GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

BULLETIN 63

CRETACEOUS ROCKS IN THE REGION OF LIARD AND MACKENZIE RIVERS, NORTHWEST TERRITORIES

D. F. Stott

Price, 75 cents

1960

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PREFACE

The Cretaceous sediments described in this report have considerable significance in the development of the Canadian petroleum industry. Cretaceous rocks of Liard and upper Mackenzie Rivers form the northern continuation of the Cretaceous succession in the provinces to the south, and the study provides many details needed to interpret Cretaceous seaways and their relationship to possible petroleum and gas reservoirs.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, October 28, 1959

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CRETACEOUS ROCKS IN THE REGION OF LIARD AND MACKENZIE RIVERS, NORTHWEST TERRITORIES

Abstract

Cretaceous rocks in southwestern Northwest Territories are described and their general distribution is outlined.

Lower Cretaceous rocks, all of Albian age and of marine origin, are included in the Fort St. John group which is divided into three formations. The Buckmghorse formation comprises basal conglomerate and sandstone and a thick succession of sideritic shale. The overlying Sikanni formation, restricted from its original definitions, contains glauconitic sandstone and siltstone. At the top, the newly defined Sully formation includes sideritic and gypsiferous shales, which are equivalent to rocks previously included by original definitions in the Sikanni formation.

Upper Cretaceous rocks are divided into the Fort Nelson, Kotaneelee, and Wapiti formations. The Fort Nelson formation, lying conformably on the Fort St. John group, is probably of Cenomanian age and consists of massive conglomerate and coarse-grained sandstone. No Turonian sediments are known in this region. The Kotaneelee formation, containing fossils of Santonian age, includes sideritic shale, some sandstone, and sandy glauconitic mudstone. The Wapiti formation contains coal, non-marine sandstone and shale.

Résumé

Le présent bulletin décrit les roches crétacées de la partie sud-ouest des Territoires du Nord-Ouest; il en indique aussi la distribution générale.

Des roches du Crétacé inférieur, toutes d'âge albien et d'origine marine, font partie du groupe Fort St. John, qui se divise en trois formations. La formation Buckinghorse comprend un conglomérat de base et du grès, ainsi qu'une épaisse succession de schiste sidérique. La formation surjacente Sikanni, moins étendue que ne le laissaient croire les premières définitions, contient du grès glauconieux et siltstone. Au sommet, la formation Sully nouvellement définie comprend des schistes sidériques et gypsifères, qui équivalent à des roches précédemment comprises dans la formation Sikanni telle que définie à l'origine.

Les roches du Crétacé supérieur se divisent en trois formations, savoir: Fort Nelson, Kotaneelee et Wapiti. La formation Fort Nelson, qui recouvre en concordance le groupe Fort St. John, remonte probablement au Cénomanien; elle est constituée de conglomérat massif et de grès à grain grossier. On n'a pas reconnu de sédiments turoniens dans cette région. La formation Kotaneelee, qui contient des fossiles d'âge santonien, comprend du schiste sidérique, une certaine quantité de grès et du mudstone glauconieux et sableux. La formation Wapiti se compose de houille, de grès d'origine non marine et de schiste.

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INTRODUCTION

Cretaceous rocks in the vicinity of Mackenzie and Liard Rivers were examined during the field season of 1957 as part of Operation Mackenzie. The region lies within the Northwest Territories between lat. 60° and 64° and extends from the western border of the Canadian Shield to long. 126° (Fig. 1).

This report is generalized due to the size of the region, the lack of closely spaced sections, and the poor exposures. Large parts of region, covered by muskeg and dense bush, are apparently underlain by Cretaceous sediments (Fig. 1) but exposures are isolated. Moreover, many of the outcrops are obscured by mudflows and talus, which makes detailed studies almost impossible.

The Cretaceous sequence is best known around Fort Liard, where it is exposed along several canyons. In the Plains, outcrops have been studied on and around Cameron Hills, Horn Plateau, Ebbutt Hills, and Martin Hills (Fig. 1); farther north, several have been examined along Redstone and Dahadinni Rivers.

Previous Work

One of the first geologists to visit the region was R. G. McConnell (1890)[1] who descended Liard and Mackenzie Rivers and reported several outcrops. The country around Great Slave Lake and Hay River was explored by Cameron (1922) in 1916 and 1917. Whittaker (1922, 1923), who spent the seasons of 1921 and 1922 along Mackenzie River between Great Slave Lake and Fort Simpson, examined rocks around Horn Plateau as well as along Trout River and other streams. Dowling (1922) worked farther north towards Fort Norman; Williams (1922) visited the region around Ebbutt Hills; Hume (1923, 1924) made a reconnaissance study of part of the Liard River and examined outcrops on Dahadinni and Redstone Rivers. A more detailed study of Cretaceous rocks around Fort Liard was made by Hage (1945), who mapped part of Petitot and Kotaneelee Rivers. Kindle (1944) studied rocks in the Liard region adjacent to the southern limits of Operation Mackenzie, and geologists of the Canol project mapped Cretaceous rocks near Mackenzie River north of Camsell Bend (Hume, 1954).

Acknowledgments

The regional boundaries of the Cretaceous system and its subdivisions are shown on the geological maps compiled by R. J. W. Douglas and D. K. Norris, included as Figures 1 and 2. W. B. Brady examined localities along the headwaters of La Biche River, and B. G. Craig and D. J. McLaren examined outcrops around Horn Plateau. The lithologic samples of the Imperial Island River No. 1 well were described by H. R. Belyea.

Invertebrate macrofossils were identified by J. A. Jeletzky, whose detailed comments, zonal and stage assignments have served as the basis of correlation; microfossil studies were made by R. T. D. Wickenden.

Capable assistance was given in the field by K. Broeder.

[1]Dates in parentheses are those of references cited on p. 2.

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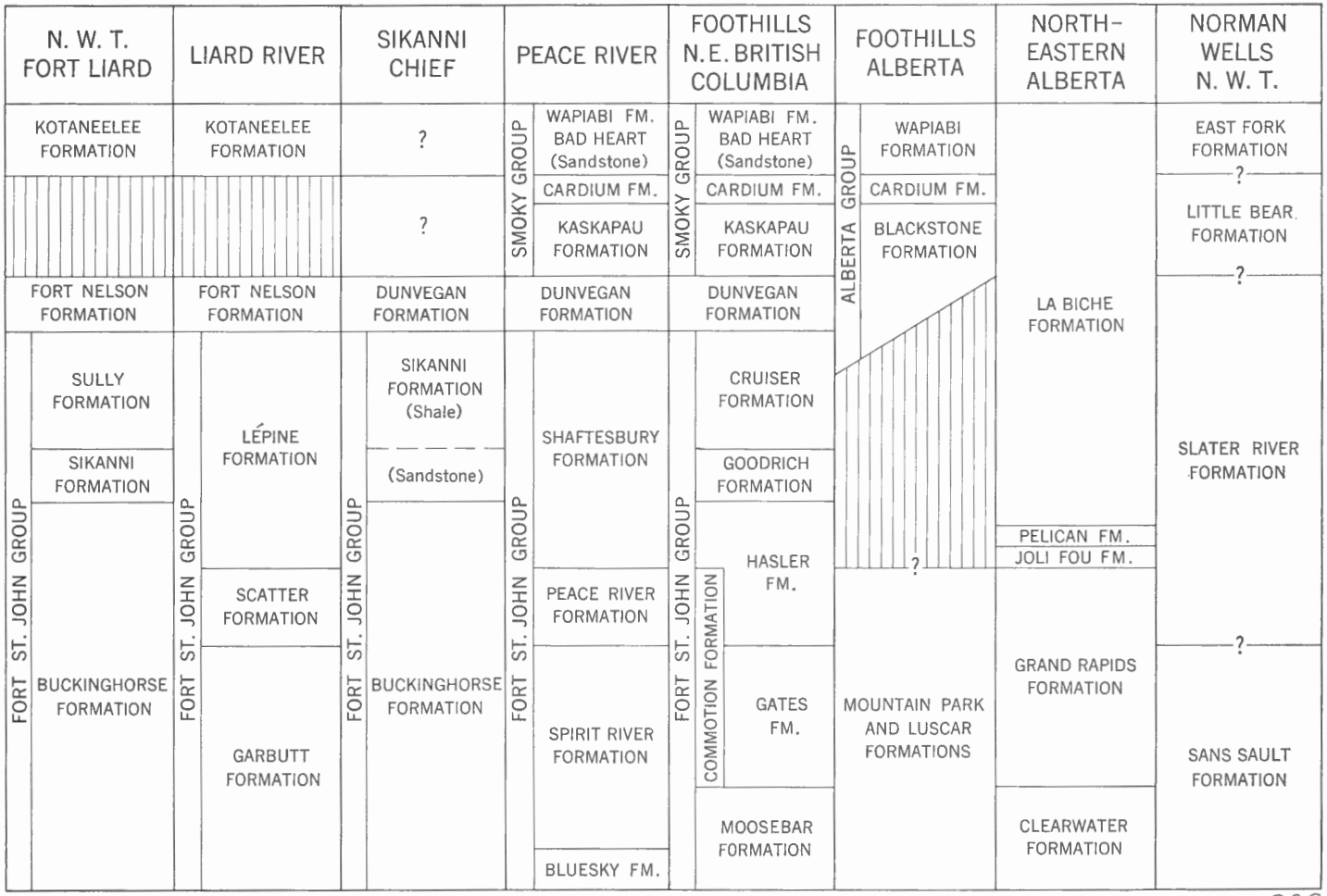
Table I

Correlation of Cretaceous Rocks of Northwest Territories with those of other Regions in Western Canada



STRATIGRAPHY

A three-fold division of the Cretaceous rocks along Liard River has been recognized from the time of earliest explorations. R. G. McConnell (1890, p. 20D) stated: "The Cretaceous section along the Liard thus shows two great shale and sandstone series separated by a heavy band of sandstone and conglomerate." The conglomerate and sandstone to which he referred are probably those now included in the Fort Nelson formation; the underlying shales, the Fort St. John group as outlined by Kindle (1944); and the upper shales, the Kotaneelee formation (*see* Fig. 3).

South of Mackenzie River, between Hay and Liard Rivers, is a large area of Cretaceous rocks (*see* Fig. 1; Douglas, 1959), most of which belongs within the Fort St. John group, although some Upper Cretaceous sediments have been mapped in the vicinity of Petitot River. The western limits of these rocks are faults along the eastern side of Liard and Nahanni ranges; the limits elsewhere are erosional. Cretaceous rocks comprise three small areas within the mountains (*see* Fig. 2); west of Liard Range, they are exposed along the valleys of Chinkeh Creek and Kotaneelee River; and in the Liard Plateau, the valleys of La Biche and Beaver Rivers lie within Cretaceous sediments. North of Mackenzie River, erosional remnants form Horn Plateau and Ebbutt Hills; east of Mackenzie River and west of Lac la Martre, a large area is considered, on the basis of topography, to be underlain by Cretaceous rocks although no outcrops were found in that region.

