Mudstone. Talus covered	40	(12.2)	805	(245.4)
9	Mudstone. Poorly exposed	20	(6.1)	765	(233.2)
8	Mudstone, black, rubbly; rusty weathering	160	(48.8)	745	(227.1)
7	Covered	75	(22.9)	585	(178.3)
6	Mudstone, black, rubbly to flaky; rusty weathering	20	(6.1)	510	(155.4)
5	Mudstone, black, rubbly; rusty weathering	80	(24.4)	490	(149.4)
4	Mudstone. Talus covered	20	(6.1)	410	(125.0)
3	Mudstone, black, rubbly; rusty weathering; some concretions; reddish brown weathering	80	(24.4)	390	(118.9)
2	Mudstone, black, rubbly; rusty weathering; yellow efflorescence; poorly developed concretionary layers	260	(79.2)	310	(94.5)
1	Mudstone, black, rubbly; rusty weathering; poorly developed concretionary layers.	50	(15.2)	50	(15.2)

Beds below are folded and not continuously exposed.

Section 64-27. Sikanni Formation, on escarpment east of Muskwa River, just north of mouth of Kluachesi River, Fort Nelson map-area, British Columbia, 58°12'N, 123°29'W. Measured in feet and converted to metres.

Sikanni Formation

Top of ridge, end of exposures.

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
23	Mostly covered by talus of sandstone blocks. Upper 50 feet (15.2 m) is sandstone, fine grained, laminated, brown; flaggy to thin bedded; crossbedded; brown weathering; some mudstone. Some lower sandstones outcrop along the ridge	470	(43.3)	812	(247.5)
22	Sandstone, fine grained, siliceous, grey; thick bedded to massive; brown to grey weathering	15	(4.6)	342	(104.2)
21	Mudstone	2	(9.6)	327	(99.7)
20	Sandstone, as above	20	(6.1)	325	(99.1)
19	Mudstone, black, blocky	6	(1.8)	305	(93.0)
18	Sandstone, fine grained, siliceous; thick bedded; some mudstone	10	(3.0)	299	(91.1)
17	Mudstone and siltstone; interbedded sandstone, 40%	7	(2.1)	289	(88.1)
16	Sandstone, fine grained, poorly laminated, brownish grey, siliceous; thick bedded to massive; grey weathering; poorly exposed at top	35	(10.7)	282	(86.0)
15	Mudstone	1	(0.3)	247	(75.3)
14	Sandstone, fine grained, laminated, cross-laminated, grey, siliceous, thick bedded to massive; brown to grey weathering; some channel-fill at base; tracks and trails	28	(8.5)	246	(75.0)
13	Mudstone, silty, blocky; few thin beds of silty sandstone and rare concretionary layer	24	(7.3)	218	(66.4)
12	Siltstone, argillaceous, black to dark grey; some mudstone; sandstone, 40%, fine grained, laminated, brownish grey weathering; platy to thin bedded	8	(2.4)	194	(59.1)
11	Mudstone, very silty, black; siltstone at top; layers of reddish brown weathering concretions	19	(5.8)	186	(56.7)
10	Sandstone, fine grained, laminated, siliceous; rusty brown to grey weathering	1	(0.3)	167	(51.0)
9	Mudstone, silty; blocky; siltier at top with argillaceous siltstone; few concretions	39	(11.9)	166	(50.6)
8	Siltstone, argillaceous; blocky; some interbedded mudstone; thin orange weathering concretions	5	(1.5)	127	(38.8)
7	Mudstone, rubbly, black; interbedded sandstone, 40%, 6 inches to one foot (152.4 mm-0.3 m) beds, laminated, rusty brown weathering	6	(1.8)	122	(37.2)
6	Mudstone, black, rubbly; rusty weathering; few concretionary layers, reddish brown weathering	49	(14.9)	116	(35.4)
5	Sandstone, fine grained, grey, siliceous; poorly bedded; knobby; brownish grey weathering	9	(2.7)	67	(20.4)
4	Sandstone, fine grained, laminated, grey siliceous; massive; brownish grey weathering; few concretions	12	(3.7)	58	(17.7)
3	Mudstone, black, silty, blocky; some lenticular sandstone; rusty weathering; some concretions, reddish brown weathering	20	(6.1)	46	(14.0)
2	Mudstone, silty, black, blocky; interbedded sandstone, 40%, fine grained, laminated, platy to flaggy; some concretions, reddish brown weathering	11	(3.4)	26	(7.9)
1	Sandstone, fine grained, laminated, grey, crosslaminated; platy to thick bedded; rusty to brownish grey weathering; few thin beds of mudstone; some concretions, reddish brown weathering.	15	(4.6)	15	(4.6)

Buckinghorse Formation

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
2	Mudstone, very silty, brownish grey; rusty weathering; blocky to platy; 4 to 6 inches (101.6-152.4 mm) beds of argillaceous laminated sandstone; some concretions	12	(3.7)	92	(28.0)
1	Mudstone, black, rubbly to blocky; rusty weathering; becoming silty and platy toward the top; reddish brown weathering.	80	(24.4)	80	(24.4)

Section 64-28. Sandstone in Buckinghorse Formation, east flank of anticline, Chischa River, Fort Nelson map-area, British Columbia, 58°34'N, 123°49'W. Measured in feet and converted to metres.

Buckinghorse Formation

Overlying beds not exposed.

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
10	Sandstone, fine grained; flaggy to thin bedded; rusty brown weathering	10	(3.0)	267	(81.4)
9	Mostly covered. Mudstone	65	(19.8)	257	(78.3)
8	Sandstone, fine grained, laminated, siliceous; platy to flaggy; brownish grey weathering; concretionary zones	14	(4.3)	192	(58.5)
7	Sandstone, very silty; platy; some mudstone	3	(0.9)	178	(54.3)
6	Sandstone, fine grained, laminated, cross-laminated, grey, siliceous; thick bedded; brownish grey weathering; concretionary zones	15	(4.6)	175	(53.3)
5	Sandstone, silty, siliceous, brownish grey; poorly bedded; brown weathering; concretionary zones	9	(2.7)	160	(48.8)
4	Sandstone, fine grained, laminated, grey, siliceous, crosslaminated; thick bedded; brownish grey weathering; concretionary zones	8	(2.4)	151	(46.0)
3	Sandstone, silty, brownish grey, siliceous, laminated; poorly bedded; concretionary zones	18	(5.5)	143	(43.6)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
2	Mudstone, black, rubbly to blocky; becoming very silty with laminated siltstone at top, grading into overlying beds; rare concretions	55	(16.8)	125	(38.1)
1	Mudstone, black, rubbly to blocky; rusty weathering; reddish brown weathering concretions and beds.	70	(21.3)	70	(21.3)
	Underlying beds not exposed.				

Section 64-29. Scatter equivalent, Buckinghorse Formation, centre of anticline, Chischa River, Fort Nelson map-area, British Columbia, 58°35'N, 123°47'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Buckinghorse Formation				
	Mudstone, black; rubbly; rusty weathering; scattered reddish brown weathering concretions.				
	(Scatter equivalent)				
23	Mudstone, blocky; rusty weathering; very silty at top, with sandy siltstone	5	(1.5)	267	(81.4)
22	Sandstone, fine grained, laminated, crosslaminated, siliceous, grey; thick bedded; brownish grey weathering	8	(2.4)	262	(80.0)
21	Mudstone, black, blocky; rusty weathering; grading upward into argillaceous siltstone	12	(3.7)	254	(77.4)
20	Sandstone, fine grained, laminated, siliceous, grey; thick bedded; brown weathering	5	(1.5)	242	(74.0)
19	Mudstone, black; rusty weathering; rubbly at base, grading upward into argillaceous, blocky siltstone	31	(9.4)	237	(72.2)
18	Siltstone, argillaceous, blocky; rusty weathering	4	(1.2)	206	(62.8)
17	Mudstone, blocky; silty, grading into overlying beds; concretionary at base	3	(0.9)	202	(61.6)
16	Sandstone, fine grained; platy	2	(0.6)	199	(61.0)
15	Mudstone, silty, platy	1.5	(0.5)	197	(60.0)
14	Sandstone, fine grained, laminated, crosslaminated, siliceous, grey; thick bedded; some beds of poorly laminated silty sandstone	46	(14.0)	195.5	(59.0)
	Shear				
13	Sandstone, fine grained, laminated; thin- to thick-bedded	7	(2.1)	149.5	(45.6)
12	Sandstone, silty, laminated, grey; thin bedded; light brown weathering; concretionary zones	6.5	(2.0)	142.5	(43.4)
11	Mudstone, black, rubbly; rusty weathering; becoming very silty and blocky at top; large reddish brown weathering concretions in lower part	66	(20.1)	136	(41.5)
10	Sandstone, fine grained, laminated, grey; platy	1	(0.3)	70	(21.3)
9	Mudstone, black, silty; platy; rusty weathering; some concretions	4	(1.2)	69	(21.0)
8	Sandstone, fine grained, laminated, cross-laminated; thin bedded; some interbeds of poorly bedded sandstone	17	(5.2)	65	(19.8)
7	Sandstone, very silty, grey, siliceous; poorly bedded; brownish grey weathering; concretionary layers	5	(1.5)	48	(14.6)
6	Sandstone, fine grained, laminated, cross-laminated, grey, siliceous; thin bedded; concretionary layers	16	(4.9)	43	(13.1)
5	Sandstone, very silty; poorly bedded	5	(1.5)	27	(8.2)
4	Sandstone, fine grained, laminated, crosslaminated, grey; thin bedded; grey weathering; concretionary layers	3	(0.9)	22	(6.7)
3	Sandstone, fine grained, silty, laminated; poorly bedded; brownish grey weathering; concretionary layers	7	(2.1)	19	(5.8)
2	Sandstone, fine grained, laminated, grey; thin bedded; some sandstone as above	3	(0.9)	12	(3.7)
1	Sandstone, very silty, grey; poorly bedded; some laminated sandstone lenses; concretionary layers.	9	(2.7)	9	(2.7)
	River level, end of exposures.				

Section 64-30. Sikanni Formation, on escarpment opposite Tuchodi River, Fort Nelson map-area, British Columbia, 58°50'N, 123°34'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Top of ridge, end of exposure.				
	Sikanni Formation				
30	Sandstone, very fine to fine grained, homogeneous to laminated, siliceous, brown to brownish grey; thin to thick bedded; few thin shaly intervals	100	(30.5)	941	(286.8)
29	Mudstone and interbedded sandstone, 40%; grades into overlying unit	30	(9.1)	841	(256.3)
28	Sandstone, fine grained; platy to flaggy; rusty brown weathering	13	(4.0)	811	(247.2)
27	Mudstone; some sandstone	8	(2.4)	798	(243.2)
	7th Sandstone				
26	Sandstone, fine grained, siliceous, brownish grey; crossbedding; light brown weathering	27	(8.2)	790	(240.8)
25	Sandstone, fine grained, laminated; interbedded mudstone, 40%	45	(13.7)	763	(232.6)
24	Sandstone, fine grained, laminated, siliceous, brownish grey; thick bedded; some mudstone, 30%	17	(5.2)	718	(218.8)
23	Mudstone, black; some interbedded sandstone, especially at top	46	(14.0)	701	(213.7)
	6th Sandstone				
22	Sandstone, fine grained, laminated, cross-laminated, siliceous, grey; thick bedded; brownish grey weathering	55	(16.8)	655	(199.6)
21	Sandstone, fine grained, laminated, siliceous, grey; thin to thick bedded; interbedded; interbedded mudstone, 40%	17	(5.2)	600	(182.9)
20	Mudstone, black	79	(24.1)	583	(177.7)
	5th Sandstone				
19	Sandstone, fine grained, laminated, siliceous, grey; thick bedded to massive; brownish grey weathering	78	(23.8)	504	(53.6)
18	Sandstone, fine grained, laminated; flaggy to thin bedded; interbedded siltstone and some mudstone	8	(2.4)	426	(129.8)
17	Mudstone, black; rubbly; becoming very silty at top, grading into overlying unit; some thin concretionary beds	40	(12.2)	418	(127.4)
	4th Sandstone				
16	Mudstone, grading upward into sandstone; flaggy to thin bedded	7	(2.1)	378	(115.2)
15	Sandstone, fine grained, laminated to mottled, siliceous, grey; thick bedded	7	(2.1)	371	(113.1)
14	Mudstone, black; several lenticular beds of sandstone, 6 to 8 inches (152.4-203.2 mm) beds, 30%; very silty at top	14	(4.3)	364	(110.9)
13	Sandstone, fine grained, laminated, cross-laminated; thick bedded; brown weathering; some thin beds of mudstone	16	(4.9)	350	(106.7)
12	Mudstone, silty; platy	5	(1.5)	334	(101.8)
11	Sandstone, fine grained, laminated, cross-laminated, siliceous; platy to flaggy; beds 6 inches to 2 feet (152.4 mm-0.6 m) interbedded mudstone, 30%, platy	25	(7.6)	329	(100.3)
10	Mudstone, black; silty; interbedded sandstone, flaggy to thin bedded; beds 2 inches to one foot (50.8 mm-0.3 m), 25%	31	(9.4)	304	(92.7)
	3rd Sandstone				
9	Sandstone, fine grained, laminated to mottled, siliceous, brownish grey; thick bedded to massive; brown weathering; much reworking giving very irregular and uneven bedding; some concretions	26	(7.9)	273	(83.2)
8	Mudstone, black; interbedded platy to flaggy sandstone, 25%	43	(13.1)	247	(75.3)
7	Mudstone, black; grading upward into interbedded sandstone, 30%, and mudstone; platy	34	(10.4)	204	(62.2)
	2nd Sandstone				
6	Sandstone, fine grained, laminated, siliceous, grey, crosslaminated; thin to thick bedded; brownish grey weathering; some cross-bedding; worm markings	12	(3.7)	170	(51.8)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
5	Sandstone, fine grained, laminated, cross-laminated, siliceous grey; thin bedded; interbedded platy mudstone, 25%	17	(5.2)	158	(48.2)
4	Mudstone, black; silty at top; reddish brown weathering, silty concretionary beds in upper half	64	(19.5)	141	(43.0)
	1st Sandstone				
3	Sandstone, fine grained, laminated, siliceous, grey; thick bedded; brown weathering	27	(8.2)	77	(23.5)
2	Mudstone, rubbly to blocky; some silty concretionary layers	22	(6.7)	50	(15.2)
1	Sandstone, fine grained, laminated, siliceous, grey; thin to thick bedded; brownish grey weathering; interbedded mudstone, 40%, silty, platy; few concretions; less mudstone at top.	28	(8.5)	28	(8.5)
	Buckinghorse Formation				
2	Mudstone, silty, dark grey; blocky to platy; rusty weathering; interbedded sandy siltstone, 40%, laminated, platy to flaggy; concretions	13	(3.9)	22	(6.7)
1	Siltstone, argillaceous; blocky to massive, rusty weathering; reddish brown weathering concretions.	9	(2.7)	9	(2.7)
	End of exposure.				

Section 64-31. Dunvegan Formation, on escarpment east of Tuchodi River, Fort Nelson map-area, British Columbia, 58°16'N, 123°25'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
	Top of ridge, end of exposure.				
21	Conglomerate, grey; massive; some crossbedding; considerable sandy matrix and very sandy at base; pebbles up to 3 inches (76.2 mm), average ½ to 1 inch (12.7-25.4 mm)	28	(8.5)	478	(145.7)
20	Sandstone, coarse grained; flaggy to thick bedded; crossbedded; conglomeratic lenses	20	(6.1)	450	(137.2)
19	Conglomerate, grey; massive; pebbles up to 2 inches (50.8 mm)	15	(4.6)	430	(131.1)
18	Mostly covered. Some argillaceous siltstone and mudstone at base	32	(9.8)	415	(126.5)
17	Conglomerate, grey; massive; some crossbedding; pebbles ½ to 1 inches (12.7-25.4 mm); much coarse grained sandstone matrix	33	(10.1)	383	(116.7)
16	Conglomerate, grey; massive; sandy matrix, and sandstone in middle; pebbles ¼ to 2 inches (6.3-50.8 mm), average one inch (25.4 mm); quartz, chert, quartzite, argillite; rounded; black, green, blue, white	42	(12.8)	350	(106.7)
15	Partly covered and inaccessible. Mudstone, black to olive brown; rubbly and flaky in talus	45	(13.7)	308	(93.9)
14	Conglomerate, grey; massive; brownish grey weathering; matrix of coarse grained sandstone; lower part is mainly sandstone with abundant streaks and lenses of pebbles, 1/8 to 4 inches (3.2-101.6 mm); rounded; black, green, pink, white, grey, blue; light yellowish brown; chert, quartz, quartzite, argillite	87	(26.5)	263	(80.2)
13	Covered. Mudstone talus at base, some at top	43	(13.1)	176	(53.6)
12	Sandstone, fine grained, silty, siliceous, greenish grey; thick bedded at base; becoming argillaceous and silty and very platy at top	7	(2.1)	133	(40.5)
11	Mudstone. Poorly exposed	3	(0.9)	126	(38.4)
10	Sandstone, medium grained, siliceous, grey; thick bedded; brownish grey weathering	7	(2.1)	123	(37.5)
9	Mudstone. Mostly covered	23	(7.0)	116	(33.4)
8	Mudstone, rubbly to blocky; dark olive grey; siltier at top	12	(3.7)	93	(28.3)
7	Mudstone, dark olive brown to dark brownish grey; blocky; very silty in upper 2 feet (0.6 m)	17	(5.2)	81	(24.7)
6	Sandstone, fine grained, to siltstone, brownish grey to greenish grey; thick bedded; greenish to rusty weathering	4	(1.2)	64	(19.5)
5	Mudstone, very silty, platy to blocky, dark brownish grey; 6 inches (152.9 mm) bed of sandstone near base	6	(1.8)	60	(18.3)
4	Sandstone, medium to coarse grained, brownish grey; massive to thick bedded; brown weathering; conglomeratic lenses	13	(4.0)	54	(16.5)
3	Conglomerate, grey; massive; some lenses and streaks of sandstone; pebbles, 1/8 to 2 inches (3.2-50.8 mm), average ½ to 1 inch (12.7-2.4 mm); sandier at top; truncates underlying beds	34	(10.4)	41	(12.5)
2	Mudstone, very silty, platy; lenticular sandstone, 50%; cut out along slope by overlying beds	3	(0.9)	7	(2.1)
1	Sandstone, fine grained, laminated, siliceous, brownish grey; thick bedded.	4	(1.2)	4	(1.2)
	End of exposure.				

Section 65-1. Dunvegan Formation, headwaters of West Klua and Adsett Creeks, Fort Nelson map-area, British Columbia, 58°07'N, 122°31'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
	Top of ridge, end of exposure.				
22	Sandstone, medium grained, brownish grey; flaggy to thin bedded, crossbedded; brown weathering; curved fractures; (Maybe 10 to 15 feet (3.4-4.6 m) more on cliff to east)	30	(9.1)	491	(149.4)
21	Sandstone, medium grained, brownish grey; flaggy to thick bedded, crossbedded; brownish grey weathering; some streaks and lenses of pebbles	23	(7.0)	461	(140.5)
20	Covered, recessive. Mudstone in talus	58	(17.7)	438	(133.5)
19	Sandstone, fine- to medium-grained, grey to brownish grey; thick bedded, crossbedded; laminated; brown weathering	5	(1.5)	380	(115.8)
18	Covered, recessive. Appears to be mudstone	38	(11.6)	375	(114.3)
17	Conglomerate, grey; massive; crossbedded; brownish grey weathering; lenses of coarse grained sandstone; pebbles average about ½ inch (12.7 mm) some are as much as 1½ inch (38.1 mm); much sandstone matrix; defined bedded appearance produced by variation in grain size	32	(9.8)	337	(102.7)
16	Sandstone, fine grained, laminated, cross-laminated; crossbedded; brownish grey weathering	2	(0.6)	305	(93.0)
15	Sandstone, medium to coarse grained; much crossbedding; streaks and lenses of pebbles and conglomerate	5	(1.5)	303	(92.4)
14	Conglomerate and sandstone (40%); massive; pebbles average ¼ to ½ inch (6.3-12.7 mm); finer conglomerate has little matrix	10	(3.0)	298	(90.8)
13	Conglomerate, greyish brown; massive; grey weathering; much medium to coarse grained sandstone matrix; pebbles average ½ inch (12.7 mm), many are over one inch (25.4 mm) and range up to 2½ inches (63.5 mm)	20	(6.1)	288	(87.8)
12	Sandstone, medium to coarse grained, very friable; brown weathering; streaks and lenses of conglomerate; partly covered at top	14	(4.3)	268	(81.6)
11	Conglomerate, grey; massive; brownish grey weathering; matrix of coarse grained sandstone	6	(1.8)	254	(77.4)
10	Sandstone, medium grained, brownish grey; massive; brown weathering; conglomerate at top; streaks and lenses of pebbles, 1/8 to ½ inch (3.2-12.7 mm)	13	(4.0)	248	(75.6)
9	Conglomerate, grey; massive; brownish grey weathering; matrix of coarse grained sandstone; some crossbedding; pebbles average ¼ to ½ inch (6.3-12.7 mm); quartz, chert, quartzite; blue, grey, black, brown, red, green	6	(1.8)	235	(7.6)
8	Covered. Approximately	70	(21.3)	229	(69.8)
	(Section continues about ½ mile (0.8 km) southwestward along slope)				
7	Conglomerate, grey; massive; crossbedded; brownish grey weathering; matrix of coarse grained sandstone (40%); pebbles average ½ inch (12.7 mm); chert, quartz, quartzite; blue, black, white, grey, brown; rounded	22	(6.7)	159	(48.5)
6	Covered. May include 10 to 20 feet (3.4-6.1 m) of conglomerate at top	61	(18.6)	137	(41.8)
5	Sandstone, fine grained, laminated to homogeneous, grey to brownish grey, cherty; thick bedded; brown weathering; some crossbedding	9	(2.7)	76	(23.2)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
4	Partly covered. Appears to be mainly sandstone, fine grained, silty; thin bedded to platy	20	(6.1)	67	(20.4)
3	Sandstone, fine grained, laminated to homogeneous, grey to brownish grey; thick bedded; some pronounced crossbedding	25	(7.6)	47	(14.3)
2	Sandstone, fine grained, laminated to homogeneous, grey; thick bedded, strongly crossbedded in upper 2 feet (0.6 m); brown weathering	10	(3.0)	22	(6.7)
1	Sandstone fine to medium grained, laminated, brownish grey; platy; brown weathering; few beds of thin bedded sandstone.	12	(3.7)	12	(3.7)

End of exposure.

Section 65-2. Dunvegan Formation, north side of Akue Creek, Fort Nelson map-area, British Columbia, 58°07'N, 123°31'W. Measured in feet and converted to metres.

DUNVEGAN FORMATION

Top of ridge, end of exposure.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
9	Conglomerate, grey; massive; much sandstone in lower 85 feet (26.0 m) but conglomerate dominates above; pebbles average ½ to 1 inch (12.7-25.4 mm), but maximum size is 5 to 6 inches (127-152.4 mm); cobbles are rounded to sub-rounded; pebbles of quartz, chert, quartzite, with few granitic ones; pebbles are well rounded; white, blue, grey, black; crossbedding is evident in places. Mostly inaccessible	242	(74.8)	594	(181.0)
8	Sandstone, medium grained, silty, not well indurated; poorly bedded, crossbedded; shaly beds at base. Mostly inaccessible	35	(10.7)	352	(107.3)

GSC Loc. 7466

Menispermites reniformis Dawson
Populites wickendeni Bell
Laurophyllum sp. Bell
Platanus newberryana Heer
Pseudoprotophyllum boreale (Dawson) Hollick
Pseudoaspidiophyllum latifolium Hollick

The above species with exception of **Populites wickendeni** have been recorded previously from the Dunvegan, the species of **Pseudoprotophyllum** being restricted so far as known to Cenomanian floras.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
7	Sandstone, coarse grained, and fine conglomerate; laminated, crosslaminated; massive; brown weathering; some beds of large pebbles	75	(19.8)	317	(96.6)
6	Covered, recessive. Presumably mudstone but may contain some conglomerate	80	(24.4)	242	(73.8)
5	Conglomerate, grey; massive; grey weathering; sandstone matrix; not so massive at top and shows some crossbedding in very coarse grained, calcareous sandstone; pebbles average 1/8 inch (3.2 mm); streaks and lenses of large pebbles; quartz, chert, quartzite; white, blue, grey, red, black, brown	45	(13.7)	162	(49.4)
4	Covered, recessive. May include some conglomerate at top	50	(15.2)	117	(35.7)
3	Sandstone, silty, argillaceous, very friable and almost unconsolidated, laminated; brownish grey weathering; numerous irregular masses of limonitic or concretionary sandstone	20	(6.1)	67	(20.4)
2	Mudstone, silty, platy; lenses of fine grained sandstone; grading into overlying beds; partly covered	18	(5.5)	47	(14.3)
1	Sandstone, fine grained, laminated, slightly calcareous, well sorted, grey; cherty; massive; some crossbedding, more bedded toward top.	29	(8.8)	29	(8.8)

FORT ST. JOHN GROUP

Sully Formation

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
7	Covered. Silty mudstone at top. May include some sandstone	22	(6.7)	57	(17.1)
6	Sandstone, fine grained, laminated, grey; thick bedded; grey weathering	3.5	(1.1)	35	(10.7)
5	Covered	2.5	(0.8)	31.5	(9.6)
4	Sandstone, fine grained, laminated, grey; thick bedded; grey weathering	3	(0.9)	29	(8.8)
3	Covered. Appears to be mainly platy siltstone but may include some sandstone	10	(3.0)	26	(7.9)
2	Sandstone, fine grained, laminated, lenticular, brownish grey; flaggy to thin bedded; light brown weathering; interbedded mudstone and platy siltstone	6	(1.8)	16	(4.9)
1	Mostly covered. Silty shale and platy sandstone.	10	(3.0)	10	(3.0)

End of exposure. Slopes below are covered with much shale talus.

Section 65-3. Buckinghorse Formation, Chlotapecta Creek, Fort Nelson map-area, British Columbia, 58°30'N, 123°53'W. Measured in feet and converted to metres.

FORT ST. JOHN GROUP

Buckinghorse Formation

Top of ridge, end of exposure.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
47	Shale, black, rubbly to flaky; rusty weathering; some platy siltstone	50	(15.2)	1558	(474.9)
46	Shale, black, rubbly; rusty weathering; interbedded sandy siltstone, platy; some silty sandstone at top, platy to flaggy	52	(15.8)	1508	(459.6)
45	Shale, black, rubbly; rusty weathering; interbedded platy siltstone; some orange weathering concretions; some sandstone at top	44	(13.8)	1456	(443.8)
44	Shale, rubbly; rusty weathering	25	(7.6)	1412	(430.4)
43	Shale, rubbly; rusty weathering; grading upward into interbedded shale and sandy siltstone (40%), platy; banded appearance	40	(12.2)	1387	(422.8)
42	Shale, rubbly, thin, platy to flaggy; very fine grained sandstone (25%)	25	(7.6)	1347	(410.6)
41	Shale, rubbly; rusty weathering; numerous lenses of channel-fill sandstone	17	(5.2)	1322	(402.9)
40	Sandstone, very fine grained, grey, flaggy; interbedded shale (40%); rusty weathering	24	(7.3)	1305	(397.8)
39	Shale, rubbly; rusty weathering	24	(7.3)	1281	(390.4)
38	Shale, black, rubbly; interbedded fine grained sandstone (30%), flaggy; rusty weathering	18	(5.5)	1257	(383.1)
37	Shale, black, rubbly to platy; interbedded sandstone (40%), very fine grained, grey; beds 2 to 6 inches (50.8-152.4 mm) very banded appearance; bentonite near base	39	(11.9)	1239	(377.6)
36	Shale, black, rubbly; rusty weathering; some thin hard silty beds	10	(3.0)	1200	(365.8)
35	Covered; creek bottom. Approximately	150	(45.7)	1190	(362.7)
34	Shale, black, splintery; rusty weathering; some concretions. Approximately	125	(38.1)	1040	(317.0)
33	Shale, black, splintery; rusty weathering; topped by 4 inches (101.6 mm) silty sandstone	25	(7.6)	915	(278.9)
	Shear				
32	Shale, black, splintery; rusty weathering; some concretions and few thin silty beds	15	(4.6)	890	(271.3)
	Shear				
31	Shale, black, splintery; rusty weathering	10	(3.0)	875	(266.7)
30	Shale, black, flaky to splintery; rusty weathering; few thin silty beds becoming more numerous toward top	82	(25.0)	865	(263.7)
29	Shale, rubbly to flaky; rusty weathering; several thin hard silty beds; mostly inaccessible	40	(12.2)	783	(238.7)
28	Shale, black, rubbly to flaky; rusty weathering	10	(3.0)	743	(226.5)
27	Shale, black, rubbly; rusty weathering; few concretions	35	(10.7)	733	(223.4)
26	Mudstone, silty; blocky; some hard beds of siltstone. Inaccessible	10	(3.0)	698	(212.8)
25	Shale, black, rubbly; rusty weathering	10	(3.0)	688	(209.7)
24	Shale, black flaky. Talus covered	55	(16.8)	678	(206.7)
23	Shale to mudstone, black, rubbly to blocky becoming flaky at top; some small dark weathering concretions	50	(12.2)	623	(189.9)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
22	Shale, black, flaky; few hard sandy beds at 60 feet (18.3 m); small dark grey weathering concretions, some pyritic centres; topped by 4 inch (101.6 mm) of silty to argillaceous, laminated sandstone	92	(28.0)	573	(174.7)
21	Shale, black, platy to flaky; few thin beds of sandstone at top	7	(2.1)	481	(177.1)
20	Shale, black, flaky to platy; concretions and beds of platy sandstone; concretionary beds, 3 to 4 inches (76.2-101.6 mm), at top	65	(19.8)	474	(144.5)
19	Shale, black, flaky to platy; some thin platy, silty lenses; thin dark weathering concretions; few thin sandstone lenses	17	(8.2)	409	(124.7)
18	Shale, black, flaky; numerous small concretions, dark grey weathering, some with pyritic centres; hard concretionary bed at top	49	(14.9)	382	(116.4)
17	Shale, black, flaky to platy; few hard sandy beds, 1 to 2 inches (25.4-50.8 mm); few concretions with pyritic centres; bentonite at 10 feet (3.4 m) and 19 ft (5.8 m)	44	(13.4)	333	(101.5)
16	Covered	16	(4.9)	289	(88.1)
15	Shale, black, flaky to platy; thin concretions in rows	10	(3.0)	273	(83.2)
14	Covered	15	(4.6)	263	(80.2)
13	Mudstone, silty, blocky to rubbly; slightly rusty weathering; brown weathering concretions; few thin seams of bentonite near top; shear at 30 feet (9.1 m)	50	(15.2)	248	(75.6)
12	Shale, black, blocky; numerous large concretions at base, becoming less numerous toward top. Inaccessible. Approximately	150	(45.7)	198	(60.3)
11	Sandstone, fine grained, laminated, cross-laminated, grey, siliceous; thick bedded; conglomerate at base	6	(1.8)	48	(14.6)
10	Mudstone, dark grey to black; bentonite at top	1	(0.3)	42	(12.8)
9	Sandstone, medium grained, grey, siliceous, pyritic; thick bedded; rusty to grey weathering	1	(0.3)	41	(12.5)
8	Mudstone and some sandstone	1	(0.3)	40	(121.2)
7	Sandstone, medium grained, grey, siliceous, pyritic; thick bedded; rusty to grey weathering	3.5	(1.1)	39	(11.9)
6	Shale	1	(0.3)	35.5	(10.8)
5	Sandstone, fine grained, grey, siliceous; thick bedded; rusty green weathering	6	(1.8)	34.5	(10.5)
4	Sandstone as above, with 3 inches (76.2 mm) of bentonite shale at top and base	1.5	(0.4)	28.5	(8.7)
3	Sandstone, fine grained, grey, siliceous; thick bedded; grey weathering	19	(5.8)	27	(8.2)
2	Sandstone, fine grained; some mudstone	1	(0.3)	8	(2.4)
1	Sandstone, fine grained, dark grey, siliceous; thick bedded; channel-fill at base.	7	(2.1)	7	(2.1)