In the northwest corner of the map-area, Cretaceous rocks outcrop along Redstone and Dahadinni Rivers, where they lie at the southern end of a basin that extends northwestward and beyond Norman Wells.

The total thickness of Cretaceous sediments in the vicinity of Fort Liard is estimated to be more than 5,600 feet; on Cameron Hills and Horn Plateau, due to convergence and erosion, it is less than 2,000 feet; and south of Trout Lake, 2,025 feet were penetrated in the Imperial Island River well.

As it is traced eastward from the mountains, the base of the Cretaceous sequence is unconformable and laps onto older Palæozoic rocks (*see* Fig. 1); along Kotaneelee River, the group lies on rocks of Permian age (*see* Pl. II). The basal contact of the system is not exposed on Petitot River but underlying fossiliferous Mississippian limestones are separated from Cretaceous shales by undated sandstone and chert. On Redstone River, Cretaceous rocks lie with marked erosional unconformity on Upper Devonian rocks (*see* Pl. I A); on the Plains, they lie on upper and middle Devonian strata.

Lower Cretaceous Series

The Fort St. John group, defined originally in the Peace River region[1], has been subdivided differently by several workers in different parts of northeastern British Columbia. The group was divided into the Garbutt, Scatter, and Lépine formations (*see* Table I and Fig. 4) by E. D. Kindle (1944) who worked in an area about 250 miles

[1]Descriptions of formations of the Fort St. John group around Peace River are summarized by McLearn and Kindle, 1950.

Table of Formations

		Wapiti formation Sandstone, coal, and carbonaceous shale	
UPPER CRETACEOUS		Kotaneelee formation Concretionary shale with some sandstone and pebbly mudstone	500′–1,000′
		Disconformity	
		Fort Nelson formation Coarse-grained sandstone, conglomerate, coal, and carbonaceous mudstone	400′–600′
		Sully formation Concretionary and gypsiferous shale	1,000′–1,500′
		Sikanni formation Fine-grained glauconitic sandstone and siltstone	300′–400′
		Buckinghorse formation	2,500′–3,000′
LOWER CRETACEOUS	Fort St. John group	Upper member: Concretionary shale with some siltstone and sandstone	
		Middle member: Argillaceous siltstone and fine-grained sandstone	
		Lower member: Concretionary shale with bentonite beds. Coarse-grained basal sandstones and conglomerate	
LOWER CRETACEOUS ?		Micaceous shales	

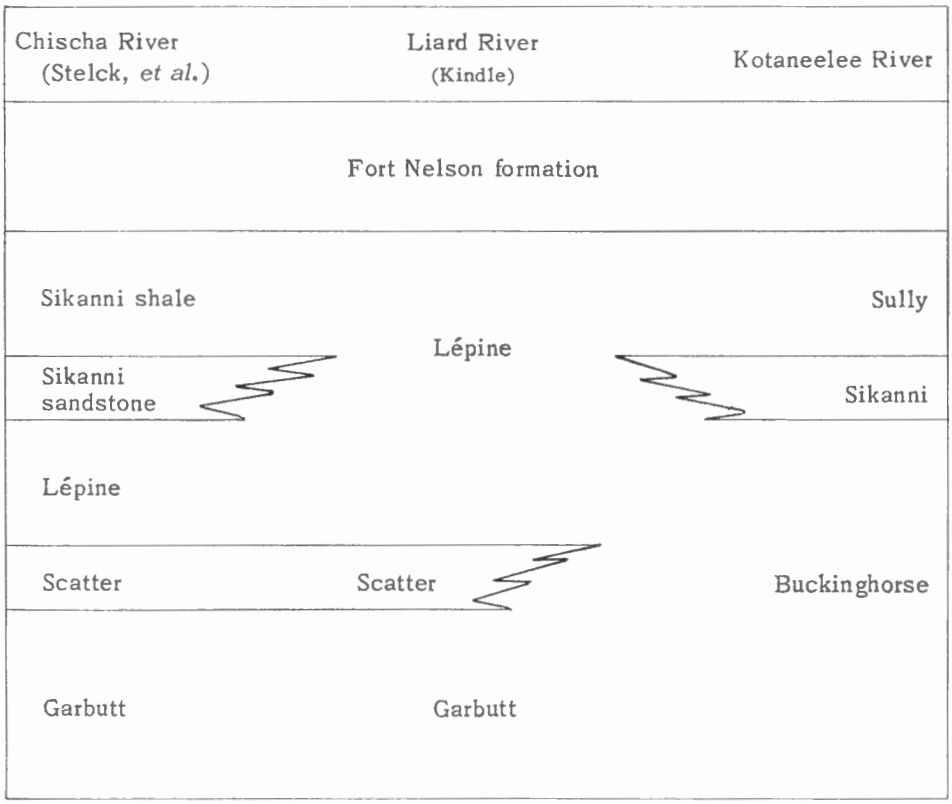


Figure 4. *Diagram showing relationships of rock units in Northwest Territories and northeastern British Columbia*

south of Mackenzie River. These formations were used by Kindle as far north as Beaver River in the Northwest Territories. Hage (1945) suggested that rocks exposed around Fort Liard could be equated with Kindle's formations but Hage did not see the complete succession and did not apply any formational names to the Lower Cretaceous rocks in this region. Fossils collected during 1957 indicate that such correlation is not entirely correct. In the Sikanni Chief region south of Kindle's sections, Hage (1944) defined two formations, the Buckinghorse formation and the Sikanni formation which included a lower sandstone member and a shale member. Stelck, *et al.* (1956) recognized a five-fold division on Chischa River[1] between Kindle's and Hage's sections (*see* Fig. 4). They recognized Hage's Sikanni formation and Kindle's Garbutt and Scatter formations. They restricted the name Lépine to the interval between the Scatter and Sikanni sandstone, thus applying it to a smaller stratigraphic interval than in the type region. Their succession was, from base upwards, Garbutt, Scatter, Lépine, Sikanni sandstone, Sikanni shale.

[1]Location of section described in personal communication from Dr. Stelck, December 8, 1958.

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The Fort St. John group in the Fort Liard-Kotaneelee region is divided into three distinct divisions which appear to correlate most closely with those outlined by Hage. Inasmuch as the two members of the Sikanni formation are mappable units, they are raised to formational status and, as the same geographic name cannot be applied to two different formations, the name Sikanni is restricted to the sandstone formerly included in the lower Sikanni member. A new formation, Sully, is proposed to include the shales above the Sikanni sandstone. The succession recognized in the southern part of the Northwest Territories is therefore, Buckinghorse, Sikanni, and Sully formations (*see* Fig. 4 and Table I). The Buckinghorse formation is divisible into three members which may correlate with the Garbutt, Scatter, and Lépine formations as used by Stelck, *et al.*

The Fort St. John group at the south end of Pointed Mountain lies on micaceous grey shales of probable Cretaceous age. Microfossils collected from this shale were identified by Wickenden who reported *Proteonina*, *Involutina* (*Ammodiscus*), *Glomospirella* ?, and *Haplophragmoides*. Wickenden considered them to be of Mesozoic age and stated that they resemble Cretaceous forms rather than Jurassic or Triassic ones. The shales may be equivalent to some part of the Bullhead group of the Peace River region. In valleys southwest of Liard Range, a unit of sandstone and shale, about which very little is known but which may be partly equivalent to these micaceous shales, has been mapped below beds assumed to be equivalent to the basal conglomerate and sandstone of the Buckinghorse formation (*see* Douglas and Norris, 1959).

Cretaceous rocks overlie progressively older beds as they are traced from Liard Range on the west to Petitot River on the east. The beds underlying Cretaceous rocks on Sully and Murky Creeks are Permian mudstones (Pl. II). The basal Cretaceous rocks are not exposed on Petitot River but are separated from rocks of Mississippian age by a thin undated unit of sandstone and cherts. Cretaceous rocks around Imperial Island River No. 1 well lie on 35 feet of bluish grey claystone, crinoidal limestone, light greenish grey shale, and green claystone with pebbles and pyrite. These beds may be detritus on the underlying Palæozoic rocks and be equivalent to the Deville beds of the southern Plains. Below this unit, the rocks consist of light green shale, fine-grained sandstone, and crinoidal limestone resembling Mississippian sediments.

Buckinghorse Formation

The Buckinghorse formation was proposed by Hage (1944) for "a thick assemblage of dark grey marine shales" with "minor, fine-grained, thin sandstone and sandy shale beds and varying amounts of brown-weathering ironstone concretions." He calculated the thickness of the type section on Sikanni Chief River to be 3,300 feet.

Dark marine Cretaceous shales in the vicinity of Fort Liard, lying above Palæozoic rocks and below massive silty sandstones of the Sikanni formation, are included in the Buckinghorse formation. The formation is not entirely exposed within the Northwest Territories, but is complete on two tributaries of Chinkeh Creek (*see* Fig. 2). The exposures on Murky Creek are designated as a standard section (*see* Appendix, section 1, and Fig. 2); the thickness of the formation there is about 2,800 feet.

Beds considered to lie within the Buckinghorse formation have been mapped in a syncline lying to the west of Kotaneelee Range. At the southern end of the range and southwest of La Biche River, beds are traced into the Garbutt and Scatter formations as mapped by Kindle (1944). Other areas believed to be underlain by the Buckinghorse formation lie west of La Biche Range, around Fantasque Lake, and along Beaver River (*see* Fig. 2). Few outcrops were examined in this region and the succession is poorly known. Part of the formation is well exposed on the east flank of the syncline on Petitot River.

Most of the Buckinghorse formation is exposed on Murky and Sully Creeks (*see* Appendix, sections 1 and 2). In this region, the formation comprises basal conglomerate, basal sandstone, lower shale, middle sandstone and siltstone, and upper shale. The middle sandstone and siltstones are tentatively correlated with the Scatter formation but definite correlation requires more detailed information.

On Sully Creek, the basal conglomerate lies abruptly on the Permian shales and the contact is that of an erosional unconformity. The conglomerate is composed of fragments ranging in size from one-half inch to six inches, but averaging between two and three inches in diameter. It consists predominantly of chert with some limestone and sandstone pebbles. In the exposure on Sully Creek, where the conglomerate is 33 feet thick, many of the fragments are subangular; in the outcrop on Kotaneelee River they are slightly smaller and most are subrounded. The matrix of the conglomerate consists of medium- to coarse-grained quartz sand.

A distinct boundary separates the conglomerate from the overlying sandstone on Sully Creek. On Kotaneelee River, a transition zone of 2 feet of mixed sand and conglomerate lies between the two massive units. The sandstone has a thickness of 20 feet on Sully Creek and 18 feet on Kotaneelee River, is medium grained, porous, brownish grey, homogeneous, and massive with subangular to subrounded grains. The sandstone, a quartz arenite, contains about 90 per cent quartz with a small amount of chert, pyrite, feldspar, and biotite; streaks of bitumen are evident. Ribbed fragments of woody plants and radiating structures resembling large palm fronds occur on the bedding surfaces.

The lower shales of the Buckinghorse formation (Pl. I B) are micaceous, rubbly, rusty weathering, and contain some sideritic concretions, pyrite, glauconite and many thin beds of creamy white bentonite. The shales are almost entirely clay near the base but become siltier towards the middle of the formation. A massive sandstone, 30 feet thick, lies within the lower shales and about 150 feet above the base of the formation on Kotaneelee River. This sandstone is composed almost entirely of quartz, contains abundant glauconite, and some carbonaceous material. It is clean and well sorted and is classed as a quartz arenite.

The middle member of the Buckinghorse formation may be equivalent to the Scatter formation. Kindle (1944) traced the Scatter formation as far north as Beaver River in Yukon Territory, just within the southern border of the region mapped in 1957. These beds on Beaver River were not examined during 1957 but ridges in a broad syncline south of La Biche River are continuous with outcrops mapped by Kindle as the Scatter formation. Sandstones in the vicinity of Fantasque Lake may

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be equivalent. The member was examined in greatest detail on Murky and Sully Creeks in the syncline between the Kotaneelee and Liard Ranges.

Both the upper and lower contacts are gradational. The member is 247 feet thick on Sully Creek (section 2) and 168 feet thick on Murky Creek (section 1). No other sections were measured. The member consists of argillaceous siltstone and sandstone with some intervals of rusty weathering shale (Pl. III A). The sandstone is fine grained, greenish grey, commonly finely crossbedded, and contains glauconite. The grains consist mainly of quartz with about 5 per cent chert. The matrix contains abundant carbonate.

As the member is traced northward and eastward, it becomes more argillaceous and shaly. On Sully Creek, two resistant sandy units are recognized but the lower one is predominantly siltstone. This lower unit is more argillaceous on Murky Creek and forms a much less prominent unit. The member cannot be recognized as a separate stratigraphic unit on Petitot River to the east, although silty beds in a similar stratigraphic position in the middle of the Buckinghorse formation are probably equivalent.

The upper member of the Buckinghorse formation, although nowhere well exposed, has been mapped southwest of Kotaneelee Range, along Kotaneelee River and along Liard River. The member is about 1,700 feet thick on Murky and Sully Creeks. Exposures are not continuous on Sully Creek (section 2). The shales which do not vary greatly in lithology, are rubbly to flaky, weather rusty, contain ironstone concretions and are very similar to those in the basal part of the Buckinghorse formation. Considerable pyrite and some glauconite were found within the basal shales on Murky Creek (section 1).

The Buckinghorse formation is 1,700 feet thick on Petitot River (section 3) and 620 feet thick in the Imperial Island River No. 1 well. The great decrease in the thickness in the lower part of the Fort St. John group is attributed to decreased sedimentation.

The contact between the Buckinghorse formation and the overlying Sikanni formation is drawn arbitrarily at the change from shale or mudstone to blocky or massive argillaceous siltstone which lies about 2,800 feet above the base of the Fort St. John group.

Age and Correlation

Only two genera of ammonities, *Lemuroceras* and *Puzosia*, were found in the lower shales of the Buckinghorse formation near Chinkeh Creek but they are significant. According to Jeletzky who identified the fossils, *Lemuroceras* cf. *L. belli* McLearn is diagnostic of the *Lemuroceras* or *Beudanticeras affine* faunal zone (McLearn and Kindle, 1950) which "is assumed to correspond with part or all of the interregional *Douvilleiceras mammilatum* zone" of earliest middle Albian age. Jeletzky reports that '*Puzosia*' *sigmoidalis* Donovan has been found in rocks of early Albian *Leymeriella* age, and "unless '*Puzosia*' *sigmoidalis* is a long ranging species which crosses the lower middle Albian boundary, it would now seem possible that the Canadian *Lemuroceras* or *Beudanticeras affine* zone also includes beds of the uppermost Lower Albian age (*Leymeriella*-zone)."

The Buckinghorse formation lies below the Sikanni formation which contains *Neogastroplites* of late Albian age. As the lower part of the formation is of earliest middle Albian age, other middle Albian zonal fossils such as *Gastroplites* may occur within the formation.

The *Lemuroceras* or *Beudanticeras affine* fauna is known to occur in the Moosebar formation of the Peace River valley, in the lower part of the Buckinghorse formation of the Sikanni Chief region, in the Clearwater formation of northeastern Alberta, and in the Sans Sault formation of Norman Wells region. The lower part of the Buckinghorse may, therefore, be correlated with these formations. The middle siltstone and upper shale members of the formation are correlated with the Scatter and lower Lépine formations of northeastern British Columbia, with the upper part of the Buckinghorse formation of its type region, and with the Commotion, Gates, and Hasler formations of the Peace River region.

Faunal List

Puzosia (sensu lato) cf. *Puzosia* sp. of Warren, 1947, and '*Puzosia*' *sigmoidalis* Donovan, 1953
Lemuroceras cf. *L. belli* McLearn
Gastroplites ? sp. indet.
Pecten cf. *P. alcesianus* McLearn

Sikanni Formation

The Sikanni formation was defined by Hage (1944, p. 11) as those beds lying between the Buckinghorse and Dunvegan formations. The type section is presumably on Sikanni Chief River where the lower part of the formation was measured and described. As originally defined, the formation consisted of two members: the lower member, 380 feet thick, consisting of four sandstones; and the upper member, about 600 feet thick, consisting of dark marine shale. As the two members form mappable units over a large region, it is proposed that they be raised to formational status. The name Sikanni is restricted to the sandstone member. The type section is that described by Hage. The Sully formation is proposed herein for the overlying shale member.

In the Fort Liard-Kotaneelee region, the Sikanni formation is the predominantly massive silty sandstone which lies above the Buckinghorse formation and below the Sully formation (*see* Fig. 3). The formation is exposed on several small streams flowing down the western slopes of Liard Range. The section on Murky Creek is designated as a standard for the Fort Liard region. The formation occurs along Petitot River (Pl. IV A) on the flanks of a broad syncline and has been traced northward towards South Nahanni. The Sikanni formation is about 350 feet thick west of Liard Range (*see* Appendix, sections 1, 2).

The Sikanni formation is partly exposed on Petitot River near its junction with Liard River where 250 feet of strata were measured (section 5). Farther upstream, on the east side of the syncline, the formation is well exposed but was not examined because of high water. The formation has an estimated thickness of more than 300 feet in the canyon of Kotaneelee River about 10 miles above its junction with Liard River. High water prevented the examination of the formation along Muskeg 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. In the Imperial Island River No. 1 well, the formation is 175 feet thick.

The basal contact of the Sikanni formation is gradational. The upper boundary also is gradational and is drawn above massive argillaceous siltstone and at the base of concretionary shale.

West of the Liard Range, the Sikanni formation consists of fine-grained sandstone, argillaceous siltstone, and some 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 irregularly shaped 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 the 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 and Correlation

The Sikanni formation contains *Posidonia* cf. *P. nahwisi* McLearn sensu lato and *Neogastroplites cornutus* (Whiteaves). According to Jeletzky, the beds containing *Neogastroplites cornutus* can be referred to the second oldest *Neogastroplites* zone (Cobban and Reeside, *in press*). Stelck, *et al.* (1956, p. 9) claim that *Posidonia* are restricted to beds older than the generalized *Neogastroplites* zone but, according to Jeletzky, collections of the Geological Survey of Canada indicate that the two faunas are in part contemporaneous although *Posidonia* may range somewhat below *Neogastroplites*. In terms of the International standard stages, the zone is considered to be of late Albian age.

The Sikanni formation is correlated with the Sikanni sandstone of the type region, the Goodrich formation and the lower part of the Shaftesbury formation, all of which contain *Neogastroplites*.

Faunal List

Posidonia cf. *P. nahwisi* McLearn sensu lato
Inoceramus sp. indet (resembles *I. concentricus* Park.)
Pteria (*Oxytoma* cf. *O. pectinata* Sow.)
Mactra ? sp. indet
Pecten (*Entolium*) sp. indet.
Turritella (sensu lato) sp. indet.
Nucula ? sp. indet.
Neogastroplites cornutus (Whiteaves)
Neogastroplites sp. indet.
Thracia cf. *T. stelcki* McLearn
Fish scales
Fossil wood

Sully Formation

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 (*see* Fig. 3). The formation is partly exposed on Kotaneelee River and at the type section on Sully Creek (section 2), where it is approximately 1,500 feet thick; it has an estimated thickness of 1,000 feet on Petitot River and 655 feet in the Imperial Island River No. 1 well.

This formation contains rubbly concretionary shales and fissile dark grey shales (Pl. IV B). Although definite palæontological evidence is lacking, the dark shales found on the Plains around Mackenzie River are believed on the basis of lithology to belong to the Sully formation. Outcrops in this region reveal only small parts of the formation.

On Sully Creek, the basal 500 feet and the upper 700 feet are composed of rubbly, sideritic, dark grey, rusty weathering shales. The middle part of the formation contains dark grey, fissile shale.

The lower part of the formation is not well exposed in the type section. About 200 feet outcrop on Kotaneelee River where much of the rock is blocky mudstone containing numerous concretions (Pl. IV B). Several outcrops occur near the mouth of the Petitot River. These shales resemble those of the Buckinghorse formation.

Flaky, fissile shales of the middle part of the Sully formation are greyish black and stained yellow by sulphur. Small rosettes and crystals of selenite occur in many places. Some bentonite is present. In contrast with the other Lower Cretaceous shales, this unit is not concretionary. These non-concretionary shales are very distinctive. They are well exposed on the west flank of Liard Range, on Petitot River and have been recognized on the Cameron Hills and Horn Plateau.

The upper shales of the Sully formation are greyish black, rusty weathering and contain concretions. The sand content increases towards the top of the formation which is gradational into the overlying Fort Nelson formation. The gradational zone is well exposed on Petitot River (*see* Appendix, section 8) where blocky mudstone grades into argillaceous siltstone. These beds grade upwards into thickly bedded, fine-grained sandstone which is overlain by medium- to coarse-grained massive sandstone.