TRIASSIC

Liard Formation

Sandstone, fine grained, grey, calcareous; thick bedded; brown weathering.

Section 65-4. Dunvegan Formation, escarpment east of Dunedin River, Tuchodi Lakes map-area, British Columbia, 58°52'N, 124°11'W. Measured in feet and converted to metres.

DUNVEGAN FORMATION

Top of ridge, end of exposures.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
25	Conglomerate, grey, massive; matrix of coarse grained sandstone; pebbles 1/8 to 2 inches (3.1-50.8 mm), some boulders up to 4 inches (101.6 mm); pebbles of quartz, chert, quartzite; blue, white, grey, black; partly inaccessible. Approximately	80	(24.4)	548	(167.0)
24	Conglomerate, grey, massive; much coarse grained sandstone matrix; pebbles ¼ to ½ inch (6.3-12.7 mm), as above	35	(10.7)	468	(142.6)
23	Covered. Farther along slope, the lower part of this interval appears to be mudstone, siltstone, and few seams of coal or coaly shale. The upper half may include conglomerate	80	(24.4)	433	(132.0)
22	Conglomerate, grey, massive; much coarse grained sandstone matrix; pebbles, ¼ to 1 inch (6.3-25.4 mm), average ¼ to ½ inch (6.3-12.7 mm). Top of this unit may be somewhat higher as large blocks cover slopes	25	(7.6)	353	(107.6)
21	Sandstone, coarse grained, grey, conglomeratic, massive; pebbles ¼ to ½ inch (6.3-12.7 mm)	20	(6.1)	328	(100.0)
20	Conglomerate, grey, massive; much coarse grained sandstone matrix; pebbles, ¼ to 4 inches (6.3-101.6 mm), average ½ to 1 inch (12.7-25.4 mm), rounded; quartz, quartzite, chert, argillite; red, green, blue, grey, white, black	30	(9.1)	308	(93.9)
19	Conglomerate, grey, massive; much coarse grained sandstone; pebbles as above	20	(6.1)	278	(84.7)
18	Sandstone, coarse grained, conglomeratic, brownish grey, massive; brownish grey weathering; crossbedded and cross-laminated; streaks and lenses of pebbles	10	(3.0)	258	(78.6)
17	Conglomerate, grey, massive; much coarse grained sandstone matrix; pebbles as above, maximum of 2 inches (50.8 mm)	11	(3.3)	248	(75.6)
16	Covered	12	(3.6)	237	(72.2)
15	Sandstone, silty, argillaceous, greenish grey, soft	2	(0.6)	225	(68.6)
14	Mudstone, very silty, olive green, blocky	7	(2.1)	223	(68.0)
13	Mudstone, dark grey to black, rubbly to blocky	6	(1.8)	216	(65.8)
12	Covered	6	(1.8)	210	(64.0)
11	Conglomerate, dark grey to brown extremely massive; dark grey weathering; pebbles ¼ to 2 inches (6.3 to 50.8 mm), averaging ½ to 1 inch (12.7 to 25.4 mm), rounded; quartz, quartzite, chert, argillite; red, green, blue, grey, white, black; some beds consist entirely of well sorted pebbles, others have matrix of coarse grained sandstone	52	(15.8)	204	(62.2)
10	Covered, recessive. Some flaky shale in talus	30	(9.1)	152	(46.3)
9	Siltstone, sandy argillaceous, laminated, dark olive grey; poorly bedded	4	(1.2)	122	(37.2)
8	Covered	5	(1.5)	118	(36.0)
7	Mudstone, very silty; some beds of argillaceous siltstone, olive brown	9	(2.7)	113	(34.4)
6	Covered, recessive. Talus of rubbly mudstone	10	(3.0)	104	(31.7)
5	Mudstone, silty, dark grey to black, blocky; dark grey weathering; few thin soft concretionary layers; some argillaceous siltstone at top	15	(4.6)	94	(28.7)
4	Siltstone, argillaceous, blocky to flaggy; some interbedded silty mudstone; dark grey weathering	7	(5.2)	79	(24.1)
3	Sandstone, fine grained, laminated, grey, siliceous; some crosslamination; massive to thick bedded; brown weathering; few intervals of platy sandstone; some concretionary masses	34	(10.4)	72	(21.9)
2	Covered, recessive. Presumably mudstone	21	(6.4)	38	(11.5)
1	Sandstone, fine grained, brownish grey, laminated, calcareous, cherty; massive, becoming thin bedded at top; some crossbedding; light yellow brown weathering; few small concretions.	17	(5.2)	17	(5.2)

FORT ST. JOHN GROUP

Sully Formation

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
1	Mudstone, silty, brownish grey, blocky; very sandy at top; some reddish brown weathering concretions.	4	(1.2)	4	(1.2)

End of exposure. Slopes below are covered with rubbly, rusty weathering shale and platy siltstone.

Section 65-5. Sikanni Formation, escarpment east of Dunedin River, Tuchodi Lakes map-area, British Columbia, 58°52'N, 124°12'W. Measured in feet and converted to metres.

Sikanni Formation

Top of ridge, end of exposure.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
68	Sandstone, medium grained, grey, siliceous; massive; some crossbedding; grades laterally and upward into coarse grained sandstone and conglomerate, massive but very lenticular; at least 15 feet (4.6 m) of conglomerate occurs near the top, well sorted; pebbles 1/8 to 1½ inches (3.2 to 38.1 mm). Approximately	40	(12.2)	1019	(310.6)
67	Sandstone, fine grained, laminated, cross-laminated, grey; flaggy; crossbedded; grey weathering	29	(8.9)	979	(298.4)
66	Covered	46	(14.0)	950	(289.6)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
65	Sandstone, fine grained, laminated, grey, siliceous; flaggy to thick bedded, some crossbedding; grey to brown weathering	31	(9.4)	904	(275.5)
64	Covered	17	(5.2)	873	(266.1)
63	Sandstone, fine grained, laminated, grey, siliceous; flaggy to thick bedded, some crossbedding; grey to brown weathering	37	(11.3)	856	(260.9)
62	Covered	73	(22.5)	819	(249.6)
61	Sandstone, fine grained, laminated, crosslaminated, grey, siliceous; thick bedded to massive; brown weathering	46	(14.0)	746	(227.4)
60	Sandstone, fine grained, laminated, grey, siliceous; platy to flaggy; some thin layers of shale and siltstone	24	(7.3)	700	(213.4)
59	Covered	33	(10.1)	676	(206.0)
58	Sandstone, fine grained, laminated, grey, siliceous; thick bedded to massive; brownish grey weathering	9	(2.7)	643	(196.0)
57	Covered	9	(2.7)	634	(193.2)
56	Sandstone, fine grained, laminated, grey, siliceous; thick bedded to massive; grey to brown weathering; some concretionary masses	64	(19.6)	625	(190.5)
55	Mudstone and sandstone (50%); becoming sandier at top and grading into overlying unit. Partly covered	25	(7.6)	561	(171.0)
54	Mudstone, very silty, blocky to platy; numerous thin platy beds of fine grained laminated sandstone and siltstone, 1 to 2 inches (25.4-50.8 mm), increasing toward top and grading into overlying unit; reddish brown weathering concretions	33	(10.1)	536	(163.4)
53	Mudstone, blacky, silty, blocky; becoming very silty at top with small reddish brown weathering concretions; 6 inches (152.4 mm) fine grained, crosslaminated, grey sandstone at top. Partly covered	7	(2.1)	503	(153.3)
52	Sandstone, fine grained, silty; poorly bedded; rusty brown weathering; some concretions	2	(0.6)	496	(151.2)
51	Mudstone, very silty, black, blocky	2	(0.6)	494	(150.6)
50	Sandstone, fine grained, laminated, grey, siliceous; thick bedded; rusty to brown weathering	3	(0.9)	492	(150.0)
49	Mudstone, very silty, black, blocky	3	(0.9)	489	(149.0)
48	Sandstone and interbedded mudstone	2	(0.6)	486	(148.1)
47	Sandstone, fine grained, laminated, cross-laminated, grey, siliceous; flaggy to thin bedded; brown weathering	2	(0.6)	484	(147.5)
46	Mudstone, silty, black, blocky; rusty weathering; few thin beds of argillaceous sandstone; becoming very silty at top and grading into overlying unit; some concretions	16	(4.9)	482	(146.9)
45	Sandstone, fine grained, laminated, grey, siliceous; thin to thick bedded; rusty weathering; some interbedded mudstone at base	5	(1.5)	466	(142.0)
44	Mudstone, black, blocky; rusty weathering; grades into overlying unit; numerous small concretions at base	18	(5.5)	461	(140.5)
43	Mudstone, coaly, black	3	(0.9)	443	(135.0)
42	Sandstone, fine grained, laminated, siliceous; thin to thick bedded; brown weathering	3	(0.9)	440	(134.1)
41	Mudstone, blocky; some concretions	2	(0.6)	437	(132.2)
40	Sandstone, fine grained, laminated, siliceous; thin to thick bedded; brown weathering; few small concretions	5	(1.5)	435	(132.6)
39	Mudstone, silty, black, blocky; grading upward into interbedded sandstone and mudstone	5	(1.5)	(430	(131.0)
38	Sandstone, fine grained, laminated, grey, siliceous; thick bedded; rusty weathering	2.5	(0.7)	425	(129.5)
37	Mostly covered. Mudstone, silty; platy at top	10.5	(3.2)	422.5	(128.8)
36	Sandstone, fine grained, grey; poorly bedded; rusty weathering; traces of wood fragments and logs	2	(0.6)	412	(125.6)
35	Mostly covered. Mudstone, black, flaky	9	(2.7)	410	(125.0)
34	Siltstone, sandy, blocky to bedded; rusty to grey weathering	2	(0.6)	401	(122.2)
33	Sandstone, fine grained, laminated, grey, crosslaminated, siliceous; thin to thick bedded; brown to grey weathering; ripple marks	10	(3.0)	399	(121.6)
32	Shale, coaly, black, platy	0.5	(0.1)	389	(118.6)
31	Mudstone, blocky; poorly exposed	6.5	(2.0)	388.5	(118.4)
30	Sandstone, fine grained, grey, laminated, crosslaminated, siliceous; flaggy to thick bedded; brown to rust weathering; some large ripples, producing wavy bedding; worm trails	10	(3.0)	382	(116.4)
29	Mudstone, black, rubbly	2	(0.6)	372	(113.4)
28	Sandstone, argillaceous and silty; poorly bedded; rust to grey weathering	3	(0.9)	370	(112.8)
27	Mudstone. Mostly covered	4	(1.2)	367	(111.9)
26	Sandstone, argillaceous, crosslaminated; poorly to irregularly bedded, thin bedded to massive; rust to grey weathering	7	(2.1)	363	(110.6)
25	Covered	7	(2.1)	356	(108.5)
24	Sandstone, fine grained, laminated, grey, siliceous; flaggy, to thick bedded at top; brown weathering; strongly crosslaminated; some mudstone and siltstone at base	10	(3.0)	349	(106.4)
23	Sandstone, fine grained, laminated, crosslaminated, grey, siliceous; flaggy at base with some platy siltstone; thick bedded at top; brown weathering	19	(5.8)	339	(103.3)
22	Sandstone, fine grained, laminated, some crosslamination, grey, siliceous; thick bedded; greyish brown to brown weathering; few reddish brown weathering concretionary masses	13	(4.0)	320	(97.5)
21	Covered	9	(2.7)	307	(93.6)
20	Sandstone, fine grained, laminated, grey, siliceous; thick bedded; light brown weathering	6	(1.8)	298	(90.8)
19	Sandstone, fine grained, laminated, crosslaminated, grey, siliceous; thin bedded; rusty weathering; interbedded mudstone and siltstone (40%), platy; few concretions	16	(4.8)	292	(89.0)
18	Covered, recessive	14	(4.3)	276	(84.1)
17	Sandstone, fine grained, laminated to mottled, grey, siliceous; flaggy to thin bedded; grey to brown weathering; some shaly to silty intervals	16	(4.9)	262	(79.8)
16	Mudstone, black, rubbly to blocky; rusty weathering; becoming very silty at top and grading into overlying unit; reddish brown weathering concretions	24	(7.3)	246	(75.0)
15	Mostly covered. Rubbly mudstone at base	19	(5.8)	222	(67.7)
14	Sandstone, fine grained, laminated, grey, siliceous; flaggy, becoming thicker bedded at top; some crossbedding; few concretions	24	(7.3)	203	(61.9)
13	Sandstone, fine grained, finely and uniformly laminated, some crosslamination, grey, siliceous; thick bedded; grey to light brown weathering; minor channel-fill structures; concretionary layer at top	29	(8.9)	179	(54.6)
12	Sandstone, fine grained, laminated, grey siliceous; some crosslamination; flaggy to thick bedded; grey to light brown weathering; few thin shaly intervals	12	(3.7)	150	(45.7)
11	Covered	8	(2.4)	138	(42.1)
10	Mudstone, black, silty, blocky to platy; rusty weathering; interbedded fine grained argillaceous sandstone, platy to flaggy	10	(3.0)	130	(39.6)
9	Partly covered. Mudstone, black; rusty weathering; few small reddish brown weathering concretions	21	(6.4)	120	(36.6)
8	Sandstone, fine grained, finely and uniformly laminated, grey, siliceous; thin to thick bedded; rusty grey weathering; few thin platy intervals; some large concretionary masses	10	(3.0)	99	(30.2)
7	Shale, silty, dark grey, platy; grading upward into overlying unit	2.5	(0.7)	89	(27.1)
6	Sandstone, fine grained, laminated, grey, siliceous; thin bedded to massive; brownish grey weathering; few thin shaly layers with small concretions	10.5	(3.2)	86.5	(26.4)
5	Shale, silty, black, platy; some siltstone and sandstone, platy to flaggy	3	(0.9)	76	(23.2)
4	Sandstone, fine grained, finely and uniformly laminated, grey, siliceous; thick bedded; grey weathering; few shaly beds	20	(6.1)	73	(22.2)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
3	Sandstone, fine grained, finely and uniformly laminated to homogeneous, grey, siliceous; thick bedded to massive; grey weathering; some crosslamination; few flaggy intervals; some small channel-fill structures, few concretions	23	(7.0)	53	(16.2)
2	Sandstone, fine grained, finely and uniformly laminated, grey, siliceous; thin- to thick-bedded; grey weathering; some crosslamination; some orange weathering concretions	17	(5.2)	30	(9.1)
1	Sandstone, fine grained, laminated, well sorted, grey, siliceous; flaggy to thin bedded; some platy, silty mudstone and siltstone, increasing toward top; all grey to brown weathering.	13	(4.0)	13	(4.0)
	Buckinghorse Formation				
	End of exposures. Slopes below covered by shale and sandstone talus.				

Section 65-6. Dunvegan Formation, Tsoo Tableland north of Kledo Creek, Maxhamish map-area, British Columbia, 59°01'N, 123°32'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
	Top of ridge, end of exposure.				
19	Conglomerate, grey, massive; grey weathering; pebbles 1/8 to 1 inch (3.2-25.4 mm), averaging ½ inch (12.7 mm), well rounded; coarse grained sandstone matrix	55	(16.8)	570	(173.7)
18	Sandstone, coarse grained, massive; grey weathering; some crossbedding and channelling; small pebbles disseminated throughout; grades laterally into conglomerate as above	11	(3.3)	515	(157.0)
17	Covered	38	(11.5)	504	(153.6)
16	Conglomerate, grey, massive; grey weathering; pebbles 1/8 to 3 inches (3.2-76.2 mm), averaging ½ to 1 inch (12.7-25.4 mm); much coarse grained sandstone matrix	13	(4.0)	466	(142.0)
15	Sandstone, medium grained, grey, soft to friable, recessive; thick bedded to massive; brown weathering; crossbedded	19	(5.8)	453	(138.1)
14	Conglomerate, grey, massive; grey weathering; pebbles 1/8 to 1 inch (3.2-25.4 mm), averaging ¼ to ½ inch (6.3-12.7 mm); much coarse grained sandstone matrix; partly inaccessible	40	(12.2)	434	(132.3)
13	Conglomerate, grey, massive; grey weathering; pebbles ½ to 2 inches (12.7-50.,8 mm), averaging 1 to 1½ inches (25.4-38.1 mm), much coarse grained sandstone matrix	12	(3.7)	394	(120.1)
12	Conglomerate, as below; pebbles average ½ inch (12.7 mm), some are 2 inches (50.8 mm); much sandstone matrix	12	(3.7)	382	(116.4)
11	Covered	8	(2.4)	370	(112.8)
10	Conglomerate, grey, massive; grey weathering; pebbles, well rounded; quartz, quartzite, chert, argillite; 1/8 to 1½ inch (3.2 to 38.1 mm); averaging ¼ to ½ inch (6.3-12.7); grey, blue, white, green, pink, black; much coarse grained sandstone matrix	28	(8.5)	362	(110.3)
9	Covered	3	(0.9)	334	(101.8)
8	Conglomerate, grey, massive; grey weathering; pebbles ¼ to ½ inch (6.3-12.7 mm); much sandstone matrix	20	(6.1)	331	(100.9)
7	Covered	82	(25.0)	311	(94.8)
6	Conglomerate, grey, massive; crossbedding; grey weathering; pebbles 1/8 to ½ inch (3.2-12.7 mm); averaging ¼ to ½ inch (6.3-12.7 mm) but larger toward top; much coarse grained sandstone matrix	48	(14.6)	229	(69.8)
5	Covered. May include some conglomerate at top	120	(36.6)	181	(55.2)
4	Sandstone, fine grained, laminated, cross-laminated, grey, flaggy to massive; crossbedded; brown weathering	26	(7.9)	61	(18.6)
3	Sandstone, coarse grained, and conglomerate (30%); massive; brown weathering; disseminated pebbles in sandstone	24	(7.3)	35	(10.7)
2	Conglomerate, grey, massive; pebbles ¼ to ½ inch (6.3 to 12.7 mm), well sorted and rounded; some sandstone matrix	7	(2.1)	11	(3.3)
1	Sandstone, medium grained, grey, siliceous, laminated, massive; crossbedded; brown weathering.	4	(1.2)	4	(1.2)
	Underlying beds not exposed.				

Section 65-7. Garbutt and Scatter Formations, on Chimney Creek between Lepine Creek and Scatter River, Toad River map-area, British Columbia, 59°32'N, 124°47'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Section measured north cliff above creek. For more complete Scatter section, see Section 65-8.				
	Scatter Formation				
1	Sandstone, fine grained, laminated, cross-laminated, grey; flaggy to thin bedded; grey weathering; some interbedded siltstone, silty sandstone, and flaky shale in basal 10 feet (3.1 m); somewhat wavy to irregularly bedded; some large concretions.	63	(19.2)	63	(19.2)
	Garbutt Formation				
9	Mudstone, silty, dark grey; grading upward into thin, platy siltstone with some sandstone at top; rusty weathering; banded appearance. Approximately	175	(53.3)	861	(262.4)
8	Covered. Estimated	200	(60.1)	686	(209.1)
7	Mudstone to shale, black, flaky to rubbly some thin, platy to flaggy sandy siltstone and fine grained sandstone, rusty weathering; striped or banded appearance; few reddish brown weathering concretions; some beds of sandstone toward top, 6 to 8 inches (152.4-203.2 mm); thick, lenticular to channel-fill	105	(32.0)	486	(148.1)
6	Mudstone to shale, flaky to rubbly; slightly rusty weathering; thin platy siltstone (20%); siltier at top, grading into overlying unit	25	(7.6)	381	(116.1)
5	Siltstone, argillaceous, sandy, laminated to homogeneous; interbedded mudstone (40%); one foot (0.3 m) of sandstone at top, fine grained, grey, brownish grey weathering; some concretions	26	(7.9)	356	(108.5)
4	Mudstone and siltstone; some reddish brown weathering concretions; few beds of sandstone with some crossbedding in sets of 3 to 5 inches (76.2-127.0 mm)	75	(22.9)	330	(100.6)
3	Mudstone, black, blocky to rubbly; lenses and thin beds of siltstone (20%) and some silty sandstone; some large reddish brown weathering concretions	35	(10.7)	255	(77.7)
2	Mudstone, black, blocky to rubbly; somewhat rusty weathering; numerous thin silty lenses and beds; banded or striped appearance; some concretions; becoming siltier at top. Some crossbedding or channel-fill is evident in beds of intercalated shale and siltstone	170	(51.8)	220	(67.0)
1	Covered. Estimated.	50	(15.2)	50	(15.2)
	Contact with Triassic Toad Formation is not exposed. For some distance downstream, mudflows and slides cover all bedrock. However, from bedding attitude, contact must be close to lowest exposure described above.				

Section 65-8A. Scatter Formation, on Chimney Creek between Lepine Creek and Scatter River, Toad River map-area, British Columbia, 59°32'N, 124°47'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Upper part of section measured on north cliffs above creek. For upper beds at creek level, see Sections 65-8B and 65-8C.				
	Top of ridge, end of exposure.				
	Lepine Formation				
2	Mudstone to siltstone, argillaceous, blocky to platy; some reddish brown weathering concretions	15	(4.6)	50	(15.2)
1	Shale to mudstone, rubbly to blocky; rusty weathering; very large reddish brown weathering concretions.	35	(10.7)	35	(10.7)
	Contact with underlying formation is gradational.				
	Scatter Formation				
	Tussock Member				
45	Siltstone, sandy, blocky to platy; large reddish brown weathering concretions	5	(1.5)	1241	(378.2)
44	Mudstone, silty, blocky; reddish brown weathering concretions; grades into overlying unit	23	(7.0)	1236	(376.7)
43	Siltstone, argillaceous to mudstone; blocky; rusty weathering	7	(2.1)	1213	(369.7)
42	Mudstone, blocky to rubbly; rusty weathering; reddish brown weathering concretions	14	(4.3)	1206	(367.6)

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
41	Siltstone, argillaceous; row of reddish brown weathering concretions at base	12	(3.7)	1186	(361.5)
40	Mudstone, black, rubbly to blocky; rusty weathering	12	(3.7)	1186	(361.5)
39	Siltstone, argillaceous, to mudstone, silty; platy; rusty weathering; reddish brown weathering concretions	8	(2.4)	1174	(357.8)
38	Mudstone, black, rubbly to blocky; rusty weathering; reddish brown weathering concretions; resistant silty unit in middle; grades into overlying beds	25	(7.6)	1166	(340.4)
37	Siltstone, sandy, argillaceous, laminated; blocky to thin bedded; some concretions and interbedded mudstone	29	(8.9)	1141	(347.8)
	Wildhorn Member				
36	Covered, recessive. Mudstone exposed in this interval elsewhere. Estimated	600	(1829)	1112	(338.9)
	Bulwell Member				
35	Sandstone, fine grained, laminated, grey; flaggy to thin bedded; brown weathering; interbedded mudstone (30%)	13	(3.9)	512	(156.0)
34	Siltstone, sandy to argillaceous; blocky to bedded; interbedded sandstone	5	(4.6)	499	(152.1)
33	Covered, recessive, presumably mudstone. Approximately	45	(13.7)	494	(150.6)
32	Mudstone, black, silty, blocky; interbedded platy siltstone; rusty weathering	12	(3.7)	449	(136.9)
31	Covered. Approximately	25	(7.6)	437	(133.2)
30	Siltstone, argillaceous; poorly bedded; blocky to massive	3	(0.9)	412	(125.6)
29	Covered	5	(1.5)	409	(124.7)
28	Sandstone, fine grained, laminated, glauconitic, siliceous	3	(0.9)	404	(123.1)
27	Mudstone, silty, highly glauconitic; blocky to platy	8	(2.4)	401	(122.2)
26	Sandstone, fine grained, laminated, glauconitic, siliceous; flaggy; some interbedded mudstone	3	(0.9)	393	(119.8)
25	Mudstone, black, silty, blocky; rusty weathering	6	(1.8)	390	(118.9)
24	Sandstone, fine grained, highly glauconitic, green, siliceous, laminated; platy to thin bedded	2	(0.6)	384	(117.0)
23	Covered. Highly glauconitic mudstone at top	4	(1.2)	382	(116.4)
22	Sandstone, fine grained, glauconitic, greenish grey, siliceous; platy to thin bedded; grey weathering; some interbedded mudstone	7	(2.1)	378	(115.2)
21	Covered at base. Mudstone, silty, blocky; some interbedded sandstone near top	52	(15.8)	371	(113.0)
20	Sandstone, fine grained, grey, laminated; flaggy to thin bedded; greenish brown weathering	11	(3.3)	319	(97.2)
19	Sandstone, fine grained, grey, laminated, glauconitic; thin to thick bedded, some crossbedding; brown weathering; few thin layers of mudstone; some reddish brown weathering concretions	15	(4.6)	308	(93.9)
18	Mudstone, platy; mostly covered	4	(1.2)	293	(89.3)
17	Sandstone, fine grained, highly glauconitic, laminated, crosslaminated, greenish grey, siliceous; flaggy to thick bedded; greenish grey weathering; some mottling; some thin layers of glauconitic mudstone; few reddish brown weathering concretions	9	(2.7)	289	(88.1)
16	Mudstone, sandy, greenish grey, highly glauconitic; green to rusty weathering	5	(1.5)	280	(85.3)
15	Covered. Approximately	25	(7.6)	275	(83.8)
14	Sandstone, fine grained, laminated, grey, siliceous; flaggy to thin bedded, wavy bedded; brown weathering	19	(5.8)	250	(76.2)
13	Sandstone, fine grained, laminated, glauconitic, grey; flaggy to thin bedded; interbedded silty, flaky shale	14	(4.3)	231	(70.4)
12	Siltstone, sandy, to sandstone, very fine-grained, argillaceous; laminated; blocky to poorly bedded	4	(1.2)	217	(65.1)
11	Sandstone, fine grained, laminated, glauconitic, greenish grey; flaggy to thin bedded; some reddish brown weathering concretions	5	(1.5)	213	(64.9)
10	Mudstone, black, very silty, blocky; grading into argillaceous siltstone; rusty weathering; some concretions	11	(3.3)	208	(63.4)
9	Sandstone, fine grained, laminated, greenish grey; some mottling at top; thick bedded	17	(5.2)	197	(60.0)
8	Sandstone, fine grained, laminated, greenish grey; flaggy to thick bedded; brown weathering; some crossbedding	21	(6.4)	180	(54.9)
7	Partly covered. Mainly sandstone as below	14	(4.3)	159	(48.5)
6	Sandstone, fine grained, homogeneous, greenish grey, glauconitic, siliceous; thick bedded; brown weathering; bedding is less prominent at top; slight crossbedding; mottled; worm burrows; reddish brown weathering concretions; large **Spirophyton**-like structures	27	(8.2)	145	(44.2)
5	Sandstone, fine grained, laminated, crosslaminated, glauconitic, greenish grey, siliceous; in part, argillaceous; flaggy to thick bedded but bedding is not prominent; reddish brown weathering concretionary masses	20	(6.1)	118	(36.0)
4	Sandstone, fine grained, laminated, crosslaminated, glauconitic, greenish grey; flaggy to thin bedded; brown to brownish grey weathering; some thin interbeds of silty mudstone; some concretionary masses	15	(4.6)	98	(29.9)
3	Sandstone, fine grained, laminated, grey; beds 2 to 8 inches (50.8-203.2 mm), slightly irregular; few thin layers of mudstone	24	(7.3)	83	(25.3)
2	Sandstone, fine grained, laminated, some crosslaminated, grey, glauconitic; beds 2 to 6 inches (50.8-152.4 mm); grey to brownish grey weathering; interbedded argillaceous siltstone; some concretions	35	(10.7)	59	(18.0)
1	Sandstone, fine grained, laminated, slightly argillaceous, grey; flaggy to platy; dark grey weathering; interbedded argillaceous siltstone and mudstone (25%); sandstone increases toward top; few reddish brown weathering concretions.	24	(7.3)	24	(7.3)
	Contact with underlying Garbutt Formation is transitional with only a downward decrease in number and thickness of sandstone beds until succession becomes entirely mudstone.				
	Garbutt Formation				
	Mudstone and interbedded siltstone (see Section 65-7).				