Age and Correlation

Posidonia nahwisi McLearn var. *goodrichensis* was collected from the basal shales of the Sully formation on Kotaneelee River. According to Jeletzky, this fauna is of late Albian age. The *Neogastroplites* fauna collected on Sully Creek came from the underlying Sikanni formation, and these fossils indicate that the formation is not older than late Albian. The Sully formation is correlated with the shale above the Sikanni sandstone of the type region, the Cruiser formation, and upper part of the Shaftesbury formation. It may be correlated with the upper part of the Lépine formation of the Fort Nelson region as both are stratigraphically below the Fort Nelson formation. However, the Lépine formation in its type locality has a much greater stratigraphic range as it includes beds containing *Gastroplites* of middle Albian age (Kindle, 1944, p. 12).

Although no fossils have been reported from the Slater River formation in the Norman Wells region, the lithology is similar to that of the Sully formation and the two are considered equivalent.

Faunal List

Posidonia nahwisi McLearn var. *goodrichensis* McLearn
Posidonia nahwisi McLearn sensu lato

Fort St. John Group Undivided

Cretaceous shales on the Plains north and east of Fort Liard have been mapped as Fort St. John group undivided due to the lack of detailed information. The writer considers that most of the Cretaceous rocks in this region are equivalent to the Sully formation but beds equivalent to the Buckinghorse and Sikanni formations may be present.

Redstone River Region

Cretaceous rocks along Redstone River were examined by Hancock (*in* Hume, 1954, p. 54). Hume traversed the region around Dahadinni River and mapped Cretaceous rocks in a syncline between Dahadinni and Redstone Rivers (1924, p. 3B; Map 2022). The correlation of these rocks with the more southerly formations is not well known, nor can they be correlated readily with Cretaceous divisions outlined in the Canol project (Hume, 1954). It is probable that the Cretaceous rocks in the Redstone River region are equivalent to the Buckinghorse formation or the Sans Sault formation as described by Stewart (1945).

More than 75 feet of dark grey shale overlies Devonian shales and underlies a massive coarse-grained sandstone with some conglomerate on Redstone River northwest of Mount Heywood. Local relief on the surface of the Devonian rocks is between 10 and 15 feet (Pl. I A). The shale above the unconformity is silty, quartzose, and micaceous. It does not contain siderite nor does it resemble shales of the Fort St. John group. As the shales do not resemble Palæozoic rocks in this region, they may be of very early Cretaceous or Jurassic age and may be equivalent to the shales below the Buckinghorse formation on Kotaneelee River which they resemble lithologically.

Massive sandstone lies near or at the base of the Cretaceous sequence and therefore does not correspond stratigraphically with either Fort Nelson or Little Bear formation which are lithologically similar. More probably, it lies at the base of the Fort St. John equivalent, and is equivalent to the basal Buckinghorse sandstone and conglomerate on Kotaneelee River. However, it could also be a higher sandstone within the basal shales of the group. Similar sandstone and conglomerate, considered to lie at the base of the Cretaceous succession, are exposed on Dahadinni River southeast of Cloverleaf Lake. The lithologically similar sandstone and conglomerate reported by Hume (1924) to be present near Cloverleaf Lake is probably equivalent. The sandstone is medium to coarse grained, greyish green, with carbonaceous streaks and lenses; it weathers dusky yellow. Chert pebbles are scattered through some of the beds.

Near the mouth of Dahadinni River, fine-grained, argillaceous sandstone and dark grey, concretionary shale are exposed. This sandstone may be equivalent to the Sikanni sandstone.

Cameron Hills-Hay River Region

Dark grey, concretionary shales are exposed at several places along Cameron River near the edge of the northern escarpment of Cameron Hills. Approximately 100 to 125 feet of fissile or rubbly shale with yellow sulphur staining contain reddish brown weathering sideritic concretions. On a small creek west of Cameron River and at a lower elevation than the concretionary shales, 30 feet of dark grey fissile shale with abundant selenite contain thin layers and streaks of yellow sulphur. No exposures of shale were seen along the eastern edge of the hills.

Cameron (1922), in his examination of the country around Hay River, found several outcrops of Cretaceous shales above Grumbler Rapids. These rocks were called the Meander shales and were described as dark grey marine shales containing spheroidal concretions, ironstone bands, and numerous crystals of selenite. The shales on Hay River were below water level when a traverse was made in 1957. They resemble those around Cameron Hills and probably are equivalent to the Sully formation.

Whittaker (1923) suggested that the high land south of Tathlina Lake was underlain by Cretaceous strata. A traverse of Kakisa River and a long traverse south of Trout River towards Cameron Hills revealed no outcrops. A small outcrop, reported by Whittaker (1923), was examined on Trout River about 67 miles above its mouth. The outcrop consists of fissile, dark grey shale containing several bands of bentonite, numerous thin lenses of yellow sulphurous clay and minute selenite crystals concentrated along bedding planes. As no concretions are present in the shale at this locality, the beds may be equivalent to the non-concretionary beds of the Sully formation.

Horn Plateau

Whittaker named the Cretaceous rocks exposed on Horn Plateau the Mountain shales (1922, p. 54B). He described them as thin, fissile, sulphur-stained, brown to black shales, weathering yellow and containing bands of hydrous aluminum silicate, minute crystals of gypsum, and septarian concretions. Two exposures of dark grey to black shale with some concretions were found near the large stream which flows southward from the hills. In an area of recent landslide, about 50 feet of fissile shale with selenite crystals are exposed. Some ironstone concretions are present in the drift but none was found in place. On the east side of Horn Plateau dark grey to black, concretionary shales weathering to a soft clay are present. Black, noncalcareous, fissile shale with abundant selenite crystals is exposed on Willowlake River on the north side of Horn Plateau. The shale weathers dark yellowish orange to greyish yellow and is pyritic.

Martin Hills

Shales and sandstones are well exposed on the southeast corner of the escarpment (*see* Appendix, section 7). About 100 feet of rubbly to fissile rusty weathering, concretionary shale is overlain by fine-grained, olive-grey sandstone. The sandstone is

laminated, platy, finely crossbedded and ripple-marked. The shale is similar to the upper part of the Sully formation and the sandstone is correlated with the transition beds at the base of the Fort Nelson formation.

Some shale and sandstone are exposed on the northeastern edge of the escarpment of Martin Hills. These sediments appear to be similar to those outlined in the described section (*see* Appendix, section 7).

Ebbutt Hills

The shales exposed on Ebbutt Hills were considered to be Upper Devonian and were shown as Simpson shales on Map 1957 by Williams (1922, p. 57B). Ironstone concretions up to 3 feet in diameter were described but no fossils were found in the shales. Williams reported later (1937, p. 102) that he found Cretaceous fossils in nodules which he concluded came from the erosion of the strata of the Ebbutt Hills.

Due to heavy vegetation, no landing was made near the outcrops on Ebbutt Hills although a helicopter with floats could land on small lakes at some distance from the outcrops. Black shales are exposed along the southern side of the hills and in several gullies on the eastern escarpment. Several outcrops in one large stream on the eastern escarpment might possibly give a composite section. The shales underlying Ebbutt Hills are herein tentatively included in the Cretaceous system. Abundant ironstone concretions were found to be more typical of Cretaceous shales and are rare to absent in the Devonian shales. Furthermore, the hills have an elevation and topographic form similar to the Martin Hills and Horn Plateau, both known to contain Cretaceous beds.

Upper Cretaceous Series

Hage (1945) divided the Upper Cretaceous strata into three units: the basal one, consisting of pebble-conglomerate and coarse-grained sandstone, was assigned to the Fort Nelson formation; the overlying shales were named the Kotaneelee formation; the third formation, comprising medium-grained, grey sandstone, pebble-conglomerate, and some coal, was correlated with the Wapiti formation.

Fort Nelson Formation

Kindle (1944, p. 13) included beds of conglomerate and sandstone exposed on cliffs along the river below Fort Nelson in the Fort Nelson formation and designated as the type section the better exposed beds on Liard River between Toad and Beaver Rivers. The formation is more than 600 feet thick in the type region. He suggested (op. cit., p. 15) that the Fort Nelson formation might be the northern equivalent of the Dunvegan formation.

The best exposures of the Fort Nelson formation in the Northwest Territories are on Petitot River, where massive beds in the trough of a syncline form the walls of a narrow canyon (*see* Pl. III B). The formation there is 450 to 500 feet thick. Only the lower part of the formation is exposed on Sully Creek; isolated outcrops are present near Chinkeh Creek, and partial sections can be examined along Kotaneelee

River. On Martin Hills and west of Trout Lake the formation has been mapped but it is rarely exposed and the boundaries are assumed.

On Sully Creek the basal beds consist of fine-grained, very soft and porous, finely laminated, crossbedded sandstone, which grades downward into the Sully formation. The exposures on Kotaneelee River consist mainly of medium-grained sandstone with chert pebbles, very similar to that found on Petitot River. Iron oxide and carbonaceous material are fairly abundant.

The well-exposed section on Petitot River (*see* Appendix, section 8) can be divided into three distinct units (*see* Fig. 3). The lowest consists of coarse-grained, crossbedded, massive sandstone including chert pebbles. This grades upwards into a blocky mudstone unit containing coal and lenses of conglomerate, which is overlain by beds of conglomerate and coarse-grained sandstone. The conglomerate, composed mainly of chert with some quartzite, contains pebbles ranging from one-eighth to one-half inch in diameter. The top of the formation is marked by a 10-to-15-foot bed of conglomerate. The sand grains are subrounded and are composed of quartz, chert, and some rounded flakes of biotite.

The sequence of beds considered to be the Fort Nelson formation in the Imperial Island River No. 1 well is similar to that on Petitot River. The formation is 550 feet thick but some of the uppermost beds may possibly lie within the Kotaneelee formation. The basal 260 feet contains coarse-grained sandstone with carbonaceous material and plant fragments, and apparently grades downward into shale; the middle 160 feet contains shale and fine-grained sandstone; and the upper part contains coarse-grained sandstone.

In 1923, Whittaker (p. 99B) reported that 50 to 150 feet of coarse, white to rusty yellow friable sandstone, which he called Rabbitskin sandstones, were present northeast of Rabbitskin River and "caps Horn Mountains". This sandstone was not examined in 1957 but it may be equivalent to the Fort Nelson formation.

Age and Correlation

The Fort Nelson formation is unfossiliferous but has been correlated with the Dunvegan formation of Cenomanian age (McLearn and Kindle, 1950; Henderson, 1954). This correlation appears logical although the formation could be somewhat older and could possibly range as high as Turonian as it is overlain by younger beds.

The Little Bear formation in the vicinity of Norman Wells, consisting of sandstone, conglomerate, and coal (Stewart, 1945), may be partly equivalent to the Fort Nelson formation. However, fossils of Turonian age have been reported from the Little Bear formation (Hume, 1954). If, as is generally assumed, the Fort Nelson is strictly equivalent to the Dunvegan formation of Cenomanian age, the Little Bear formation is not completely equivalent.