Section 65-8B. Tussock Member of Scatter Formation, on Chimney Creek between Lepine Creek and Scatter River, Toad River map-area, British Columbia, 59°32'N, 124°47'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	Thickness (m)	Height Above Base feet	Height Above Base (m)
	Measured on south side of creek.				
	End of exposure.				
	Scatter Formation				
	Tussock Member				
12	Siltstone, argillaceous to sandy, blocky	7	(2.1)	149	(45.4)
11	Mudstone, silty, blocky; grading upward into argillaceous siltstone with some sandy beds	13	(4.0)	142	(43.3)
10	Siltstone, sandy to argillaceous; blocky to bedded; rusty weathering	6	(1.8)	129	(39.3)
9	Mudstone, black, rubbly to blocky	19	(5.8)	123	(37.5)
8	Siltstone, sandy to argillaceous; blocky to bedded; rusty weathering	5	(1.5)	104	(31.7)
7	Mudstone, black, rubbly to blocky; rusty weathering; some reddish brown weathering concretions	8	(2.4)	99	(30.2
6	Sandstone, very silty to argillaceous; blocky to thin bedded; rusty weathering	7	(2.1)	91	(27.7)
5	Covered, recessive	28	(8.5)	84	(25.6)
4	Sandstone, silty to argillaceous, grey; blocky to thin bedded; grey weathering	10	(3.0)	56	(17.1)
3	Siltstone, sandy to argillaceous, laminated; grey weathering	8	(2.4)	46	(74.0)
2	Mudstone, black, silty, blocky; rusty weathering; grades into overlying unit	10	(3.0)	38	(11.6)
1	Siltstone, sandy to argillaceous, dark grey, blocky; rusty weathering; some lenses of laminated siltstone; some reddish brown weathering concretions.	28	(8.5)	28	(8.5)
	Wildhorn Member				
	Mudstone, black, silty, blocky; rusty weathering; reddish brown weathering concretions; grades into overlying unit.	25	(7.6)		
	End of continuous exposure.				

Section 65-8C. Tussock Member of Scatter Formation on Chimney Creek between Lepine Creek and Scatter River, Toad River map-area, British Columbia, 59°32'N, 124°47'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Measured on north side of creek.				
	Remainder of section is not readily measured but appears to consist of at least three more units of siltstone, each about 20 feet thick.				
	Scatter Formation				
11	Siltstone, argillaceous, blocky	5	(1.5)	115	(35.0)
10	Mudstone, silty, blocky	9	(2.7)	110	(33.5)
9	Siltstone, argillaceous, blocky; some mudstone; reddish brown weathering concretions	8	(2.4)	101	(30.8)
8	Mudstone, silty, blocky; some argillaceous siltstone, platy; grading into overlying beds	10	(3.0)	76	(23.2)
7	Siltstone, argillaceous, blocky; rusty weathering; reddish brown weathering concretions	7	(2.1)	83	(25.3)
6	Mudstone, silty, blocky; reddish brown weathering concretions	10	(3.0)	76	(23.2)
5	Siltstone, sandy; some argillaceous sandstone, blocky to thin bedded; reddish brown weathering concretions	14	(4.3)	66	(20.1)
4	Mudstone, silty, blocky; grading into siltstone	10	(3.0)	52	(15.8)
3	Siltstone, sandy to argillaceous; some sandstone, blocky to bedded; some concretions	6	(1.8)	42	(12.8)
2	Siltstone, argillaceous, blocky; grading downward into silty mudstone	27	(8.2)	36	(11.0)
1	Siltstone, sandy to sandstone, argillaceous; laminated; blocky to thin bedded; some cleaner sandstone at top; some interbedded mudstone; few concretions	9	(2.7)	9	(2.7)
	End of continuous exposure.				

Section 65-9. Lepine Formation, Liard River, east side and north of Lepine Creek, Toad River map-area, British Columbia, 59°29'N, 124°46'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Lepine Formation				
	End of accessible exposures.				
	Beds of Sikanni Formation occurring higher on escarpment and to the south are described in Section 65-15. However, those beds are several hundred feet above the following section.				
42	Shale and interbedded platy siltstone; few large yellowish concretions, 2' x 4', (0.6-1.2 m) and rows of reddish brown weathering concretions	110	(33.5)	2292	(698.6)
41	Shale, black, rubbly, and interbedded platy siltstone; rusty weathering; rows of reddish brown weathering concretions. 4 inches (1.2 mm) bed of cone-in-cone structure at 55 feet (16.8 m). Inaccessible	140	(42.7)	2182	(665.0)
40	Shale, black, rubbly; interbedded hard, platy, argillaceous siltstone (20%); rusty weathering; few concretions	40	(12.2)	2042	(622.4)
39	Shale, rubbly; rusty weathering; rows of reddish brown weathering concretions. Inaccessible	245	(74.7)	2002	(610.2)
38	Shale, rusty weathering. Inaccessible and partly covered. Approximately	200	(61.0)	1757	(535.5)
37	Shale, black, rubbly; rusty weathering; interbedded thin, platy, sandy siltstone (15%); banded appearance. Inaccessible	90	(27.4)	1557	(474.6)
36	Shale, black, rubbly; rusty weathering; some platy, hard, silty beds	60	(18.3)	1467	(447.1)
35	Shale, as below. Mostly covered	45	(13.7)	1407	(428.8)
34	Shale, black, rubbly to blocky; rusty weathering; few concretions; some cone-in-cone structure	40	(12.2)	1362	(415.1)
33	Shale, as below. Mostly covered. Approximately	100	(30.4)	1322	(402.9)
32	Shale, black, rubbly; rusty weathering. Mostly covered	35	(10.7)	1222	(372.5)
31	Covered. Approximately	30	(9.1)	1187	(361.8)
30	Shale, black, rubbly; rusty weathering. Inaccessible	45	(13.7)	1157	(352.6)
29	Shale, black, rubbly; rusty weathering; few rows of reddish brown weathering concretions and few disseminated concretions (base of waterfall)	20	(6.1)	1112	(338.9)
28	Shale, black, rubbly; rusty weathering	10	(3.0)	1092	(332.8)
27	Shale, black, rubbly; rusty weathering; some reddish brown weathering concretions	30	(9.1)	1082	(329.8)
26	Shale, as below. Partly covered. Approximately	45	(13.7)	1052	(320.6)
25	Shale, black, rubbly; rusty weathering; few reddish brown weathering concretions; selenite crystals	80	(24.4)	1007	(306.9)
24	Shale, black, rubbly; rusty weathering; mostly covered. Approximately	50	(15.2)	927	(282.5)
	(fork in creek and waterfall on main branch. Section above continues along northerly branch)				
23	Shale, black, rubbly; rusty weathering; reddish brown weathering concretionary layers	30	(9.1)	877	(267.3)
22	Covered	5	(1.5)	847	(258.2)
21	Shale, black, very rubbly; rusty weathering; few reddish brown weathering concretions; hard silty concretionary bed at top	45	(13.7)	842	(256.6)
20	Shale, black, very rubbly; rusty weathering. Mostly covered	68	(20.7)	797	(242.9)
19	Shale, black, very rubbly; rusty weathering; poorly developed concretionary zones	20	(6.1)	729	(222.2)
18	Shale, black, rubbly; rusty weathering; poorly developed concretionary zones	45	(13.7)	709	(216.1)
17	Shale, black, rubbly. Mostly covered	24	(7.3)	664	(202.4)
16	Shale, black, rubbly; rusty weathering; few concretions	15	(4.6)	640	(195.1)
15	Shale, black, rubbly; rusty weathering; few reddish brown weathering concretions	20	(6.1)	625	(190.5)
14	Covered	20	(6.1)	605	(184.4)
13	Shale, black, rubbly; rusty weathering; few reddish brown weathering concretions	85	(25.9)	585	(178.3)
12	Shale, black, rubbly; weathering; few thin reddish brown weathering concretions	50	(15.2)	500	(152.4)
11	Shale, black, rubbly; rusty weathering; some rows of thin reddish brown weathering concretions	105	(32.0)	450	(137.2)
	GSC Loc. 69185 **Stelckiceras liardense** (Whiteaves)				
10	Covered	5	(1.5)	345	(105.1)
9	Shale, black, rubbly; rusty weathering	15	(14.6)	340	(103.6)
8	Shale, black, rubbly to splintery; rusty weathering; some reddish brown weathering concretions; (waterfall)	35	(10.7)	325	(99.1)
	Shear and drag fold; little, if any, repetition of beds				
7	Shale, black, rubbly to splintery; rusty weathering; few reddish brown weathering concretions	40	(12.2)	290	(88.4)
	GSC Loc. 69180 **Stelckiceras liardense** (Whiteaves)				
6	Shale, black, rubbly to splintery; rusty weathering; some rows of reddish brown weathering concretions	55	(13.7)	250	(76.2)
	GSC Loc. 69182 Gastroplitid ammonites resembling **Stelckiceras liardense** (Whiteaves) more than any other representative of this species group but not identifiable definitively either generically or specifically				
5	Shale, black, rubbly to flaky; rusty weathering; rows of reddish brown to light yellow brown weathering concretions	30	(9.1)	195	(59.4)
4	Shale, black, rubbly; rusty weathering; thin reddish brown weathering concretions	25	(7.6)	165	(50.3)
3	Shale, as above. Mostly covered	35	(10.7)	140	(42.7)
2	Shale, black, flaky to rubbly; rusty weathering; some reddish brown weathering concretions	50	(15.2)	105	(32.0)
1	Shale, black, flaky; much yellow efflorescence; rows of reddish brown weathering concretions; thin bentonite layers at 21, 32, and 44 feet (6.4, 9.7 and 13.4 m); selenite crystals; many oval concretions with ammonites.	55	(16.8)	55	(16.8)
	GSC Loc. 69179 **Stelckiceras liardense** (Whiteaves) fish remains				

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	End of exposure; almost at river level.				
	The position of the Lepine-Scatter contact is probably about 200 to 300 feet (61.0-91.4 m) below. The upper Scatter is exposed farther upstream on the east side of the river.				

Section 65-10A. Dunvegan, Sully, Sikanni, and Lepine Formations, east side of Liard River, opposite Scatter River, Toad River map-area, British Columbia, 59°37'N, 124°40'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Top of ridge, end of exposures.				
	DUNVEGAN FORMATION				
6	Conglomerate, massive. Mostly covered to inaccessible. Approximately	300	(91.4)	611	(185.9)
5	Conglomerate, grey, massive; pebbles average 1 inch, (25.4 mm), some are 4 inches (101.6 mm); much sandstone matrix; pebbles consist of quartz, chert, quartzite, rounded to well rounded; blue, grey, white, black, green	60	(18.3)	311	(94.8)
4	Covered	125	(38.1)	251	(76.5)
3	Mudstone; 5-8 feet (1.5-2.4 m), sandstone in middle and about 10 feet (3.0 m) sandstone, massive, brown weathering, at top. Inaccessible	50	(15.2)	126	(38.4)
2	Lignite	1	(0.3)	76	(23.2)
1	Sandstone, argillaceous at base, becoming cleaner at top, friable; mostly not bedded; light grey weathering; some concretionary zones. Mostly inaccessible. Approximately.	75	(22.9)	75	(22.9)
	FORT ST. JOHN GROUP				
	Sully Formation				
	Upper concretionary member				
	See Section 65-10B for more detailed description of this member.				
25	Inaccessible. This interval consists of very silty mudstone elsewhere along slope. Approximately	100	(30.4)	997	(303.9)
24	Sandstone, fine grained, laminated, grey; poorly bedded; some is thick bedded to massive; concretionary at top	12	(3.7)	897	(273.4)
23	Mudstone, blocky; beds of flaggy sandstone, (20%). Mostly talus covered	20	(6.1)	885	(269.7)
22	Sandstone, fine grained, laminated, crosslaminated; grey weathering; flaggy	3	(0.9)	865	(263.6)
21	Shale, black; rusty weathering; some thin platy siltstone. Inaccessible or talus covered	125	(38.1)	862	(262.7)
20	Shale, black; rusty weathering; thin platy siltstone; few concretions	20	(6.1)	737	(224.6)
19	Covered	20	(6.1)	717	(218.5)
	Flaky shale member				
18	Shale, black, flaky to fissile; much yellow efflorescence; light grey weathering	130	(39.6)	697	(212.4)
17	Shale, black, flaky to fissile; interbedded platy siltstone (30%). This unit forms seepage horizon, giving dark colour along cliffs. Mostly inaccessible	21	(6.4)	567	(172.8)
16	Shale, black, flaky to fissile; some interbedded platy siltstone (10%-15%); light grey weathering	55	(16.8)	546	(166.4)
15	Shale, black, flaky to fissile; light grey weathering; much yellow efflorescence; hard silty bed at top. Mostly inaccessible	65	(16.8)	491	(148.7)
14	Mudstone to shale, black, flaky to fissile; light grey weathering; much yellow efflorescence; hard bed at top	70	(21.3)	426	(129.8)
13	Mudstone to shale, black, flaky, soft; grey weathering; yellow efflorescence. Mostly mud and talus covered	75	(22.9)	356	(108.5)
	Lower concretionary member				
12	Mudstone, black, rubbly to blocky; rusty weathering; rows of reddish brown weathering concretions	25	(7.6)	281	(85.6)
11	Mudstone as below. Mostly covered	20	(6.1)	256	(78.0)
10	Mudstone, black, rubbly; rusty weathering; few reddish brown weathering concretions	70	(21.3)	236	(71.9)
9	Mudstone as below. Mostly covered	10	(3.1)	166	(50.6)
8	Mudstone, black, rubbly; rusty weathering; few thin reddish brown weathering concretions	5	(3.0)	156	(47.5)
7	Mudstone, black, rubbly to blocky. Mostly mud covered	65	(19.8)	151	(46.0)
6	Mudstone, black, rubbly to blocky; grey to rusty weathering; some reddish brown weathering concretions	30	(9.1)	86	(26.2)
5	Mudstone, soft, black, rubbly. Mostly mud covered	10	(3.1)	56	(17.1)
4	Mudstone, soft, black, rubbly; grey weathering; some concretions in upper part	30	(9.1)	46	(14.0)
3	Mudstone, black, rubbly. Mostly covered	5	(1.5)	16	(4.9)
2	Mudstone, soft, dark brownish grey to black, rubbly; rusty weathering; rare reddish brown weathering concretions	10	(3.1)	11	(3.3)
1	Mudstone, silty, rubbly to blocky; 4 to 5 inches (101.6-127.0 m) conglomeratic sandstone, channel-fill at base; disseminated pebbles as much as 1 inch (25.4 mm) in diameter; 1 inch (25.4 mm) of fine conglomerate at top.	1	(0.3)	1	(0.3)
	Sikanni Formation				
15	Mudstone to argillaceous siltstone, rubbly to blocky; rusty weathering; platy to flaggy sandstone (20%), fine grained, laminated	14	(4.3)	433	(132.0)
14	Sandstone, fine grained, laminated, cross-laminated, grey; crossbedded; platy to thin bedded; grey weathering; some interbedded mudstone	5	(1.5)	419	(127.7)
13	Mudstone, black, rubbly; few thin platy beds of siltstone; rusty weathering	18	(5.5)	414	(126.2)
12	Siltstone, argillaceous, and mudstone, silty, black; interbedded fine grained sandstone, laminated, grey, grey weathering, platy to flaggy, crossbedded; very sandy in upper 2 feet (0.6 m)	11	(3.3)	396	(120.7)
11	Mudstone, silty, blocky; interbedded siltstone, sandy, laminated, platy, (20%), grey weathering; some concretions	22	(6.7)	385	(117.3)
10	Mudstone as below. Mostly covered	90	(27.4)	363	(110.6)
9	Mudstone, black, blocky; rusty weathering; few reddish brown weathering concretions	10	(3.0)	273	(83.2)
8	Mudstone, blocky; some rows of concretions; prominent 6 inches (152.4 mm) beds of concretionary sandstone at top	32	(9.7)	263	(80.2)
7	Mudstone, black, rubbly; rusty weathering; numerous rows of reddish brown weathering concretions, spaced 1 to 2 inches (25.4-50.8 mm); banded appearance; few concretions above 45 feet (13.7 m)	80	(24.4)	231	(70.4)
6	Mudstone, black, rubbly; rusty weathering. Mostly talus covered	30	(9.1)	151	(46.0)
5	Mudstone, black, rubbly to blocky; rusty weathering; few rusty weathering concretions	50	(15.2)	121	(36.9)
4	Mudstone, black, rubbly to blocky; rusty weathering; rows of reddish brown weathering concretions; some fine-grained, grey, platy to flaggy sandstone; definite bedded appearance; thin bed of conglomeratic sandstone between 35 feet (10.7 m) and 40 feet (12.2 m) with some disseminated pebbles as much as one inch (25.4 mm) in diameter	40	(12.2)	71	(21.6)
3	Mudstone, black, rubbly to blocky; rusty weathering; few thin beds of concretionary sandstone	20	(6.1)	31	(9.4)
2	Mudstone, black, rubbly to blocky; rusty weathering; few 1 to 2 inches (25.4 to 50.8 mm) beds of concretionary sandstone; some concretions	10	(3.0)	11	(3.3)
1	Sandstone, fine grained, laminated, grey; platy to thin bedded; slightly rusty weathering; concretionary at top.	1	(0.3)	1	(0.3)
	Lepine Formation				
17	Mudstone, black, rubbly to blocky; rusty weathering; some reddish brown weathering concretions; selenite crystals	61	(18.6)	930	(283.5)
16	Mudstone, black, rubbly; rusty weathering; few small reddish brown weathering concretions; three prominent rows of reddish brown weathering concretions at top	122	(37.2)	869	(264.9)
15	Mudstone, as below	20	(6.1)	747	(227.7)
14	Mudstone, black, rubbly; rusty weathering; few reddish brown weathering concretions	40	(12.2)	727	(221.6)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
13	Mudstone, black. Mostly covered	60	(18.3)	687	(209.4)
12	Mudstone, black, rubbly; some concretions	85	(25.9)	627	(191.1)
11	Mudstone, black, rubbly; rusty weathering; some concretions	60	(18.3)	542	(165.2)
10	Mudstone, black, rubbly to blocky; rusty weathering; few concretions	35	(10.7)	482	(146.9)
9	Mudstone, black, silty, blocky; some rows of concretions. Inaccessible and partly covered	75	(22.9)	447	(136.2)
8	Mudstone, black, silty, blocky; rusty weathering; some concretions	65	(19.8)	372	(113.4)
7	Mudstone, black, rubbly to blocky. Inaccessible	52	(15.8)	307	(93.6)
6	Mudstone, black, rubbly to blocky; rusty weathering; some concretions	95	(28.9)	255	(77.7)
5	Mudstone, black, blocky; some thin hard platy siltstone beds (10%); some concretions	30	(9.1)	160	(48.8)
4	Mudstone, black, blocky; rusty weathering; some reddish brown weathering concretions; row of light yellow brown weathering concretions at top	20	(6.1)	130	(39.6)
3	Mudstone, rubbly; rusty weathering; large reddish brown weathering concretions, 6 to 8 inches x 2 to 4 feet (152.4-203.2 mm x 0.6-1.2 m)	20	(6.1)	110	(33.5)
2	Mudstone, black, rubbly to blocky; rusty weathering; selenite crystals; rows of reddish brown weathering concretions; 6 inch (152.4 mm) bed of cone-in-cone structure at top, capped by concretionary material	60	(18.3)	90	(27.4)
1	Mudstone, black, rubbly to blocky; rusty weathering; reddish brown weathering concretions; few very large "kettle" concretions near top.	30	(9.1)	30	(9.1)
	River level, end of exposure.				

Section 65-10B. Upper Concretionary Member of Sully Formation, east side of Liard River, opposite Scatter River, Toad River map-area, British Columbia, 59°37'N, 124°40'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
	Remainder of formation is inaccessible at this locality.				
9	Sandstone, white weathering; poorly bedded; coal at top. Inaccessible	15	(4.5)	154	(46.9)
8	Mudstone and interbedded sandstone. Inaccessible	15	(4.5)	139	(42.4)
7	Sandstone, fine grained, soft and friable; crossbedded; some conglomerate with pebbles 1/8 to ¼ inch (3.1-6.3 mm)	15	(4.5)	124	(37.8)
6	Coal, sub-bituminous, black	1	(0.3)	109	(33.2)
5	Sandstone, fine grained, homogeneous, grey, soft, and friable; poorly bedded; grey weathering	24	(7.3)	108	(32.9)
4	Siltstone, very argillaceous, soft, dark grey; grades into overlying beds	5	(1.5)	84	(25.6)
3	Sandstone, grey, very friable and soft, fine grained, laminated, argillaceous; grey weathering	8	(2.4)	79	(24.1)
2	Mudstone, very silty, and argillaceous sandstone	25	(7.6)	71	(21.6)
1	Sandstone, fine grained, argillaceous, laminated, grey, soft to friable; poorly bedded, some beds of mudstone	46	(14.0)	46	(14.0)
	Sully Formation				
	Upper concretionary member				
8	Mudstone, silty; interbedded sandstone, fine grained, laminated, flaggy to thin bedded	23	(7.0)	308	(93.9)
7	Sandstone, fine grained, laminated; flaggy to thin bedded	9	(5.8)	285	(86.9)
6	Mudstone, very silty, blocky; some interbedded sandstone; sandier at top	45	(13.4)	276	(84.1)
5	Sandstone, fine grained, laminated, grey; flaggy to thin bedded; grey weathering; some slump structures; some mudstone	8	(2.4)	231	(70.4)
4	Mudstone, silty, blocky; rusty to brown weathering; fine grained, laminated sandstone (20%), platy to flaggy; some concretions	23	(7.0)	223	(68.0)
3	Sandstone, fine grained, laminated, friable, grey; thick bedded; grey weathering	3	(0.9)	200	(61.0)
2	Mudstone, rubbly, soft, black to brownish grey; rusty to brown weathering; some thin layers of sandstone; concretions	182	(55.5)	197	(60.0)
1	Mudstone, black, rubbly to blocky; rusty weathering; some sandy beds and concretions.	15	(4.8)	15	(4.8)
	Underlying beds are part of Flaky shale member.				

Section 65-11. Type section of Scatter Formation, Scatter River about 1 mile upstream from Liard River, Toad River map-area, British Columbia, 59°37'N, 124°44'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Lepine Formation				
	About 50 to 60 feet (15.2 to 18.2 m) of shale is exposed above the following units but is inaccessible. Section begins on south side of river.				
2	Mudstone, black, rubbly to blocky; rusty weathering; some very large reddish brown weathering concretions; shale becomes very silty at top; row of large concretions at top	50	(15.2)	90	(27.4)
	GSC loc. 69168 **Gastroplites kingi** McLean **Gastroplites canadensis** (Whiteaves) (common) **Gastroplites** sp. indet. (rare)				
	GSC loc. 69169 **Inoceramus** cf. **I. cadottensis** McLearn var. **altifluminis** McLearn				
	GSC loc. 69170 **Gastroplites kingi** McLearn **Gastroplites aff. G. canadensis** (Whiteaves) **Gastroplites spiekeri** McLearn (rare) Indeterminate gastroplitid ammonite				
	GSC loc. 69171 **Gastroplites kingi** (Whiteaves)				
1	Mudstone, black, silty, blocky; rusty weathering; some large reddish brown weathering concretions; glauconite.	40	(12.2)	40	(12.2)
	Contact is gradational without pronounced change from siltstone to mudstone.				
	Scatter Formation				
	Tussock Member				
82	Siltstone, sandy, mottled, grey; blocky to bedded; grey weathering; some concretions	9	(2.7)	1143	(348.4)
81	Concretionary layer, reddish brown weathering	1	(0.3)	1134	(345.6)
80	Mudstone, silty, blocky	8	(2.4)	1133	(345.3)
79	Siltstone, argillaceous to sandy, blocky to massive; large reddish brown weathering concretions	9	(2.7)	1125	(342.9)
78	Mudstone, silty, black, blocky; grey weathering; grades into overlying unit	10	(3.0)	1116	(340.2)
77	Sandstone, fine grained, silty to argillaceous, blocky to massive; mottling; some reddish brown weathering concretions; large **Spirophyton**(?) structures	8	(2.4)	1106	(337.1)
76	Siltstone, very argillaceous, to mudstone, blocky to massive; grey weathering; some large concretions	24	(7.3)	1098	(334.7)
75	Sandstone, silty to argillaceous, mottled, grey, massive to blocky; worm burrows; large reddish brown weathering concretions at base	6	(1.8)	1074	(327.3)
74	Mudstone, very silty, black, blocky; large reddish brown weathering concretions	7	(2.1)	1068	(325.5)
73	Sandstone, silty to argillaceous, fine grained, grey, laminated; thin to thick bedded; grey weathering	6	(1.8)	1061	(323.4)
72	Mudstone, black, blocky. Inaccessible	10	(3.0)	1055	(321.6)
	(section continues on north side of river)				
71	Sandstone, fine grained, laminated, grey; poorly bedded; flaggy to thin bedded, crossbedded; brown weathering	23	(7.0)	1045	(318.5)
70	Sandstone, fine grained, laminated, silty, grey; flaggy to thin bedded; some interbedded mudstone; **Spirophyton**-like structures	20	(6.1)	1022	(308.5)
69	Covered	10	(3.0)	1002	(305.4)
68	Sandstone, argillaceous to silty, olive grey; poorly bedded; light brown weathering	35	(10.7)	992	(302.4)
67	Siltstone, argillaceous to sandy, olive grey; blocky to bedded; some concretions	10	(3.0)	957	(291.7)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
66	Mudstone, very silty, to argillaceous siltstone; blocky to bedded; rusty weathering; few reddish brown weathering concretions; grading upward into sandy siltstone as above; worm markings	15	(4.6)	947	(288.6)
65	Siltstone, argillaceous, blocky; grading upward into argillaceous, bedded, fine grained sandstone	7	(2.1)	932	(284.1)
64	Mudstone to argillaceous siltstone, blocky; rusty weathering; some reddish brown weathering concretions	5	(1.5)	925	(281.9)
63	Siltstone, argillaceous, olive brown, blocky; grading upward into sandstone, fine grained, siliceous, grey, flaggy to thin bedded	9	(2.7)	920	(280.4)
62	Siltstone to sandstone, very fine grained, argillaceous, laminated, grey, slightly mottled; poorly bedded; grading upward into laminated sandstone, fine grained, thin bedded; reddish brown weathering concretions	18	(5.5)	911	(277.7)
	Wildhorn Member				
61	Mudstone, very silty; grades upward into argillaceous siltstone, blocky to bedded, rusty weathering; some concretions	60	(18.3)	893	(272.2)
60	Siltstone, laminated, argillaceous; interbedded sandstone, fine grained, laminated, flaggy; some small reddish brown weathering concretions	2	(0.6)	833	(253.9)
59	Mudstone, black, silty, blocky; rusty weathering; grades upward into argillaceous siltstone; some reddish brown weathering concretions in upper part	39	(11.9)	831	(253.3)
58	Mudstone, black, silty, blocky; rusty weathering; grades into argillaceous siltstone; two prominent reddish brown weathering concretionary beds at base and one at top	10	(3.0)	792	(241.4)
57	Mudstone, black, rubbly to blocky; rusty weathering; some concretions	71	(21.6)	782	(238.3)
56	Mudstone, black, rubbly; rusty weathering; rare reddish brown weathering concretions	60	(18.3)	711	(216.7)
55	Mudstone, black, rubbly to blocky; rusty weathering; some concretions, 6 to 8 inches x 12 to 18 inches (152.4-203.2 mm x 0.3-.5 m)	65	(19.8)	651	(198.4)
54	Mostly covered at river level but mudstone exposed in slopes above. Approximately	175	(53.3)	586	(178.6)
	Bulwell Member				
53	Sandstone, fine grained, laminated, glauconitic, siliceous, grey; thin to thick bedded; grey weathering; interbeds of silty mudstone; some reddish brown weathering concretions	7	(2.1)	411	(125.3)
52	Mudstone, black, silty, blocky; rusty weathering; highly glauconitic in upper 1 foot	14.5	(4.4)	404	(123.1)
51	Mudstone, black, silty, blocky; rusty weathering; 6 inches silty glauconitic sandstone at top; some large reddish brown weathering concretions	7	(2.1)	389.5	(118.7)
50	Mudstone, black, silty, blocky; rusty weathering; grading upward into argillaceous, glauconitic siltstone	8	(2.4)	382.5	(116.6)
49	Sandstone, fine grained, laminated, glauconitic, siliceous, greenish grey, well sorted; flaggy to thin bedded, crossbedded; grey to greenish grey weathering; some interbedded glauconitic mudstone; reddish brown weathering concretions and concretionary layers	19	(5.8)	374.5	(114.1)
48	Mudstone, silty, to siltstone, argillaceous, glauconitic, blocky; rusty weathering	5	(1.5)	355.5	(108.3)
47	Sandstone, fine grained, laminated, glauconitic, grey; flaggy to thin bedded; some interbedded rusty weathering mudstone; concretionary layer at base	1.5	(0.5)	350.5	(106.8)
46	Mudstone, green, highly glauconitic	1	(0.3)	349	(106.4)
45	Mudstone, black, silty, glauconitic, blocky; rusty weathering	10	(3.0)	348	(106.1)
44	Mudstone, black, silty, glauconitic, blocky; rusty weathering; some laminated siltstone at top; row of reddish brown weathering concretions and glauconite at base	8.5	(2.6)	338	(103.0)
43	Sandstone, fine grained, glauconitic, siliceous, grey; flaggy to thin bedded; grey to greenish grey weathering; very shaly at top; interbedded mudstone and siltstone in 2 to 6 inch (50.8-152.4 mm) beds; some reddish brown weathering concretions	8	(2.4)	329.5	(100.4)
42	Mudstone, silty, blocky; highly glauconitic at top	5	(1.5)	321.5	(98.0)
41	Mudstone, silty, glauconitic, blocky; rusty weathering; thin laminated, fine grained, glauconitic sandstone at top	3.5	(1.0)	316.5	(96.5)
40	Mudstone, highly glauconitic, green; thin, interbedded, laminated, glauconitic sandstone	1	(0.3)	313	(95.4)
39	Mudstone to siltstone, argillaceous, blocky, glauconitic; rusty weathering; some reddish brown concretions	8	(2.4)	312	(95.1)
38	Mudstone, silty, black, glauconitic, blocky; rusty weathering; thin, highly glauconitic sandstone at top; some reddish brown weathering concretions	14	(4.3)	304	(92.6)
37	Siltstone, argillaceous, glauconitic; grading into laminated sandstone at top	2	(0.6)	290	(88.4)
36	Mudstone, black, silty, highly glauconitic; green to rusty weathering; concretionary layer at base	2	(0.6)	288	(87.8)
35	Sandstone, fine grained, laminated, crosslaminated, siliceous, glauconitic, well sorted, greenish grey; flaggy to thin bedded; some thin layers of silty mudstone; greenish grey weathering; large reddish brown weathering concretionary masses	4	(1.2)	286	(87.2)
34	Mudstone, silty, black, glauconitic, blocky; rusty weathering; few lenses of laminated, glauconitic siltstone	5	(1.5)	282	(85.9)
33	Sandstone, fine grained, laminated, greenish grey	1.5	(0.5)	277	(84.4)
32	Mudstone, silty, black, glauconitic, blocky; rusty weathering	4.5	(1.3)	275.5	(84.0)
31	Sandstone, fine grained, laminated, crosslaminated, greenish grey; greenish grey weathering; reddish brown weathering concretionary layer at base	1	(0.3)	271	(82.6)
30	Mudstone, very silty, highly glauconitic in upper half, blocky; rusty weathering; some large reddish brown weathering concretions; layers of glauconite near top	2.5	(0.7)	270	(82.3)
29	Sandstone, fine grained, laminated, crosslaminated, siliceous, glauconitic, grey; thin bedded, crossbedded; greenish grey weathering; thin interbeds of silty mudstone; few large concretions	4.5	(1.3)	267.5	(81.5)
28	Mudstone, black, glauconitic, blocky; rusty weathering; highly glauconitic at top	6	(1.8)	263	(80.2)
27	Mudstone, silty, black, highly glauconitic, blocky; rusty weathering; some layers of almost pure glauconite; some concretions	19	(5.8)	257	(78.3)
26	Sandstone, fine grained, laminated, crosslaminated, grey, siliceous, glauconitic; greenish grey weathering; some reddish brown weathering concretions	2	(0.6)	238	(72.5)
25	Mudstone, black, highly glauconitic; some platy siltstone; large irregular concretions	3	(0.9)	236	(71.9)
24	Sandstone, fine grained, laminated, crosslaminated, glauconitic; thin- to thick-bedded; thin layers of highly glauconitic mudstone; concretions	16	(4.9)	233	(71.0)
23	Mudstone, rusty weathering	3	(0.9)	217	(66.1)
22	Sandstone, fine grained, grey; not well bedded, crossbedded	4	(1.2)	214	(65.2)
21	Mudstone, black, rubbly to blocky; rusty weathering	9	(2.7)	210	(64.0)
20	Sandstone, very fine grained, siliceous, laminated, crosslaminated, grey; not well bedded, flaggy to thin bedded; grey weathering (weathers much darker than massive sandstone below); some crossbedding, channel-fill, and large-scale crossbedding; mottling and worm burrows; lenses and layers of platy siltstone and mudstone; some large concretions	27	(8.2)	201	(61.3)
19	Sandstone, argillaceous, grey, laminated; thin bedded, poorly bedded; grey weathering; concretionary masses; lower part grades down slope into sandstone of underlying unit	6	(1.8)	174	(53.0)
18	Sandstone, fine grained, laminated, siliceous, glauconitic, grey, well sorted; massive; grey weathering; few thin shaly intervals at base of large-scale crossbeds; large reddish brown to maroon weathering concretionary masses	17	(5.2)	168	(51.2)
17	Sandstone, fine grained, glauconitic, siliceous, grey; thick bedded to platy at top	2	(0.6)	151	(46.0)
16	Mudstone, black, platy; some platy siltstone; reddish brown weathering concretions	1	(0.3)	149	(45.4)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
15	Sandstone, fine grained, laminated, siliceous, glauconitic, well sorted, crosslaminated, grey; thick bedded; grey to light brownish grey weathering; large-scale crossbedding	12	(3.7)	148	(45.1)
14	Shale, platy; some siltstone and concretions	0.5	(0.1)	136	(41.4)
13	Sandstone, fine grained, laminated, well sorted, siliceous, glauconitic, grey; thick bedded to massive; grey to light brown weathering; few shaly intervals; large-scale cross-bedding and channel structures	12.5	(3.8)	135.5	(41.3)
12	Mudstone, platy, and argillaceous siltstone; lenses out along slope	1	(0.3)	123	(37.5)
11	Sandstone, fine grained, laminated, glauconitic, siliceous, grey; thick bedded to massive; grey to light brown weathering; large-scale crossbedding; some shaly intervals	12.5	(4.7)	122	(37.2)
10	Sandstone, fine grained, well sorted, glauconitic, siliceous, grey; flaggy to thick bedded; thin beds of platy siltstone and mudstone; much crossbedding and channel-fill structure	8.5	(2.6)	109.5	(33.4)
9	Sandstone, fine grained, laminated, glauconitic, siliceous, grey; massive; grey to light brown weathering; concretions and platy mudstone at base	6	(1.8)	101	(30.8)
8	Sandstone, fine grained, laminated, siliceous, well sorted, grey, glauconitic; thick bedded, crossbedded; grey to light brown weathering; some platy lenses	9	(2.7)	95	(28.9)
7	Sandstone, fine grained, laminated; platy; some concretions (these are the basal beds of a thick succession of sandstone with much large-scale crossbedding and channel structure)	1	(0.3)	86	(26.2)
6	Sandstone, fine grained, well sorted, glauconitic, laminated, siliceous, grey; thick bedded; grey to light brown weathering; lenses of platy siltstone; minor channelling and slump structures	5	(1.5)	85	(25.9)
5	Sandstone, as below; platy siltstone and concretions at top and base; grades into more massive sandstone along slope	1.5	(0.1)	80	(24.4)
4	Sandstone, fine grained, well sorted, glauconitic, siliceous, laminated, crosslaminated, grey; thick bedded to massive, crossbedded; grey to light brownish grey weathering; some concretionary zones	11.5	(3.5)	78.5	(23.9)
3	Sandstone, fine grained, laminated, crosslaminated, siliceous, grey; thin- to thick-bedded; grey weathering; glauconitic; few thin beds of platy siltstone and mudstone; some concretionary layers	11	(3.3)	67	(20.4)
	(section continues on south side of river)				
2	Sandstone, fine grained, laminated, crosslaminated, glauconitic, siliceous, grey; flaggy to thin bedded; brown to dark grey weathering; thin interbeds of mudstone; more thickly bedded at top; some reddish brown weathering concretions	28	(8.5)	56	(17.1)
1	Sandstone, fine grained, argillaceous, siliceous, brownish grey; poorly bedded with much slumping and contortion; brown weathering.	28	(8.5)	28	(8.5)
	Garbutt Formation				
4	Siltstone, argillaceous to sandy, grey; blocky to bedded; becoming very resistant and massive at top; olive grey weathering; reddish brown weathering concretions	34	(10.4)	120	(36.6)
3	Mudstone, silty, to argillaceous siltstone; platy; rusty weathering; reddish brown weathering concretions; grades into overlying beds	30	(9.1)	86	(26.2)
2	Mudstone, silty, blocky; rusty weathering; some reddish brown weathering concretions	45	(13.7)	56	(17.1)
1	Siltstone, argillaceous; blocky to bedded; rusty weathering; row of concretions at top.	11	(3.3)	11	(3.3)