If the Fort Nelson formation is no younger than Cenomanian, then a considerable time interval is not represented in the sedimentary record as sediments of Turonian age are unknown. This hiatus could be due to non-deposition, or the region may have been subject to erosion during part of Turonian time as suggested by Stelck (1955).

Kotaneelee Formation

The Kotaneelee formation as defined by Hage (1945, p. 21) consists of 500 to 1,000 feet of dark grey shale with some thin sandstone and minor conglomerate. The formation lies above the Fort Nelson conglomerate and below some Upper Cretaceous medium-grained sandstone (Fig. 3). The type locality was not specifically designated by Hage but presumably includes the outcrops on Kotaneelee River (Fig. 2) where most of the formation is exposed. This formation is present on Petitot River above the Fort Nelson formation in the canyon but the exposures there were not examined because of flood conditions in the canyon. The lower 140 feet of Hage's section on Petitot River is mostly concealed. According to him 20 feet of grey shale is exposed above the Fort Nelson formation and 20 feet of shale and fine-grained sandstone lies above a covered interval of 100 feet. Above these beds, 5 feet of conglomerate is overlain by 10 feet of fine-grained sandstone and 175 feet of grey shale containing a few concretions. The upper part of the section consists of 10 feet of medium-grained sandstone lying below 5 feet of dark grey shale.

The lower 70 feet of the formation on Kotaneelee River (section 9) contains blocky mudstone, which grades upward into sandy mudstone with disseminated chert pebbles. The mudstone contains numerous glauconitic pellets, chert and quartz grains, and oolites and aggregates of carbonate stained by siderite. The oolites have centres of quartz or mudstone and are surrounded by rims of glauconite or possibly chamosite. In a few oolites, the rim has been replaced by carbonate. Some of the glauconite pellets have also been replaced by carbonate. Overlying these beds is 15 feet of massive green, very argillaceous, coarse-grained sandstones which contain quartz, chert, quartzite, some argillite, and biotite flakes.

Above the sandy unit is about 260 feet of rubbly, dark grey, rusty weathering shale which contains reddish brown weathering sideritic concretions. Some thin-bedded, fine-grained sandstone occurs near the top of this section. The sandstone is comprised of approximately 50 per cent quartz, 40 per cent chert, and 5 per cent rock fragments. The large percentage of chert here contrasts greatly with the low percentage in the Lower Cretaceous sandstones.

Farther downstream, approximately 200 feet of shale is exposed. This shale appears to be near the top of the formation and is similar to that previously described. It grades upwards into massive argillaceous siltstone that contains some fine-grained, laminated sandstone. Thickly bedded sandstone at the top of the cliff is apparently marine and is included in Kotaneelee formation.

Age and Correlation

The fauna collected from above the coarse-grained sandstone of the Kotaneelee formation is reported by Jeletzky to represent the combined zones of *Scaphites depressus* and *Scaphites* (*Clioscaphites*) *vermiformis*. These zones are found in the lower part of the Wapiabi formation of the Alberta Foothills and also in the Bad Heart sandstone of the Peace River region. They are dated by Jeletzky as early Santonian age in terms of the International standard stages.

It is not known if the basal beds of the Kotaneelee formation are strictly equivalent to the base of the Wapiabi formation, as fossils typical of the basal Wapiabi beds have not been reported. It is possible that the basal beds could contain equivalents of the Cardium and Blackstone formations of Turonian age.

The Kotaneelee formation is probably stratigraphically equivalent to the East Fork formation in the vicinity of Norman Wells. The East Fork formation consists of marine shale and overlies the Little Bear formation which is reported to contain fossils of Turonian age.

Faunal List

Inoceramus cf. *I. tenuirostris* Meek and Hayden
Inoceramus cf. *I. stantoni* Sokolov
Pteria (*Oxytoma*) *nebrascana* Evans and Shumard
Pteria (*Oxytoma*) *linguliformis* Meek and Hayden
Modiolus sp. indet.
Cyrena ? sp. indet.
Gyrodes sp. indet.
Scaphites (*Clioscaphites* ?) cf. *S. saxitonianus* McLearn
Inoceramus cordiformis Sow. var. *haenleini* Muller
Inoceramus ex gr. *cordiformis* Sow. sensu lato
Inoceramus sp. indet. (n. sp. ?)
Anomia cf. *A. subquadrata* Stanton
Legumen ? sp. indet.
Serpula sp. indet.

Hage (1945) reported the following fossils:

Oxytoma nebrascana
Inoceramus lobatus Goldfuss cf. var. *lundbreckensis* McLearn cf. also *I. patootensis* Loriol
Anomia cf. *A. subquadrata*
Baculites ovatus

Wapiti Formation

A sequence of medium-grained sandstone and conglomerate overlying the Kotaneelee formation was mapped but not named by Hage (1945) who correlated it with the Wapiti formation of the Peace River region. The name is now applied to the rocks because of their similar lithology and approximately equivalent stratigraphic position.

Hage examined 25 feet of sandstone and conglomerate on Pretty Hill and also an outcrop on Liard River above the mouth of Kotaneelee River (op. cit., p. 23):

> The sandstone is banded, medium- to coarse-grained, feldspathic, buff weathering, calcareous, and both massive and thinly bedded. It is overlain by a seam of low-grade coal 15 inches thick . . . No fossils were found in the upper sandstone beds, but a non-marine origin is indicated by the coal and carbonaceous material present.

Several erosional remnants of the upper marine sandstone of the Kotaneelee formation have been mapped around Kotaneelee River. Non-marine beds which would be included in the Wapiti formation may lie above the Kotaneelee sandstones but were not seen in this vicinity.

ECONOMIC GEOLOGY

The Cretaceous rocks of this region may be potential sources or reservoirs of petroleum and gas. No commercial production has been obtained from the Cretaceous rocks in the single well that has penetrated them.

The basal sandstone and conglomerate of the Buckinghorse formation have good porosity. The beds have a thickness of 50 to 60 feet and may be widely distributed. They probably occur at the base of the Cretaceous sequence throughout the region although with variable thickness. As these sandstones are overlain by shale, they would make a good stratigraphic trap. Traces of bitumen, noted in this sandstone, indicate the former presence of petroleum and the possibility that in the subsurface the sandstone may contain oil or gas. The basal Buckinghorse rocks are lithologically similar to the Bluesky, Dina, and McMurray sandstones of Alberta which occupy equivalent stratigraphic positions in the Cretaceous sequence. These beds have all produced petroleum, indicating that the similar basal Buckinghorse beds may be potential reservoir rock.

Sandstones of the Sikanni formation are not so porous as those of the Buckinghorse formation but could be potential reservoirs. In the Chinkeh Creek region, the Sikanni formation is very argillaceous. Towards the south, however, the formation contains cleaner and better sorted sandstone and lies between two thick marine shales.

The Fort Nelson formation may also be a potential reservoir rock. It is porous but is not as widely distributed as the Buckinghorse sandstones. The formation does, nevertheless, have a greater thickness of porous beds. The most favourable region may be south of the Fort Liard region where the beds are overlain by the shales of the Kotaneelee formation.

The lack of Turonian marine sediments could have important economic significance in that the Fort Liard region may have been a land area during part or all of Turonian time. If so, near-shore sand deposits which could be potential reservoirs might be expected towards Norman Wells where Turonian marine shales have been recognized (Hume, 1954). Near-shore deposits might also be expected towards the Peace River region where Turonian marine strata are known to occur.

APPENDIX

Stratigraphic Sections

Section 1. Lower Cretaceous formations, Murky Creek, tributary of Chinkeh Creek, west flank of Liard Range, N.W.T.

Unit	Sikanni Formation	Thickness in Feet: Unit	Thickness in Feet: Height above base
20	Shale, slightly silty, fissile to rubbly, dark grey to greyish black, rusty weathering; few concretions at top, 3″ × 6″, moderate brown weathering; trace of glauconite	9	361
19	Mudstone, silty, to siltstone, blocky; grading downward into less silty mudstone, dark grey, rusty weathering; bedded appearance; few ironstone concretions, 4″ × 8″, light brown weathering, with pelecypod fragments; bedding arches over concretions; trace of glauconite	5	352
18	Shale, to mudstone, silty, rubbly to somewhat blocky, dark grey to greyish black, rusty weathering. Mostly covered with talus	10	347
17	Mudstone, silty, blocky to massive, greyish black, rusty weathering; few thin sandstone beds; less silty towards base; few small concretions	14	337
16	Sandstone, fine grained, greenish grey, weathers pale olive, thinly bedded, 2″–4″, strongly but thinly crossbedded; and shale, as above, 40% This unit grades into silty shale upslope	10	323
15	Sandstone, fine grained, greenish grey, weathers pale olive to dusky yellow weathering, calcareous, glauconitic; 4″–6″ beds, finely but strongly crossbedded, numerous concretions in shaly intervals and common at top of sandstone beds; and shale, 30%	8	313
14	Shale, platy, to mudstone, blocky, dark grey to greyish black, rusty weathering; bedded appearance; few thin sandstone beds; few ironstone concretions, light brown weathering	10	305
13	Shale to mudstone, silty, blocky at top, becoming rubbly towards base, greyish black, rusty weathering, bedded appearance; few bands of siltstone towards top; light brown weathering concretions, 3″ × 6″ in rows, containing numerous pelecypod fragments and rare fish scale	6	295
12	Siltstone to mudstone, dark grey to brownish grey, glauconitic; numerous small concretions, some with shell fragments; trace of glauconite and pyrite	25	289
11	Siltstone, argillaceous, brownish grey, laminated, massive, soft; with 1′ of sandstone, fine grained, laminated and crossbedded at top; few concretions near top	10	264
10	Siltstone, argillaceous, to mudstone, silty, massive, greyish black to brownish grey, rusty weathering; scattered concretions, 8″ × 12″, light brown weathering; some glauconite	35	254

Unit		Thickness in Feet: Unit	Thickness in Feet: Height above base
9	Mudstone, blocky to slightly rubbly, greyish black, rusty weathering; has slightly more bedded appearance than overlying rocks; some glauconite	15	219
8	Siltstone, argillaceous, to mudstone, silty, blocky to massive, rusty weathering; few concretions; thin lenses of soft, laminated siltstone	30	204
7	Siltstone, argillaceous, finely laminated and crossbedded, massive to blocky; few lenses of well indurated, cross-laminated siltstone, glauconitic, dark grey to brownish grey, rusty weathering; rare concretions	26	174
6	Siltstone to mudstone, blocky, dark grey, rusty weathering, becoming slightly rubbly at base; few concretions, 3″ × 6″	32	148
5	Mudstone, blocky to rubbly at base, greyish black, rusty weathering; few thin siltstone bands at top showing cross lamination; few large 2′ × 4′ concretions	16	116
4	Siltstone, argillaceous, greyish black to brownish grey, rusty weathering, massive; few concretions	15	100
3	Covered	50	85
2	Siltstone to mudstone, bedded, greyish black, rusty weathering	15	35
1	Siltstone, argillaceous, massive, greyish black to brownish grey, rusty weathering	20	20
	BUCKINGHORSE FORMATION		
29	Covered	1,500	2,783
28	Shale, rubbly, dark grey to brownish grey, rusty weathering, with concretions, 4″ × 8″, containing numerous shell fragments	103	1,283
27	Shale, rubbly, dark grey to brownish grey, rusty weathering, rare concretion; considerably pyrite; trace of glauconite	39	1,180
26	Shale, rubbly; grading upwards into mudstone, silty, dark grey to greyish black, rusty weathering, glauconitic; few concretions; bedded appearance	61	1,141
25	Covered. Slumped shale	40	1,080
24	Siltstone, argillaceous, massive, grey, rusty weathering; poorly bedded	7	1,040
23	Siltstone, argillaceous, glauconitic; grading upwards into more massive and sandy siltstone with two feet of thinly laminated, platy sandstone at top	47	1,033
22	Covered	25	986
21	Shale, platy, dark grey; some thin siltstone bands	10	961
20	Siltstone, 50%, grey; in ½″–2″ beds, finely crossbedded; thin, platy to rubbly shale	17	951
19	Shale, rubbly; with siltstone, 25%, rusty weathering micaceous; trace of glauconite	30	934

Unit		Thickness in Feet	
		Unit	Height above base
18	Siltstone, interbedded with shale, 50%, platy, rusty weathering; beds ½″–1″; siltstone dominant at the top; few concretions, 8″ × 12″; glauconite	32	904
17	Shale, fissile to rubbly; 3″ × 6″ concretions in lower 15′	40	872
16	Shale, fissile to rubbly, greyish brown to dusky yellowish brown; few small concretions in rows	15	832
15	Covered. Shale with concretions	30	817
14	Shale, rubbly, rusty weathering; concretions 3″ × 6″, moderate brown weathering; trace of glauconite and pyrite	30	787
13	Shale, rubbly, greyish black, rusty weathering; concretionary bands near base, and few small scattered concretions; 1½″ creamy white bentonite at top, few thin layers in unit; trace glauconite; considerable fine pyrite	26	757
12	Shale, rubbly, greyish black, rusty weathering; numerous minute selenite crystals on some bedding surfaces; small concretions, 2″ × 4″, moderate brown weathering; trace of glauconite; some fine pyrite	16	731
11	Covered	50	715
10	Shale, rubbly, greyish black, rusty weathering, with silty bands, especially in upper part, 2″ × 3″ concretions	50	665
9	Shale, rubbly, rusty weathering; few concretions	55	615
8	Shale, rubbly, greyish black, rusty weathering; rare concretions	105	560
7	Shale, rubbly, with 3″ × 6″ concretions	115	455
6	Shale, silty, greyish black, rusty weathering; thin bands of siltstone; numerous concretions; some thin bentonites	65	340
5	Mudstone, to shale; blocky to rubbly, greyish black, rusty weathering; more fissile towards base, topped by concretionary band; numerous small concretions in upper 10′; few thin bentonite bands; pyritic aggregates	52	275
4	Shale, much as above, rusty weathering; concretions at top	25	223
3	Mudstone to shale, blocky at top, greyish black, rusty weathering; scattered concretions; trace of glauconite	33	198
2	Shale to mudstone, rubbly, rusty weathering at top, sandy; concretions at top and in upper third, few scattered ones towards base; abundant glauconite	165	165
1	Sandstone, fine to medium grained, quartzose, olive-grey to dark brownish grey, argillaceous streaks; in 4″–1′ beds, contains white cherty (?) pebbles; ribbed fragments of woody remains (Total thickness at this locality not known)		

Section 2. Fort Nelson, Sully, Sikanni and Buckinghorse formations, Sully Creek, west flank of Liard Range, N.W.T.

Unit		Thickness in Feet: Unit	Thickness in Feet: Height above base
	FORT NELSON FORMATION		
1	Sandstone, fine grained, grey, weathers light brownish grey, soft, porous, some cross-lamination, carbonaceous fragments, massive beds 1′–6′	30	116
	SULLY FORMATION		
14	Sandstone, fine grained, finely cross-laminated, carbonaceous; shale, 50%	25	1,436
13	Shale, platy to rubbly, greyish black, rusty weathering; with some thin bands of siltstone, finely cross-laminated	40	1,411
12	Sandstone and shale, as above; massive 3′ bed at base	8	1,371
11	Sandstone and shale, 50%; 4″–6″ beds, rusty weathering; few concretions	13	1,363
10	Shale, rubbly, greyish black, rusty weathering; yellow sulphur staining, bedded appearance	150	1,350
9	Covered	200?	1,200
8	Shale and sandstone interbedded; rusty weathering, platy. Sandstone, fine grained, laminated, carbonaceous, grey, lensy	50	1,000
7	Covered	200	950
6	Shale, flaky, fissile, greyish black to black; much yellow sulphur staining	70	750
5	Covered	100	680
4	Shale, fissile, black, grey to slightly rusty weathering; sulphur staining; few layers of bentonite; small rosettes of selenite	80	580
3	Shale, as in 4 at top. About half-way down cliff, shales change to rusty weathering, rubbly with reddish brown weathering ironstone concretions	50	500
2	Covered	400	450
1	Shale, blocky to rubbly, greyish black, rusty weathering; concretions	50	50
	SIKANNI FORMATION		
8	Siltstone, argillaceous, blocky to massive, greyish black to brownish grey, rusty weathering; bedded appearance, few concretions; thin siltstone lenses showing cross-lamination; glauconite	60	357
7	Mudstone, silty, greyish black to dark grey, rusty weathering; few ironstone concretions; some thin laminated siltstone	25	297
6	Mudstone, silty, blocky, greyish black, rusty weathering; some large concretions	65	272

Unit		Thickness in Feet	
		Unit	Height above base
5	Covered	50	207
4	Mudstone, as above	29	157
3	Siltstone to mudstone, dark grey, rusty weathering, few concretions; glauconite	36	128
2	Siltstone to mudstone, as above; rubbly at base	35	92
1	Siltstone to mudstone, as above	57	57
	BUCKINGHORSE FORMATION		
32	Shale, silty at top, becoming rubbly at base, greyish black, rusty weathering; ironstone concretionary bands	50	2,855
31	Mostly covered	200	2,805
30	Shale, rubbly to flaky, rusty weathering; ironstone concretions	50	2,605
29	Covered	300	2,555
28	Shale, as above; concretions	50	2,255
27	Covered	100	2,205
26	Shale, as above; concretions	100	2,105
25	Covered	500	2,005
24	Shale, rubbly, rusty weathering; some ironstone concretions	50	1,505
23	Covered	150	1,455
22	Shale, as above	50	1,305
21	Covered	100	1,255
20	Siltstone, argillaceous, massive, sandy at top; bedded	10	1,155
19	Shale, rubbly to platy, dark grey, rusty weathering; concretions	20	1,145
18	Sandstone, fine grained, greenish grey, finely cross-laminated, massive, glauconitic, concretionary	28	1,125
17	Sandstone, fine grained, greenish grey, finely cross-laminated; shale, 50%; some concretions	5	1,097
16	Shale, rubbly, rusty weathering; concretions	115	1,092
15	Shale, rubbly	50(?)	977
14	Sandstone, fine grained, greenish grey, finely cross-laminated, glauconitic, platy	3	927
13	Siltstone, sandy, argillaceous; wavy bedded, 2″–4″	16	924
12	Shale, platy; interbedded, thinly laminated sandstone	55	908
11	Siltstone, argillaceous, dark grey, rusty weathering; large concretions at top	19	853
10	Shale, platy; some thin layers of cross-laminated siltstone; some concretions	112	834

Unit		Thickness in Feet: Unit	Thickness in Feet: Height above base
9	Shale, fissile to rubbly, rusty weathering; bentonite bands	65	722
8	Covered	75	657
7	Shale, rubbly, rusty weathering	50	582
6	Covered	75	532
5	Shale, platy to blocky, massive	50	457
4	Covered	100	407
3	Shale, rubbly to blocky, greyish black, rusty weathering, concretions; thin bentonite layers	250	307
2	Sandstone, medium grained, brown; argillaceous streaks and patches. Upper surface is slightly pitted	24	57
1	Conglomerate to breccia, composed mainly of chert fragments with some limestone and sandstone, ½"–6", subangular; massive, but shows some bedding; weathers medium grey	33	33
	PERMIAN		
	Mudstone, calcareous, dark grey; weathers light grey to white; laminated but not well bedded; contains brachiopods in scattered lenses; upper 2' contains some chert fragments—not a conglomerate but a gritty to pebbly mudstone	16	16

Section 3. Buckinghorse formation, Petitot River, N.W.T. east side of syncline, downstream from Bovie Lake structure

	Overlying beds not exposed		
28	Shale to mudstone, silty, bedded, rusty weathering; rare concretionary band	32	1,313
27	Mudstone, blocky, rusty weathering; some thin bands of siltstone	22	1,281
26	Shale to mudstone, rubbly, rusty weathering; few concretions	35	1,259
25	Mudstone, silty; some sandstone	12	1,224
24	Mudstone to shale, rubbly, rusty weathering	57	1,212
23	Siltstone to mudstone, rusty weathering, dark grey to black	6	1,155
22	Mudstone to shale, rubbly, rusty weathering	13	1,149
21	Sandstone, fine grained, greenish grey, finely laminated	3	1,136
20	Mudstone, rubbly, rusty weathering; few concretions	48	1,133
19	Sandstone, as above	1	1,085
18	Shale to mudstone, rubbly to slightly blocky, rusty weathering, greyish black; few concretions; large 3' concretion at top	104	1,084
17	Shale to mudstone, as above	104	980
16	Mudstone, greyish black, blocky, rusty weathering	15	876

Unit		Thickness in Feet: Unit	Thickness in Feet: Height above base
15	Siltstone, platy, bedded, light brownish grey	20	861
14	Shale, silty, greyish black, rusty weathering	25	841
13	Siltstone, thinly bedded, and shale, rubbly, rusty weathering; sandier at top	25	816
12	Shale to mudstone, blocky, rusty weathering; few concretions and thin siltstone bands	40	791
11	Shale, rubbly to blocky at top, rusty weathering, greyish black; some large reddish brown concretions	40	751
10	Mostly covered. Appears to be rubbly, rusty weathering shale	25	711
9	Siltstone, argillaceous to mudstone, silty, rusty weathering, some concretions and thin beds of sandstone	46	686
8	Sandstone and siltstone with shale. Sandstone, fine grained, brownish grey, 2″–12″ beds, few concretions	57	640
7	Mudstone to shale, silty, rusty weathering, few concretions	13	583
6	Sandstone and shale interbedded as below	11	570
5	Shale, silty, rusty weathering	9	559
4	Sandstone, fine grained, greenish grey, finely laminated, thinly bedded with interbeds of shaly siltstone	23	550
3	Mudstone to siltstone, very thinly bedded, rusty weathering, siltier at top	25	527
2	Sandstone, fine grained, laminated, thinly bedded, shale and concretionary bands	2	502
1	Covered	500 ±	500
	Underlain by undated unit of chert and sandstone which lie above rocks of Mississippian age		

Section 4. Sikanni formation, Kotaneelee River, N.W.T.