End of continuous exposure.

Section 65-12. Garbutt Formation, south side of Scatter River, Toad River map-area, British Columbia, 59°38'N, 124°58'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Measurement begins on north side of river.				
	Scatter Formation				
	Sandstone, very fine to fine grained, laminated, grey, siliceous; thin to thick bedded; grey to brown weathering. Several units are exposed along escarpment.				
	Garbutt Formation				
13	Covered. There is a possibility that some lower sandstone of the Scatter Formation is not exposed. The measurement indicates a maximum thickness of the upper shales of the Garbutt	550	(167.6)	944	(287.7)
	Measurement continues in small tributary on south side of river, directly across from north escarpment.				
12	Mudstone, to argillaceous siltstone; resistant. Inaccessible. Estimated	75	(22.9)	394	(120.1)
11	Mudstone and interbedded sandstone; flaggy to thin bedded. Inaccessible. Estimated	25	(7.6)	319	(97.2)
10	Mudstone, very silty, and interbedded siltstone; some sandstone beds. Estimated	40	(12.2)	294	(89.6)
9	Mudstone, silty, black, blocky to platy; rusty weathering; interbedded platy siltstone, becoming siltier toward top; some slump structure; some large concretions	50	(15.2)	254	(77.4)
8	Sandstone, fine grained, laminated; flaggy; some concretions	1	(0.3)	204	(62.2)
7	Mudstone, black, rubbly; rusty weathering; some reddish brown weathering concretions	60	(18.3)	203	(61.9)
6	Mudstone, black, silty. Partly talus covered	18	(5.5)	143	(43.6)
5	Mudstone, black, silty, blocky to platy; rusty weathering; some reddish brown weathering concretions	30	(9.1)	125	(38.1)
	GSC loc. 48971 (110-115 ft above base section) **Bathysiphon** spp. **Hippocrepina barksdalei** (Tappan) - two specimens **Saccammina** sp. **Ammodiscus** sp., small, thin **Miliammina** sp., poorly preserved **Haplophragmoides concavus** (Chapman) - two specimens				
	GSC loc. C-48969 (100 to 105 ft above base section) **Bathysiphon** sp. **Hippocrepina** sp., small - one specimen **Saccammina** spp., poorly preserved **Ammodiscus** sp., small, poorly preserved - one specimen **Miliammina** sp. - one specimen **Haplophragmoides multiplum** Stelck and Wall - one specimen **H.** spp. **Ammobaculites** sp. - one specimen ?**Uvigerinammina** sp. - poorly preserved ?**Gravellina** sp., poorly preserved - two specimens				
4	Mudstone, black, blocky to platy; considerable crossbedding	20	(6.1)	95	(28.6)
3	Mudstone, black, blocky to platy; rusty weathering; interbedded platy argillaceous siltstone; shows considerable crossbedding; rows of reddish brown weathering concretions	15	(4.6)	75	(22.9)
	GSC loc. C-48961 (60-65 ft above base section) **Bathysiphon** spp. **Ammodiscus** spp., poorly preserved - one very small and one medium-sized species with one specimen each ?**Miliammina** sp. - one fragment **Haplophragmoides** sp. **Gaudryina nanushukensis** Tappan - two poorly preserved specimens **Gravellina** sp. - one specimen indeterminate agglutinated rectilinear forms.				
2	Mudstone, black, silty, rubbly to platy; rusty weathering; grading upward into interbedded, rusty weathering; mudstone and argillaceous platy siltstone; rows of reddish brown weathering concretions	45	(13.7)	60	(18.3)
	GSC loc. C-48954 (15-20 feet above base section) ?**Reophax** or ?**Ammobaculites** (incomplete) sp. **Haplophragmoides** sp. - dominant **Trochammina** sp. - two specimens ?**Uvigerinammina** sp. - two specimens				
1	Mudstone, black, silty, rubbly to platy; rusty weathering; thin platy siltstone; thin seam of bentonite at base; reddish brown weathering concretionary layers.	15	(4.6)	15	(4.6)
	Contact with underlying Triassic Toad Formation is not exposed at this locality. It is exposed upstream where the Garbutt shales lie directly on Toad beds. No conglomerate, pebbles, nor sandstone is present in the basal Garbutt. A thin seam of bentonite occurs 6 inches (152.4 mm) above the base. Another bentonite seam occurs about 2 feet (0.6 m) above the base in greenish glauconitic shale.				

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)

Note: The following two samples are from the exposure upstream from Section SI 65-12 where the Garbutt shales lie directly on the Triassic Toad Formation.

GSC loc. 48996 (about 20 ft above Triassic)
Bathysiphon sp.
Saccammina sp.
Glomospira corona Cushman and Jarvis - common
Glomospirella scaphoidea (McGill and Loranger)
Reophax sp.
Haplophragmoides concavus (Chapman)
H. sp.
Textularia sp.
Trochammina spp. - two species with one specimen each
Gaudryina tailleuri (Tappan)
?**Gravellina** sp., poorly preserved - two specimens.

GSC loc. 48999 (5-10 ft above Triassic)
Bathysiphon spp.
Saccammina spp.
Ammodiscus rotalarius Loeblich and Tappan
Glomospira corona Cushman and Jarvis - common
Glomospirella scaphoidea (McGill and Loranger)
Reophax troyeri Tappan
R. sp.
Haplophragmoides concavus (Chapman)
H. sp.
Trochammina sp. - one specimen
Gaudryina tailleuri (Tappan)

Section 65-13. Garbutt Formation, Toreva Creek, southwesterly tributary of Scatter River, Toad River map-area, British Columbia, 59°38'N, 124°52'W. Measured in feet and converted to metres.

This section was measured from creek level up the shale slope to the base of the Scatter sandstones. Most of the latter are inaccessible at this locality.

Scatter Formation

Sandstone, fine grained, laminated, thin to thick bedded. Inaccessible.

Garbutt Formation

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
14	Siltstone, argillaceous, blocky to bedded; massive appearance; some sandstone beds at top. Inaccessible. Approximately	50	(15.2)	924	(281.6)
13	Siltstone, argillaceous, blocky to platy; interbedded mudstone; rusty weathering	35	(10.7)	874	(266.4)
12	Mudstone, silty, blocky; grades upward into argillaceous, platy siltstone and interbedded mudstone; reddish brown weathering concretions	147	(44.8)	839	(255.7)
11	Mudstone, rubbly, becoming siltier and blocky near top; rusty weathering; some reddish brown weathering concretions. Mostly inaccessible	160	(48.8)	692	(210.9)
10	Mudstone, black, rubbly; rusty weathering; few reddish brown weathering concretions	55	(16.7)	532	(162.1)
9	Mudstone, black, rubbly to blocky; rusty weathering; platy to flaggy sandstone (15%); few concretions and topped by concretionary layer	52	(15.8)	477	(145.4)
8	Mudstone, black, rubbly; rusty weathering; becoming siltier at top with some platy siltstone; few rows of reddish brown weathering concretions	40	(12.2)	425	(129.5)
7	Mudstone, black, rubbly; rusty weathering; few concretions. Partly covered	15	(4.6)	385	(117.3)
6	Mudstone, as below; some rows of concretions. Mostly covered	33	(10.0)	370	(112.8)
5	Mudstone, to argillaceous siltstone, platy; rusty weathering; banded appearance	12	(3.7)	337	(102.7)
4	Sandstone, silty; fine grained, laminated, grey; platy to thin bedded; interbedded mudstone and platy siltstone (40-50%) in 2 to 12 inch (50.8-304.8 mm) beds, rusty weathering	27	(8.2)	325	(92.0)
3	Mudstone, talus covered	38	(11.5)	298	(90.8)
2	Covered. Approximately	·250	(76.2)	260	(79.2)
1	Mudstone, black, platy; rusty weathering; thin platy siltstone and glauconitic sandstone; large reddish brown weathering concretions. Partly covered.	10	(3.0)	10	(3.0)

Contact with underlying Triassic Toad Formation is abrupt without any trace of basal sandstone or conglomerate. Shale lies directly on calcareous siltstone and sandstone, medium to dark grey, platy to thin bedded, with some interbedded calcareous shale.