5	Inaccessible. Finely laminated sandstone, thickly bedded	200	268
4	Sandstone, fine grained, greenish grey, finely crossbedded, platy, massive appearance	25	68
3	Siltstone, argillaceous, sandy, blocky, dark grey, rusty weathering; mostly covered	18	43
2	Sandstone, fine grained, greenish grey, grey to brownish weathering, finely and uniformly laminated, massive; rare large concretion	13	25
1	Siltstone to sandstone, finely laminated, greenish grey, interbedded with silty mudstone, beds 2″–6″; few concretionary bands; greenish grey weathering	12	12
	Underlying beds not exposed		

Section 5. Sikanni formation, Petitot River, N.W.T., about a mile above junction with Liard River

Unit		Thickness in Feet	
		Unit	Height above base
	Upper beds not exposed.		
19	Sandstone, fine grained, thickly bedded	2	252
18	Siltstone, argillaceous, to mudstone, somewhat bedded, dark grey, rusty weathering	13	250
17	Sandstone, much as below; slightly more argillaceous at base	34	237
16	Sandstone, argillaceous, massive, grey to brownish green, laminated, crossbedded; few large concretions	55	203
15	Sandstone, silty, finely laminated and crossbedded, massive, brown, light brown weathering; large swirls on bedding surfaces	18	148
14	Sandstone, silty, finely laminated and crossbedded, somewhat platy; some concretions	15	130
13	Sandstone, silty, finely laminated and crossbedded, thickly bedded; some concretions	9	115
12	Siltstone and shale interbedded; mostly talus covered	29	106
11	Sandstone, fine grained, grey, laminated, crossbedded; some concretions	3	77
10	Siltstone, as below	10	74
9	Sandstone, fine grained, grey, laminated, crossbedded; some concretions	9	64
8	Siltstone, argillaceous, greyish black to brownish grey, rusty weathering, blocky; round concretions	6	55
7	Sandstone, fine grained, grey, finely laminated and crossbedded	5	49
6	Siltstone, argillaceous, rusty weathering; lenses of laminated siltstone, reddish brown concretions, some contain large wood fragments	10	44
5	Sandstone to siltstone, grey, grey to rusty weathering, finely laminated and crossbedded; few concretionary zones	5	34
4	Siltstone, argillaceous, blocky, greyish black, rusty weathering; few concretions	6	29
3	Sandstone to siltstone, grey, grey to rusty weathering, finely laminated and crossbedded; few concretionary zones	4	23
2	Siltstone, argillaceous, blocky, greyish black, rusty weathering; few concretions	7	19
1	Siltstone, finely laminated, grey, light brown to rusty weathering; some beds of argillaceous siltstone; concretions, reddish brown weathering	12	12
	Underlying beds not exposed		

Section 6. Sikanni formation, junction of Muskeg and Liard Rivers, N.W.T.

Unit		Thickness in Feet: Unit	Thickness in Feet: Height above base
	Higher beds not exposed		
3	Sandstone, fine grained, silty, brownish grey, light greyish brown weathering, finely laminated and finely crossbedded, glauconitic	50	86
2	Siltstone, argillaceous, brownish grey, rusty weathering, finely laminated, crossbedded; thin shale interbeds	29	36
1	Siltstone, argillaceous, to mudstone, greyish black to brownish grey, rusty weathering	7	7
	Underlying beds not exposed		

Section 7. Sully formation, southeast side of Martin Hills, N.W.T.

	Higher beds not exposed		
15	Mostly talus covered. Shale, rubbly to platy; with some thin beds of fine-grained, platy sandstone; few small concretions in shale	20	181.5
14	Sandstone, fine grained, light olive-grey, weathers pale olive-grey; thin interbeds of silty shale; beds 4″–6″, more thickly bedded at top; finely laminated; some 2″ × 6″ concretions near base	14.5	161.5
13	Shale, fissile to rubbly, greyish black, rusty weathering, micaceous; becomes siltier towards top; few interbeds of fine-grained, laminated sandstone	27	147
12	Sandstone, fine grained, and shale. Sandstone, light olive-grey, pale olive-grey weathering, finely laminated and crossbedded, micaceous, platy; some sandstone has structures which indicate burrow filling; ripple-marked	22	120
11	Shale, fissile to rubbly, to mudstone, silty, greyish black, rusty weathering; selenite crystals scattered through shale; reddish brown concretions, some with pyritic centres	33	98
10	Shale, fissile to rubbly, dark grey to greyish black, rusty weathering; flaky at base, becoming siltier and blocky towards top	18	65
9	Mudstone, blocky, to shale, rubbly, greyish black, rusty weathering; 3″ concretionary layer at top	7.5	47
8	Sandstone, silty, medium grey, weathers light olive-grey, finely laminated, crossbedded, platy, few thin shale partings; layer of 1″ concretions at base	1.5	39.5
7	Shale, rubbly to slightly blocky, silty, greyish black, brown weathering; becomes siltier towards top with 1 foot of finely laminated sandstone 2 feet below top; upper 2 feet quite silty within lenses of finely crossbedded sandstone	9	38
6	Sandstone, silty to argillaceous, grey, fine grained, laminated and crossbedded, platy; lustre-mottling	1.5	29

Unit		Thickness in Feet: Unit	Thickness in Feet: Height above base
5	Shale, rubbly to fissile, greyish black, medium brown weathering; becomes siltier towards top with few thin sandstone lenses	6	27.5
4	Sandstone, as in unit 2, crossbedded	0.5	21.5
3	Shale, rubbly to fissile, micaceous, greyish black, medium brown weathering; becomes platy and silty at top; traces of glauconite	4	21
2	Sandstone, silty to argillaceous, light olive-grey, micaceous, moderate yellowish brown to light brown weathering, finely laminated and crossbedded, platy; grades into underlying unit	1	17
1	Talus covered. Appears to be shale, rubbly to fissile, micaceous, greyish black; few thin interbeds of fine-grained sandstone	16	16

Section 8. Fort Nelson formation, Petitot River, N.W.T., composite section measured at lower end of canyon and downstream

	Higher beds not exposed		
10	Conglomerate, much as in underlying beds	10	449
9	Conglomerate and coarse-grained, massive pebbly sandstone; pebbles of quartzite and chert, $\frac{1}{8}''$–$\frac{1}{2}''$. Beds are 5′–10′ thick, at least three of conglomerate, but most of section is inaccessible; some crossbedding	160	439
8	Mudstone, blocky, with beds of coarse-grained pebbly sandstone; mudstone is greyish brown, rusty weathering. Interval is not well exposed	44	279
7	Sandstone, coarse grained, grey to brownish grey, massive; pebbles in lenses and streaks	5	235
6	Covered	110	230
5	Sandstone, medium grained, platy, irregularly bedded	2	120
4	Pebble gravel, showing some crossbedding	2	118
3	Sandstone, coarse grained, massive, grey, crossbedded; lenses and streaks of small pebbles	11	116
2	Sandstone, medium to coarse grained, brownish grey, pebbly, massive	50	105
1	Sandstone, fine grained, laminated, thickly bedded; tends to be recessive, transitional	55	55
	SULLY FORMATION		
	Mudstone, blocky; grades into argillaceous siltstone with bands of laminated siltstone	42	

Section 9. Kotaneelee formation, Kotaneelee River, N.W.T., composite section

Unit		Thickness in Feet	
		Unit	Height above base
	Higher beds not exposed		
12	Shale, greyish black with medium brown weathering concretions. Upper part grades into massive argillaceous siltstone containing beds of laminated sandstone. Beds of sandstone at top are inaccessible	200	548
11	Shale, greyish black, rusty weathering, inaccessible	55	348
10	Sandstone, fine grained, homogeneous, limonitic stained, 4″–6″ beds	11	293
9	Shale, rubbly; reddish brown concretions	17	282
8	Shale, rubbly to blocky, greyish black, rusty weathering. Mostly covered	120	265
7	Shale, greyish black, concretionary. Mostly covered by mud slides	60	145
6	Sandstone, coarse grained, argillaceous, greenish grey, massive, pebbly, glauconitic	15	85
5	Shale to mudstone, rubbly to blocky, greyish black, rusty weathering	20	70
4	Siltstone, argillaceous, massive, greenish grey, sandy; concretionary layer at top with some pebbles	5	50
3	Shale to mudstone, rubbly, greyish black, rusty weathering; few scattered pebbles	22	45
2	Mudstone, silty, greyish black, rusty weathering, selenite crystals, massive appearance; few small concretions; sandy at base with more pebbles towards top; concretionary layer at top	15	23
1	Mudstone, slightly silty, greyish black; weathers slightly rusty to brownish grey, grades into overlying beds	8	8
	Underlying beds not exposed but apparently are very close to Fort Nelson formation		

Section 10. Log of Cretaceous Rocks, Imperial Island River No. 1 Well

Location: Lat. 60°09′29″N, long. 121°08′16″W

Elevation: 2,278 feet (Ground), 2,288 feet (K.B.)

Total depth: 8,233 feet

Summary log by H. R. Belyea of samples to 2,090 feet depth, stored at Geological Survey of Canada, Calgary, Alberta.

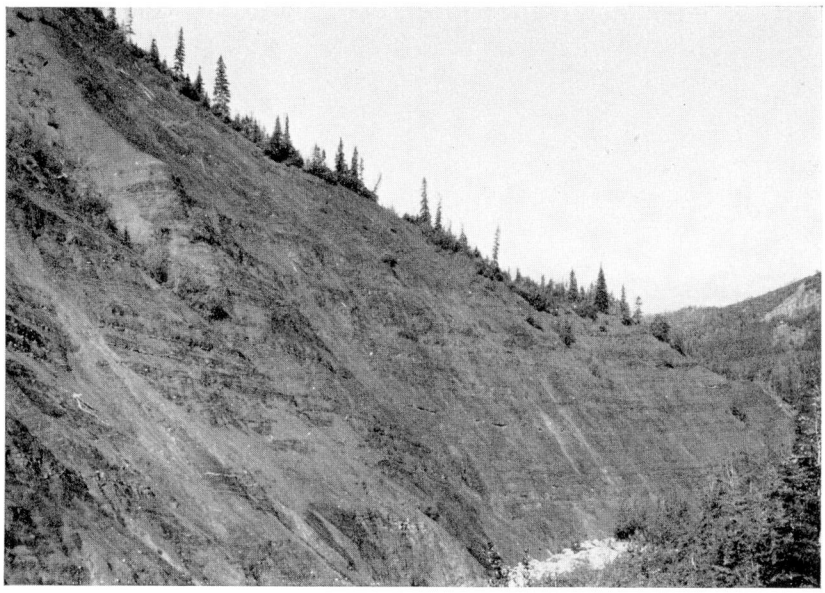
Depth (feet)	
	Fort Nelson Formation
70— 100	Sandstone, light grey, salt-and-pepper, calcareous, quartz and scattered dark grains, fine to medium grained, angular; limonite, shale, grey, dark grey with plant fragments
100— 150	Shale, light grey, in part silty, fissile, micaceous, some sandstone; bentonite (?) at 120-130
	(Above beds may be Kotaneelee formation)
150— 200	Sandstone, light grey, medium to coarse grained, calcareous, angular, poorly sorted; shale, grey to yellow-grey, micaceous; carbonaceous specks
200— 330	Shale, grey, non-calcareous, flaky, in part silty, micaceous; some sandstone and limestone, grey, finely crystalline, dense, probably concretions at 210-230
330— 360	Shale as above, and sandstone, light grey, medium to coarse grained (samples poor)
360— 440	Sandstone, grey, fine grained, grades down to siltstone; largely quartz, micaceous; calcite cement; plant fragments
440— 490	Samples poor, probably sandstone and siltstone as above, and grey silty shale
490— 570	Sandstone, light grey, fine to coarse grained, quartz and dark grains, poorly sorted, angular; finer grained and grades to siltstone 510-550; some grey shale; limestone, grey, finely crystalline, sandy 510-520
570— 640	Shale and sandstone, shale, grey, silty to sandy, grades to siltstone; plant fragments; sandstone, grey, fine grained, some light grey, medium grained at 610-620; similar to sandstones above; ironstone (concretions?) at 630-640
	Fort St. John Group
	Sully Formation
640— 750	Shale, grey, non-calcareous
750— 830	Shale, as above; in part silty; grades to siltstone; ironstone (concretions?), silty bentonitic (?) 780—790
830—1,180	Shale, dark grey, fissile, non-calcareous; some grey siltstone, probably laminal
1,180—1,295	Shale, as above; sandstone, grey to light grey, quartzose, fine grained, micaceous; small green grains; angular
	Sikanni Formation
1,295—1,470	Sandstone, light grey, fine grained, quartzose, dark grains and glauconite (?), pink grains, mica, calcite cement, in part friable; fair porosity; grey shale laminae; shale prominent 1,300—1,400, 1,350—90; bentonite (?) 1,380—90
	Buckinghorse Formation
1,470—1,550	Sandstone and shale, probably lensing and laminated
1,550—2,090	Shale, dark grey; siltstone, grey argillaceous, probably as lenses
	Underlying beds—Deville (?) formation and Mississippian ?

Stott, 3-3-57

A. *Erosional unconformity between Devonian and Cretaceous (?) shales, Redstone River, N.W.T.*

Plate I

B. *Lower shales of Buckinghorse formation, headwaters of Murky Creek, N.W.T.*

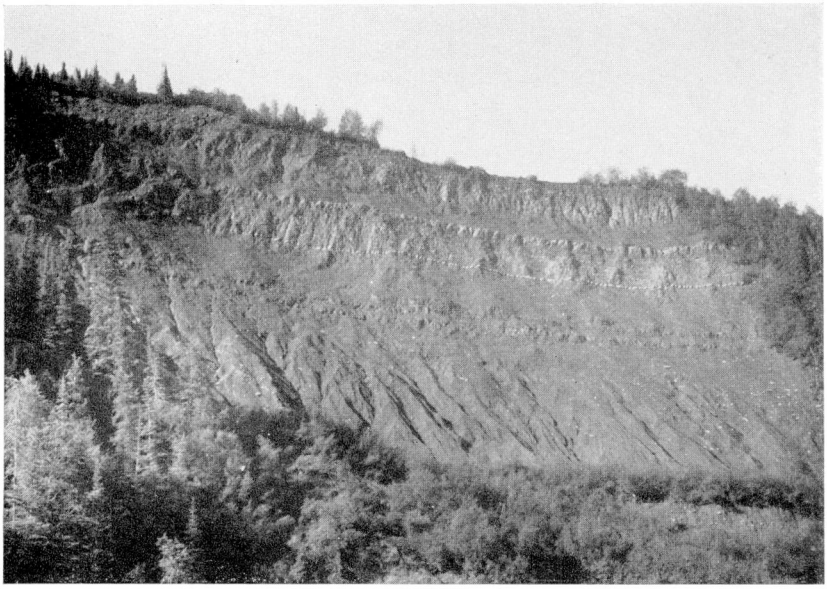


Stott, 1-6-57

Stott, 2-2-57

Plate II

Erosional unconformity between Permian mudstone and Cretaceous conglomerate, headwaters of Sully Creek, west of Liard Range, N.W.T.

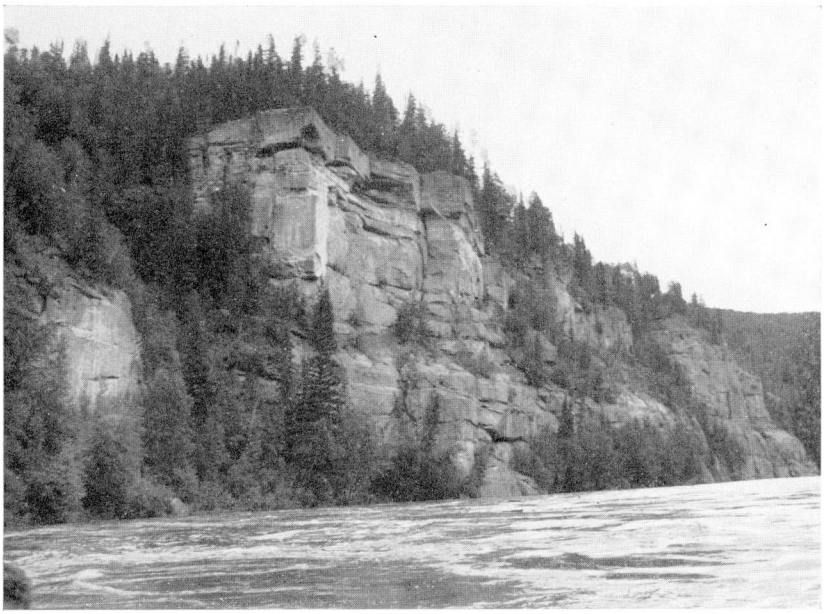


Stott, 1-4-57

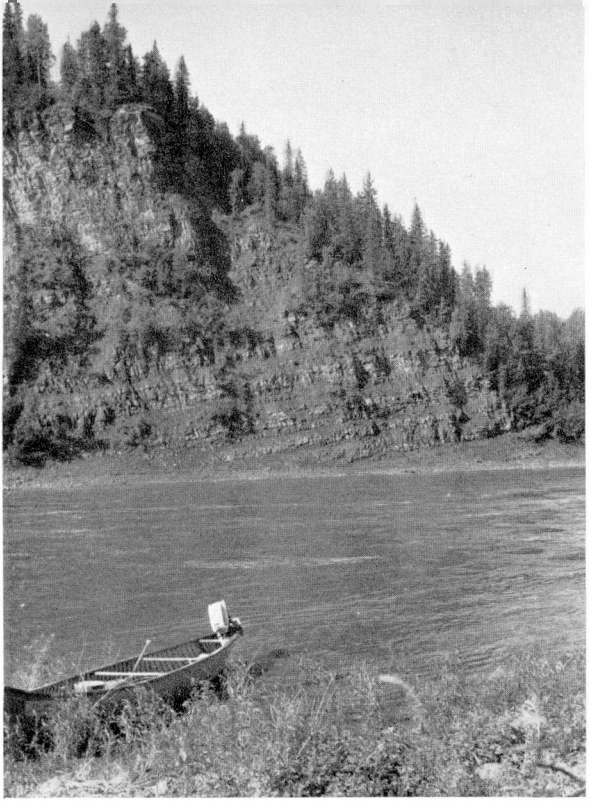
A. Middle siltstones of Buckinghorse formation, headwaters of Murky Creek, N.W.T.

Plate III

B. Dunvegan sandstone, canyon of Petitot River, N.W.T.



Stott, 2-8-57



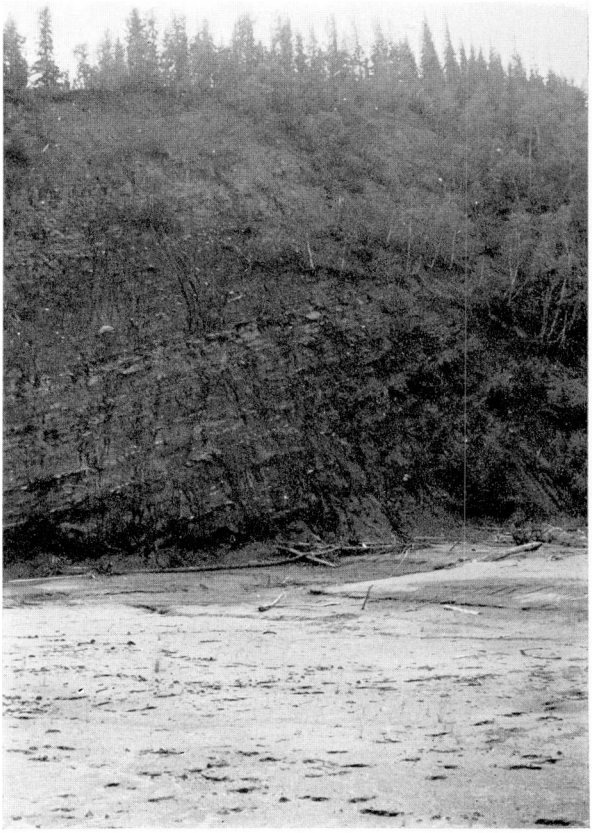
Stott, 2-6-57

Plate IV

A. Sikanni formation, Petitot River, about a mile above Liard River, N.W.T.

Plate IV

B. Basal shales of Sully formation, Kotaneelee River, N.W.T.



Stott, 2-4-57