Section 65-14 Dunvegan Formation, north side of major bend in Beaver River about 8 miles upstream from junction with Crow River, Toad River map-area, British Columbia, 59°55'N, 124°17'W. Measured in feet and converted to metres.

DUNVEGAN FORMATION

End of exposure.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
20	Conglomerate, grey, massive; crossbedded; brown to grey weathering; pebbles ½ to 1 inch (12.7-25.4 mm)	15	(4.6)	377	(114.9)
19	Covered	8	(2.4)	362	(110.3)
18	Sandstone, very coarse grained, to very fine grained conglomerate; massive; brown weathering	23	(7.0)	354	(107.9)
17	Covered	4	(1.2)	331	(100.9)
16	Sandstone, conglomeratic; massive; crossbedded	11	(3.4)	327	(99.7)
15	Covered. Approximately	20	(6.1)	316	(96.3)
14	Sandstone, coarse grained to conglomeratic, brown; massive; crossbedded; brown weathering	10	(3.0)	296	(90.2)
13	Sandstone, coarse grained; conglomeratic with pebbles as much as 3 inches (76.2 mm); some layers of gravel; becoming finer grained toward top; massive; slightly friable	25	(7.6)	286	(87.2)
12	Sandstone and conglomerate, partly covered; recessive	12	(3.7)	261	(79.6)
11	Conglomerate, grey; massive; crossbedded; pebbles average 1 inch (25.4 mm), some as much as 4 inches (101.6 mm)	20	(6.1)	249	(75.9)
10	Conglomerate, grey; massive; pebbles average ½ inch (12.7 mm); much sandstone matrix	10	(3.0)	229	(69.8)
9	Conglomerate, grey; massive; grey weathering; pebbles average ½ to 1 inch (12.7-25.4 mm), some as much as 3 inches (76.2 mm); quartz, chert, quartzite; blue, grey, black, white, green	45	(13.7)	219	(66.7)
8	Siltstone, argillaceous, carbonaceous; platy; brown weathering	5	(1.5)	174	(53.0)
7	Sandstone, fine grained, brownish grey; massive	4	(1.2)	169	(51.5)
6	Mudstone. Mostly covered	20	(6.1)	165	(50.3)
5	Sandstone, fine grained, laminated, brownish grey; thin to thick bedded; interbedded mudstone, silty, (50%)	22	(6.7)	145	(44.2)
4	Sandstone, fine grained, brownish grey, laminated; massive; brown weathering; shaly interval in centre; partly covered at base	33	(10.1)	123	(37.5)
3	Covered	60	(18.3)	90	(27.4)
2	Conglomerate, grey; massive; grey weathering; pebbles 1/8 to 1 inch (3.2-25.4 mm); chert, quartz, quartzite; blue, grey, black, white; coarse grained sandstone matrix	25	(7.6)	30	(9.1)
1	Sandstone, coarse grained, conglomeratic, crosslaminated; massive.	5	(1.5)	5	(1.5)

End of exposures.

Section 65-15 Sikanni Formation, escarpment east of Liard River, northeast of Lepine Creek, Toad River map-area, British Columbia, 59°28'N, 124°46'W. Measured in feet and converted to metres.

Sikanni Formation

Top of ridge, end of exposure.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
9	Sandstone, fine grained, laminated, grey; thick bedded to massive; brown weathering; some coarser sandstone at top and blocks of conglomeratic sandstone in talus. Approximately	45	(13.7)	457	(139.3)
8	Mostly covered and inaccessible, recessive. Mudstone with some sandstone at top	110	(33.5)	412	(125.6)
7	Sandstone, fine grained, laminated, grey; thick bedded; light brown to grey weathering. Approximately	65	(19.8)	302	(92.0)
6	Sandstone, fine grained, laminated, grey, slightly argillaceous; flaggy; interbedded mudstone (25%) decreasing toward top	25	(7.6)	237	(72.2)
5	Mostly covered. Mudstone, black; becoming siltier at top with some sandstone; some reddish brown weathering concretions	58	(17.7)	212	(64.6)
4	Sandstone and mudstone; 2 to 4 inch beds (50.8-101.6 mm)	7	(2.1)	154	(46.9)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
3	Sandstone, fine grained, grey; platy to flaggy, to thin bedded; brownish grey weathering; some interbedded mudstone and siltstone (20%)	41	(12.5)	147	(44.8)
2	Mostly covered, recessive. Mudstone and siltstone, grading into overlying beds	80	(24.4)	106	(32.0)
1	Sandstone, fine grained, laminated, grey; flaggy to thin bedded; rusty brown to grey weathering; some crossbedding; interbedded mudstone (25%).	26	(7.9)	26	(7.9)
	Lepine Formation				
1	Mudstone, black, silty; slight rusty weathering; interbedded platy, hard siltstone; numerous concretionary layers.	112	(34.1)	112	(34.1)
	End of exposures.				

Section 65-16 Basal Lepine and upper Scatter Formations, east side of Liard River, opposite Garbutt Creek, Toad River map-area, British Columbia, 59°25'N, 124°50'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Lepine Formation				
9	Shale, black, flaky; much yellow efflorescence				
	GSC loc. 69174 Indeterminate gastroplitid ammonites fish vertebrae				
8	Shale, black, silty; rubbly to blocky; rusty weathering; numerous reddish brown weathering concretions; abundantly fossiliferous	350	(106.7)	1005	(306.2)
	GSC loc. 69176 [in upper 100 feet (30.4) - in place] **Gastroplites** aff. **allani** McLearn (predominates) **Gastroplites allani** McLearn (less common) **Gastroplites canadensis** (Whiteaves) (rare) **Gastroplites** aff. **stantoni** McLearn (= **G.** cf. **flexicostatus** Jeletzky (unique specimen) Indeterminate pelecypods				
	GSC loc. 69175 [in talus between 250 to 300 feet (76.2-91.4 m) above base] **Gastroplites** aff. forms transitional between **G. kingi** McLearn and **Gastroplites canadensis** (Whiteaves) **Gastroplites allani** McLean and variants (less common than either of other two species) **Inoceramus** cf. **cadottensis** McLearn				
	GSC loc. 69177 [in place approximately 260 feet (109.7 m) above base] **Gastroplites spiekeri** McLearn **Gastroplites** (s. lato) sp. indet. **Inoceramus** cf. **anglicus** Woods				
	GSC loc. 69173 [in talus at 250 feet (76.2 m) above base] **Gastroplites** cf. **kingi** McLearn **Gastroplites** cf. **G. canadensis** (Whiteaves) **Gastroplites**? sp. indet.				
	GSC loc. 69178 [in talus at 100 feet (30.4 m) above base] **Gastroplites kingi** McLearn and morphological variants				
	Scatter Formation (equivalent)				
7	Siltstone, argillaceous, blocky; rusty weathering; interbedded silty mudstone; reddish brown weathering concretions	55	(16.8)	655	(199.6)
6	Mudstone, black, blocky; rusty weathering; reddish brown weathering concretions	75	(22.9)	600	(182.9)
5	Mudstone, black, blocky; rusty weathering; reddish brown weathering concretions; few thin beds of siltstone	130	(39.6)	525	(160.0)
4	Mudstone, black, rubbly to blocky; becoming very silty at top; large reddish brown weathering concretions	120	(36.6)	395	(120.4)
3	Mudstone, black, rubbly; rusty weathering; large reddish brown weathering concretions	150	(45.7)	275	(83.8)
2	Covered. Estimated	75	(22.9)	125	(38.1)
1	Mudstone, black, rubbly; rusty weathering; reddish brown weathering concretions.	50	(15.2)	50	(15.2)
	Bulwell member				
	Sandstone, fine grained, silty to argillaceous, siliceous, brownish grey.				

Section 65-17. Dunvegan Formation, on escarpment east of Liard River, directly across from Scatter River, Toad River map-area, British Columbia, 57°38'N, 124°40'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	Most of section is inaccessible except along grassy slope at edge of cliffs.				
	DUNVEGAN FORMATION				
	Top of ridge, end of exposures.				
13	Covered	35	(10.7)	516	(157.3)
12	Conglomerate, grey; massive; crossbedded; pebbles average ½ inch (12.7 m) but some as much as 3 inches (76.2 mm), rounded; chert, quartzite, quartz, argillite; grey, green, red, blue, black, white; considerable sandstone matrix in upper part	85	(25.9)	481	(946.7)
11	Sandstone, soft, friable; flaggy; grades into overlying unit	20	(7.6)	396	(120.7)
10	Conglomerate, grey; massive; somewhat recessive	65	(19.8)	376	(114.6)
9	Mudstone, not well exposed	60	(18.3)	311	(94.8)
8	Conglomerate, grey; massive; brownish grey weathering; crossbedded; pebbles average ½ to 1 inch (12.7 to 25.4 mm), some as much as 3 inches (76.2 mm), rounded; quartz, chert, quartzite; green, grey blue, black white	65	(19.8)	251	(76.5)
7	Mudstone, brownish grey; thin interbeds of silty, concretionary sandstone	45	(13.7)	186	(56.7)
6	Sandstone, coarse grained to conglomeratic; massive; dark brown weathering; crossbedding	15	(4.6)	141	(43.0)
5	Mudstone, dark grey at base, rusty olive weathering at top; interbedded sandstone in upper part	20	(6.1)	126	(38.4)
4	Sandstone, coarse grained to conglomeratic; massive; dark brown weathering; crossbedded	15	(4.6)	106	(32.3)
3	Mudstone	15	(4.6)	91	(27.7)
2	Coal, black	1	(0.3)	76	(23.2)
1	Sandstone, fine- to medium-grained, friable; poorly bedded; light grey to white weathering; grades downward into underlying beds.	75	(22.9)	75	(22.9)
	Sully Formation				
	Mudstone, concretionary. Mostly covered.				

Section 65-18. Dunvegan Formation, at big bend of Liard River, west of Beaver River, Toad River map-area, British Columbia, 59°54'N, 124°29'W. Measured in feet and converted to metres.

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
	DUNVEGAN FORMATION				
	End of exposures.				
15	Conglomerate, grey; massive; pebbles as below, averaging ½ to 1 inch (12.7-25.4 mm), sandstone matrix	42	(12.8)	524	(159.7)
14	Mostly covered. Some mudstone with argillaceous and conglomeratic sandstone at base	35	(10.7)	482	(146.9)
13	Conglomerate, grey; massive; grey to brown weathering; pebbles ¼ to ½ inch (6.3-12.7 mm), maximum 1½ inches (38.1 mm); much sandstone matrix; becoming less conglomeratic and sandier at top	40	(12.2)	447	(136.2)
12	Covered, recessive. Appears to be friable conglomeratic sandstone	19	(5.8)	407	(124.1)
11	Conglomerate, massive; grey to brown weathering; pebbles average ¼ to ½ inch (6.3-12.7 mm); quartz, quartzite, argillite, chert; white, grey, green, blue, black, red; much sandstone matrix	55	(16.8)	388	(118.3)
10	Covered. Appears to be mainly conglomerate along cliffs to west	25	(7.6)	333	(101.5)
9	Conglomerate, massive; brown weathering; pebbles average 1½ inches (38.1 mm), maximum 6 to 7 inches (152.4-177.8 mm), decreasing in average size toward top; chert, quartzite; quartz, argillite; white, grey, green, blue, black, red; well washed but sandstone matrix increasing toward top	70	(21.3)	308	(93.9)

Unit	Lithology	Thickness feet	(m)	Height Above Base feet	(m)
8	Sandstone, very coarse grained to conglomeratic; numerous laminae of pebbles; crossbedded; gravelly	41	(12.5)	238	(72.5)
7	Mostly covered. Mudstone	19	(5.8)	197	(60.0)
6	Mostly covered, recessive. Mudstone with coal at top	17	(5.2)	178	(54.2)
5	Sandstone, fine grained, grey, laminated, soft and friable; crossbedded; massive; grey weathering; weathers recessive	17	(5.2)	161	(49.1)
4	Covered	85	(25.9)	144	(43.9)
3	Sandstone, fine grained, laminated, grey; massive; crossbedded; grey to light brownish grey weathering	30	(9.1)	59	(18.0)
2	Covered	25	(7.6)	29	(8.9)
1	Sandstone, fine grained, grey, laminated; massive; brown weathering.	4	(1.2)	4	(1.2)
	End of exposure.				

Section 65-19. Bulwell Member of Scatter Formation, west flank of anticline on Crow River, Toad River map-area, British Columbia, 59°51'N, 124°35'W. Measured in feet and converted to metres.

	Wildhorn Member				
	Shale, black. Inaccessible.				
	Bulwell Member				
16	Sandstone, silty to argillaceous; mottled; some interbedded mudstone. Mostly inaccessible	15	(4.6)	401	(122.2)
15	Mudstone to argillaceous siltstone, blocky	22	(6.7)	386	(117.6)
14	Sandstone, silty; blocky to thick bedded; brown weathering	9	(2.7)	364	(110.9)
13	Mudstone, very silty, blocky	5	(1.5)	355	(108.2)
12	Sandstone, silty, grey; blocky to thick bedded; brown weathering	7	(2.1)	350	(106.7)
11	Mudstone, very silty, blocky; some argillaceous siltstone	32	(9.7)	343	(104.5)
10	Sandstone, silty, argillaceous, glauconitic; thick bedded to blocky	5	(1.5)	311	(94.8)
9	Siltstone, sandy, grey, very argillaceous; blocky to massive; rusty weathering; grades into mudstone in upper half	17	(5.2)	306	(93.3)
8	Mudstone, silty, blocky. Partly covered	20	(6.1)	289	(88.1)
7	Mudstone, grading upward into argillaceous siltstone. Partly covered	32	(9.7)	269	(82.0)
6	Sandstone, argillaceous, silty, glauconitic, green to grey; platy; some interbedded glauconitic siltstone	12	(3.7)	237	(72.2)
5	Mudstone. Partly covered	20	(6.1)	225	(68.6)
4	Sandstone, fine grained, grey; massive to thick bedded; brown weathering	105	(32.0)	205	(62.5)
3	Siltstone and mudstone. Mostly covered	18	(5.5)	100	(30.4)
2	Sandstone, fine grained, laminated, siliceous, grey; flaggy to thick bedded; brown weathering; glauconitic	28	(8.5)	82	(25.0)
1	Sandstone, fine grained, grey, laminated, siliceous, glauconitic; flaggy to thick bedded; brown weathering; some silty mudstone in upper 14 feet (4.3 m).	54	(16.5)	54	(16.5)
	River level, end of exposure.				

INDEX

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada