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GEOLOGICAL RECONNAISSANCE ALONG FORT NELSON, LIARD AND BEAVER RIVERS, NORTHEASTERN BRITISH COLUMBIA AND SOUTHEASTERN YUKON

REPORT AND MAP

By

E. D. Kindle

OTTAWA

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MINES AND GEOLOGY BRANCH

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Illustration

Preliminary map, Nelson Forks, B. C. and Yukon.

GEOLOGICAL RECONNAISSANCE ALONG FORT NELSON, LIARD, AND BEAVER RIVERS, NORTHEASTERN BRITISH COLUMBIA AND SOUTHEASTERN YUKON

INTRODUCTION

During the 1943 field season, Fort Nelson River was descended for 100 miles from Fort Nelson to Liard River; Liard River was ascended as far as Hell Gate, a distance of about 85 miles; and a 40-mile traverse was run up Beaver River into southeastern Yukon. The region explored lies between latitudes 58°45' and 60°15' and longitudes 122°00' 125°30' (See Map). It is accessible by the Alaska Highway, which passes 5 miles west of Fort Nelson River at Fort Nelson and crosses Liard River 30 miles northwest of Hell Gate. Muskwa airport is 2 miles west of Fort Nelson and a branch road reaches the river from there. A highway bridge also crosses Muskwa River, about 5 miles above the junction of Muskwa and Fort Nelson Rivers. It is roughly 300 miles by road from railhead at Dawson Creek to Fort Nelson.

Except during periods of very low water Fort Nelson River is easily navigable for flat-bottomed river boats as far up as Fort Nelson. Liard River is navigable as far up as Hell Gate, but includes numerous stretches of fast, dangerous water. A short rapid with 6-foot rollers on the north side of Liard River, 2 miles below Hell Gate, may be avoided by keeping to the south side of the river. Another rapid, 4 miles below Hell Gate, can be ascended close to the north side of the river. The canyon west of Hell Gate was not visited, but McConnell (1890)[1] has given

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1 A bibliography of references is given on pages 2 and 3 of this report

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a good description of its perils. The most serious obstacle is a succession of rapids that commence 7 miles east of the highway crossing. The portage around this, known as Devil's Portage, is reported as being nearly 4 miles long and involves a 1,000-foot climb. Between Devil's Portage and Hell Gate the Liard is interrupted by nine rapids and by stretches of fast water with high rollers.

The Indians at Nelson Forks state that Beaver River may be ascended during times of high water for over 100 miles. It is a shallow, swift stream with a succession of gravel bars, over each of which the river flows with momentarily increased speed. The river is particularly fast between 38 and 60 miles upstream, where it passes through mountains that rise to elevations of about 4,500 feet. During June and July of the past year (1943) a minimum of 18 inches of water lay over nearly all of the gravel bars in the central channel of the river, but in early September the depth, as noted at the mouth of Beaver River, was only 8 inches.

The writer's party used 19-foot freight canoes powered with 9 horsepower outboard motors. These were found to be quite satisfactory on Fort Nelson and Beaver Rivers, but when loaded were slow and unsteady on Liard

River where the water is more turbulent. A narrow, flat-bottomed river boat about 35 feet long, with 2-foot sides, and powered by a 22 horsepower outboard motor, is best for use on Liard River.

Timber is abundant along Liard, Fort Nelson, and Beaver River Valleys. In places along Beaver River north of 60 degrees spruce attains a diameter of 2 feet, and poplars up to 3 feet are common. Balsam is abundant on the higher slopes, and in places birch and poplar are plentiful. Moose, black bear, wolves, and porcupine were seen on several occasions. Beaver, fox, and lynx are scarce throughout the district. Ducks and geese are rarely seen along the rivers, the swift water discouraging them from attempting to feed there. Pike, pickerel, and inconnu were caught in Beaver River near its mouth. Arctic grayling are plentiful in all of the small tributary streams of Liard River.

The writer wishes to acknowledge transportation over the Alaska Highway and other valuable assistance given by the Northwest Service Command of the United States Army through the kindness of Colonel J.P. Glandon and Colonel A.C. Lane. Student assistants L.L. Price, R.J. Merrill, and D. Robertson were of great help throughout the season. Aeroplane photographs of Liard River that had been taken by Charles Camsell in 1935 were most useful in the field. Excellent photographs of the entire area were recently supplied by the United States Army, and these were used to compile the map accompanying this report.

The map-area is underlain by Palaeozoic and Mesozoic sedimentary formations comprised largely of conglomerate, sandstone, limestone, and marine shales. The shales are a possible source of oil, and, as a number of favourable structures were found, the area is commended as a field worthy of further investigation.

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PHYSICAL FEATURES

Fort Nelson River winds through a valley bordered by boulder clay hills that rise gently to 200 or 300 feet above the stream. The valley bottom is generally ½ to 1 mile or more wide, and is formed largely of gravel overlain by fine alluvial sand and silt deposits that support a luxuriant forest growth. A thick Upper Cretaceous conglomerate formation outcrops both along and within a few miles of Fort Nelson River, between 12 and 35 miles southeast of Nelson Forks. The conglomerate forms a plateau that rises gradually in an easterly direction to an elevation of about 1,000 feet above the river. The plateau drops abruptly into the river valley along prominent escarpments (See Map) that are marked in many places by almost vertical bluffs 200 to 300 feet high. The same conglomerate formation forms an escarpment that extends northerly for over 50 miles along the east side of Toad and Liard Rivers and northeasterly for 15 miles, a few miles west of Beaver River. The escarpment is breached by Liard River 6 miles west of the mouth of Beaver River, and the latter stream breaks across it 18 miles upstream from Liard River. It forms the west boundary of a plateau that towards Toad River rises to 2,000 feet above Liard and Toad Rivers. This plateau becomes gradually lower north and east from Toad River and merges with the low but hilly country of Liard Valley.

Photographs of Liard Valley downstream from the mouth of Fort Nelson River show a low, wide valley for about 50 miles, as far as Fort Liard. Farther north the river is bordered on the west by Liard Mountains of the Mackenzie Mountain system. West of Hell Gate, 100 miles to the southwest, the Liard flows southeast around the northern border of the Rocky Mountains. The latter trend northwest, whereas Liard Mountains strike north. Between them is an area drained by Grayling, Scatter, Crow, and Beaver Rivers, in which the topography is alternately either plateau-like or mountainous, with mountains reaching elevations of about 4,500 feet. Mountains rising sharply to 3,500 feet above Beaver River Valley were encountered 38 miles up Beaver River from the Liard. These strike southwest and appear to afford some protection against cold winds to the comparatively low valleys of Crow and Beaver Rivers, which are well timbered. Anticlinal mountain folds near Hell Gate strike northwest, but 20 miles up Grayling River swing to the northeast and line up with the mountains across Crow and Beaver Rivers. East of these mountains to Liard River there is much lower plateau country with deeply incised streams. Scatter River for 10 miles west of the Liard has cut a precipitous 500-foot deep channel through a plateau that rises to about 700 feet above Liard River. The headwaters of Scatter River, 30 miles west of the Liard, are incised in a high plateau that appears,

from photographs examined, to lie mostly above timber line. Soft Lower Triassic shales along the Liard, between Toad and Grayling Rivers, form hills that rise to 300 feet above the Liard, and harder, overlying Middle Triassic beds near Crusty Creek and east of the mouth of Toad River form hills that rise to 1,000 feet above the river.

STRATIGRAPHY

General

The rocks examined in the map-area are all sedimentary. They range in age from Carboniferous to Upper Cretaceous and have an aggregate thickness of about 11,000 feet. Silurian and Devonian limestones, shales, and sandstones outcrop along Toad and Racing Rivers, 25 miles south of Hell Gate, and along Liard River, commencing 30 miles northwest of Hell Gate, and it is probable that they underlie the formations described in this report.

Table of Formations

Age	Formation	Lithology	Thickness Feet
Pleistocene and Recent		Gravel, sand, silt, boulder clay.	0 to 200+
		Unconformity	
Upper Cretaceous		Sandstone, marine shale, conglomerate, concretions.	1,000+
	Fort Nelson	Conglomerate, grit, sandstone, shale.	560+
Lower Cretaceous	Lépine	Marine shales, sandstone lenses; concretions.	2,000±
	Scatter	Sandstone, marine shales; concretions.	750±
	Garbutt	Marine shales, sandy shale; concretions.	2,000±
		Unconformity	
Middle to Late Lower Triassic	Toad	Sandstone, limestone, marine shale; dark concretions.	780 to 2,400
Early Lower Triassic	Grayling	Grey shale, ripple-marked sandstone lenses.	500+
Permian		Chert; some overlying sandstone and shale.	150+
Carboniferous (?) and Permian		Sandstone, sandy argillite, argillaceous shale, limestone.	1,600+

Permian and (?) Carboniferous

At a distance of 38 miles from the Liard, Beaver River breaks through a mountain range that rises to 3,000 feet above it. Merrill Mountain, the first on the north side of the Beaver, is composed of sedimentary rocks of Permian age with some, possibly Upper Carboniferous, strata exposed along its west side. The beds strike north 20 degrees east and dip 10 to 20 degrees southeast. The mountain rises at a 50-degree slope to 1,400 feet above the river, flattens for a short distance, and then rises gradually toward the northeast to an elevation of about 4,500 feet or 3,000 feet above the river at a point about 3 miles north of the stream. An examination of the steep, lower slope disclosed a section of grey to yellow sandstones with some calcareous and shaly beds. Fossil collections were obtained from various stratigraphic horizons on the steep southern slope of Merrill Mountain, and have been identified by A.E. Wilson of the Geological Survey. One collection, at 420 feet above the river, included Pustula sp. A, P. sp. B, Dictyoclostus sp., Leiorhynchus sp. B, Athyris sp., and Dielasma sp. A, and was stated to be of Upper Carboniferous or Permian age, probably Permian.

A second lot, collected 280 feet higher up the slope, included Buxtonia sp., Dielasma sp. B, Allorisma sp. B, and Aviculopecten sp., and was regarded as "probably of Permian age". The species of Aviculopecten may be close to Limipecten morsei Newell, but is poorly preserved.

A third collection, from 200 feet vertically below the peak of Merrill Mountain and over 2 miles north of the river, contained the following: Echinoconchus sp., cf. Marginifera sp., Leiorhynchus sp., Pugnoides sp., Dielasma sp. C, and Martiniopsis sp.

A limestone lens 2 feet thick, which lies 300 feet southwest of the locality where the last described collection was made, yielded the following: Crinoid discs, Bryozoa, Productus sp. A close to P. uralicus Tschernyschew, Marginifera sp. close to M. jisuensis Chao, Dielasma sp., and an unidentifiable brachiopod. This and the preceding collection represent strata that are almost certainly of Permian age.

Permian

The lower southeast slopes of Merrill Mountain are blanketed by a chert formation that strikes north 20 degrees east and dips 15 degrees southeast. On its projection towards the northwest it would appear to be stratigraphically higher than beds on the peak of the mountain. Where exposed in bluffs on the east flank of Merrill Mountain, 600 feet north of Beaver River, it is 150 feet thick. The chert occurs both massive and roughly laminated, and is in beds that vary from 1 to 10 feet or more in thickness. The beds are separated by layers of shale from 1 to 3 inches thick. The chert is grey to black, rust-stained on weathered surfaces, and is a brittle, highly fractured rock, traversed by numerous joint planes. It is overlain by about 30 feet of calcareous sandstone. Fossils collected from loose blocks of the calcareous sandstone at the west end of the chert bluffs, 540 feet above the river, included the following forms, identified by

A.E. Wilson and regarded as almost certainly of Permian age: Fenestellid bryozoa, Productus sp. close to P. uralicus Tschernyschew, Spirifer sp., Marginifera sp. close to M. jisuensis Chao, and cf. Sphenotus sp.

On the south side of Beaver River the chert formation extends all the way up the east flank to the top of the first mountain, 1,600 feet above the river. Two fossil species collected on the northwest side of the mountain at the water's edge, cf. Solemya sp. and Allorisma sp., were identified by A.E. Wilson as Carboniferous or Permian. The thickness of the Carboniferous (?) and Permian rocks exceeds 1,600 feet.

Triassic

Sedimentary rocks of Lower and Middle Triassic age outcrop almost continuously along Liard River for 16 miles, from Hell Gate to a point 2 miles east of the mouth of Toad River. Both Upper Triassic and Jurassic beds are missing in the section east of Toad River and black shales that overlie the Middle Triassic strata are thought to be of Lower Cretaceous age. According to McConnell (1889) Triassic rocks are also met with along Liard River west of Hell Gate. The underlying Permian rocks are well exposed 40 miles up Beaver River, but in that sector the Triassic strata are largely concealed by drift.

For 10 miles west and 2 miles east along Liard River from the mouth of Toad River, Triassic strata form a broad major anticline striking northwest, with beds on the northeast limb dipping from 10 to 35 degrees northeast and on the southwest limb up to 75 degrees southwest (See structure section on map). Numerous small anticlinal folds, generally with gentle dips, are superimposed upon the major anticline. East of Toad River the Triassic strata are overlain by Lower Cretaceous rocks that strike north and dip east at from 10 to 30 degrees. Near Hell Gate the Triassic beds are comparatively closely folded.

Grayling Formation. This name is proposed for a series of soft, laminated, friable, grey shales that outcrop almost continuously along Liard River for 4 miles west and 5 miles east of the mouth of Grayling River. At places beds of hard, ripple-marked sandstone, ranging from 1 inch to 10 feet in thickness, are interbedded with the shales. Excellent exposures of the formation appear along Grayling River in cliffs as high as 300 feet, and this is, therefore, regarded as the type locality. The shale beds somewhat resemble varved clays, and a prospector's pick may be driven from 1 to 2 inches into them in a single blow. In places along the Liard bluffs of the shale up to 100 feet high carry no sandstone; elsewhere the formation is made up of alternating layers of sandstone and shale. The sandstone beds rarely exceed 2 or 3 feet in thickness, and more commonly are less than a foot thick. A mile up Grayling River a sandstone bed, up to 10 feet thick, was seen to thin gradually and to disappear in a distance of 1,000 feet along the strike. The formation has an observed thickness of about 600 feet and the total thickness may be nearly 1,000 feet.

Several fossil shells collected on Grayling River 1 mile north of the Liard were identified by F.H. McLearn of the Geological Survey as cf. Monotis stachei Bittner, permitting a tentative dating of early Lower Triassic. This form was also found on the north side of Liard River 2 miles east of the mouth of Crusty Creek.

Toad Formation. Brown and black, platy shales and siltstone, sandstone, and limestone beds that overlie the Grayling formation form a lithological unit that has been named the Toad formation. Type localities are Toad River, 2 miles south of the Liard, and Liard River between Hell Gate and Garbutt Creek. The formation is about 800 feet thick where exposed near the mouth of the Toad on Liard and Toad Rivers, but 9 miles farther west it is nearly 2,400 feet thick. Limestone lenses less than 2 feet thick occur in this formation on the Liard near Toad River, but 9 miles west the section includes 40 feet of sandy limestone as well as individual limestone beds up to 6 feet thick (See structure section on map). On Hell Gate Island the top of the formation consists of 50 feet of limestone and sandy limestone containing Nathorstites mcconnelli Whiteaves and Daonella of late Middle Triassic age.

On Garbutt Creek, 6 miles northeast of the mouth of Toad River, the top sandstone member of the Toad formation is separated from overlying black shales by 5 feet of coarse, brown sandstone that contains some carbonized wood fragments. Black and brown shales at the base of the Toad formation are in conformable contact with laminated grey shales of the Grayling formation.

The following is a complete section of the Toad formation as exposed along Liard River near the mouth of the Toad. The sandstone beds listed at the top of the section are conformably overlain by the Lépine shales on the southeast side of the Liard about 2 miles downstream from Toad River, and the base of the formation lies conformably upon Grayling shales 1 mile downstream from the mouth of the Toad.

Top of Section	Thickness Feet
Sandstone and siltstone, minor shale beds.....	75
Limestone, black, bituminous odour, fossiliferous.	1
Shale, black, argillaceous; dark concretions; fossiliferous.....	3
Limestone, black, impure; contains Sturia sp. and Longobardites ? sp. ("Probably Middle Triassic")	2
Shale, black, argillaceous; dark concretions; fossiliferous.....	12
Limestone, black, impure; bituminous odour; fossiliferous.....	1½
Shale, black, platy; dark concretions.....	10

	Thickness Feet
Sandstone and siltstone, mostly grey to sandy yellow with some thin shale beds.....	200
Shale, black; some dark concretions; a few limestone stringers under 1 inch thick; disseminated pyrite.....	72
Limestone, light grey, fossiliferous; containing Wasatchites sp., Xenoceltites sp., Monotis cf. himaica Bittner; age "later Lower Triassic"....	½
Shale, black; dark concretions.....	3
Sandstones, siltstones, and shales, grey to brown	400
Total thickness	780

A more accessible section across the Toad formation is exposed on the north side of Liard River, 9 miles west of the section given above and 1,592 feet thicker. The fossils listed were identified by F.H. McLearn.

Top of Section	Thickness Feet
Sandstone, argillaceous, massive, thickly bedded	50
Sandstone, impure, brown, thinly bedded.....	40
Sandstone, calcareous, grey.....	40
Limestone, massive, hard, grey.....	6
Sandstone, coarse, grey, calcareous.....	4
Concealed interval, probably shale.....	100
Sandstone, clean, hard, sandy, yellow.....	35
Sandstone, grey, calcareous; alternately massive and thinly laminated.....	190
Concealed interval, probably shale.....	40
Sandstone, grey, calcareous; thick, massive beds	80
Concealed interval (shale and sandstone on south side of river).....	150
Limestone, black, sandy, fossiliferous, containing Japonites sp., Parapopanoceras sp., Longobardites sp., Ostrea sp., Trigonodus sp.; age "probably Middle Triassic".....	40
Shale, black, platy, with dark concretions containing fossils.....	35

	Thickness Feet
Sandstone, dark grey, calcareous.....	10
Shale, black, slaty.....	10
Sandstone, grey, calcareous, massive.....	6
Shale, brown, soft, crumbly.....	3
Shale, black, platy, and softer brown beds.....	10
Shale, black, platy.....	8
Sandstone, dark, impure.....	4
Shale, brown and black layered.....	3
Sandstone, calcareous; containing a few shells...	30
Shale, dark.....	1
Sandstone, calcareous, dark grey.....	18
Sandstone, impure, slightly calcareous.....	20
Shale, black, with dark concretions.....	6
Sandstone, calcareous, grey.....	12
Sandstone and shale, mostly drift covered.....	20
Sandstone, impure, dark brown; massive beds and some finely laminated beds.....	70
Shales, black.....	10
Sandstone, calcareous, thin-bedded.....	30
Calcite vein, parallel to bedding, sheared, dip 55 degrees southwest.....	
Shales, brown, platy, thin-bedded.....	75
Sandstone, calcareous, buff weathering.....	2
Shales, brown, thinly stratified, with beds of buff weathering, calcareous sandstone 6 to 12 inches thick occurring roughly every 10 feet...	300
Shales, black to brownish black, thin-bedded, platy.....	325
Sandstone, grey, impure, massive, hard.....	2
Shale and brown, sandy shale.....	40
Sandstone, buff weathering, impure, hard.....	1
Shale, brown and sandy.....	5

	Thickness Feet
Sandstone, buff weathering, impure.....	1
Shale, brown, thin-bedded, platy.....	240
Shale, black, thinly laminated, platy.....	300
Concealed interval extending easterly and probably underlain by softer, grey shales of Grayling formation.	
Total thickness	2,372

The 40-foot zone of dark, impure limestone, at 735 feet from the top of the formation, contains, in addition to the fossils listed, the remains of an ichthyosaur. G.M. Sternberg of the Geological Survey reports that the fossil vertebrae submitted to him for examination appear to belong to the genus Cymbospondylus. He says, "It compares more nearly with Cymbospondylus piscosus Leidy from the Middle Triassic of Nevada, but that species is so poorly known and the British Columbia specimen so incomplete that exact reference is not possible".

Lower Cretaceous

Approximately 4,500 feet of marine shales and sandstones of Lower Cretaceous age are exposed along Liard and Toad Rivers east of their junction. This thick column of rock has been subdivided on a basis of lithology into three formations, the Garbutt, Scatter, and Lépine. These marine shales and sandstones are the equivalent of the Fort St. John group of Peace River district.

Garbutt Formation. The name of this formation is proposed from that of the type locality on Garbutt Creek, where it is well exposed. It consists of about 2,000 feet of dark, friable shales that weather into small, rust-flecked particles. The contact of Garbutt shales with underlying Middle Triassic sandstone was observed on Garbutt Creek 5 miles north of the Liard. There, thin-bedded, well-sorted Triassic sandstones are overlain by 5 feet of coarse, brown, impure sandstone that contains carbonized wood fragments and may represent Jurassic sedimentation. The impure sandstone is overlain by black Garbutt shales exposed in a 100-foot bank. The shale in this bank contains rusty argillite beds 3 or 4 inches thick that lie from 6 to 10 feet apart. Similar argillite beds appear at intervals higher in the section, and concretions are common at some horizons. The concretions are rust stained and some have a core of fine pyrite. No fossils have been found in the Garbutt shales, but they are believed to be the equivalent of the Moosebar formation of Peace River Valley in Fort St. John district and of the lower part of the Buckinghorse formation of the Sikanni Chief area south of Fort Nelson.

Scatter Formation. 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 10 miles, commencing at a point 1½ miles west of the Liard. In this distance Scatter River has cut a rock canyon whose walls rise abruptly to from 400 to 500 feet above the valley bottom. For the first half mile the beds dip from 5 to 17 degrees east, but in the next 5 miles to the west they are horizontal. Briefly the Scatter section, from bottom to top, comprises the following: 75 feet of sandstone, 125 feet of shale, 250 feet of sandstone and shale, 200 feet of black shale, and 100 feet of sandstone and shale. Fossils collected from the upper 300 feet of the formation were identified by F. H. McLearn of the Geological Survey as ammonites of the species *Inoceramus cadottensis* of the late Lower Cretaceous *Gastroplites* zone. This would equate the Scatter formation with the Commotion formation of Pine River area, and probably with the Gates formation of Peace River foothills.

The following is a detailed section of the Scatter formation as measured along Scatter River 1½ miles west of the Liard:

Top of Section	Thickness Feet
Sandstone (strike north 15 degrees east, dip 17 degrees southeast)	3
Shale, grey, sandy, with concretions	10
Sandstone, fine-grained, with rusty concretions	3
Shale, grey, sandy, bedded, with rusty concretions	5
Sandstone, grey, hard, with rusty concretions	5
Shale, grey, bedded, with rusty concretions	10
Sandstone, clean, hard, bedded, with concretions	30
Shale, grey, bedded, sandy, with concretions	4
Sandstone, bedded, fine, with rusty concretions	3
Shale, grey, with rusty concretions	5
Sandstone, bedded, with concretions containing *Inoceramus cadottensis*	15
Shale, fine-grained, black to dark grey, sandy, with concretions containing *Inoceramus cadottensis*	200
Sandstone, bedded, with concretions	2
Shale, black to dark grey, with concretions	20
Sandstone, hard, bedded, with concretions	15
Shale, dark grey, bedded, with concretions	25
Sandstone, bedded, with concretions	2

	Thickness Feet
Shale, dark grey, with concretions	25
Sandstone, bedded, with concretions	2
Shale, dark grey, with concretions	4
Sandstone, bedded, with concretions	3
Shale, dark grey, with concretions	10
Sandstone, fine-grained, bedded, with concretions	15
Shale, dark, with concretions	3
Sandstone, bedded, with concretions	2
Shale, dark grey, with concretions	6
Sandstone, clean, bedded, with concretions	100
Shale, sandy, bedded, with concretions	25
Shale, black, friable, with many concretions	125
Sandstone, with thin shale layers and concretions	75
Total thickness	752

Lépine Formation. For 12 miles northeast and 15 miles southwest of the mouth of Scatter River the Liard is incised in a 2,000-foot thick series of grey and black marine shales that overlie the Scatter formation. These upper shales have been named Lépine formation after Lépine Creek, which flows east into Liard River 12 miles south of the Scatter. On the east bank of the Liard, opposite the mouth of Lépine Creek, the shales contain numerous concretions, and at this locality most of the concretions contain fossil shells. The following forms, collected from an horizon 200 feet above the river, were identified by F. H. McLearn as fauna of the late Lower Cretaceous, Gastroplites zone: Gastroplites cf. kingi, Inoceramus cadottensis, I. cadottensis var. altifluminis.

A zone of thin-bedded, friable, grey to black, flaky shale outcrops between elevations of 300 and 800 feet above the river on the steep slope opposite Lépine River. The lower part of the zone is studded with large, flat concretions that contain abundant specimens of Placenticeras liardense Whit., identified by F. H. McLearn as late Lower Cretaceous. The Lépine formation is believed to be the equivalent of the Cruiser and Goodrich formations of Peace River Valley, Fort St. John region, and of the Sikanni formation in the Sikanni Chief district south of Fort Nelson.

On the east side of the Liard, opposite the mouth of Scatter River, the greater part of the Lépine formation is exposed in a steep scarp slope that rises to 2,220 feet above the stream. The formation is overlain and protected from erosion by 560 feet of Upper Cretaceous conglomerate and sandstone. It consists of the following:

Top of Section	Thickness Feet
Shale, dark, with rusty concretions	30
Sandstone, straw coloured, with rusty concretions	10
Shale, dark, with rusty concretions	30
Sandstone, straw coloured, with rusty concretions	10
Shale, dark, friable, with rusty concretions	110
Shale, dark, firm, with concretions	90
Shale, friable, grey, breaking in thin flakes, with concretions	330
Sandstone and shale, with a few concretions	10
Shale, friable, with rust-stained concretions ...	15
Sandstone and shale in alternating beds, with concretions	4
Shale, soft, crumbly, with concretions	10
Sandstone in 2- to 6-inch bands with thin shale partings	10
Shale, friable, with concretions	18
Sandstone, impure, shaly, with concretions	2
Shale, dark, with 1- to 2-inch rusty argillite beds at 10- to 20-foot intervals	160
Sandstone and fine conglomerate	1
Shale, dark, rust-flecked, crumbly, with scattered iron-stained concretions and a few 1- to 2-inch beds of argillite	820
Shale, concealed beneath Liard River and drift at mouth of Scatter River, at least	340
Total thickness	2,000

Upper Cretaceous

Fort Nelson Formation. The first outcrops to be seen from Fort Nelson River below Fort Nelson are flat-topped bluffs of conglomerate, grit, and sandstone. They rise to 1,000 feet above the river at distances of 2 or 3 miles north and south of the stream and, roughly, 35 miles southeast of Nelson Forks. A few miles farther downstream the bluffs are close to the river and they form its east bank for 12 miles. They decrease gradually in height toward the northwest and disappear beneath the drift 10 miles south of Nelson Forks. The conglomerate beds strike northeast and dip from 2 to 3 degrees northwest, thus accounting for the gradual topographic slope to the northwest. The lower slopes below the nearly vertical cliffs of conglomerate that face the river are littered by a talus of huge conglomerate blocks that conceal the underlying shale

formation. The bluffs were climbed in two places, 3 miles apart, and at each place were found to comprise about 400 feet of conglomerate with minor beds of sandstone. The conglomerate forms both thin and thick massive beds, and in places shows well-defined crossbedding. Much of the conglomerate is of grit size with a scattering of larger pebbles; in other beds the pebbles are close packed and range from 1 to 3 inches in diameter. The pebbles are of quartz, chert, slate, argillite, quartzite, chalcedony, jasper, and minor calcite or limestone.

Because the conglomerate beds are well exposed along Fort Nelson River they have been named the Fort Nelson formation; they are, however, equally well exposed, together with the underlying Lépine shale, in a scarp along the east side of Liard River, and this is, consequently, held to be the type locality. The Fort Nelson formation underlies a plateau that rises 2,000 feet above Liard River northeast of the Toad. The plateau has an easterly slope and loses altitude in a northeasterly direction. A scarp that rises from the water's edge to the top of the plateau extends northeast along the Liard for nearly 25 miles, from near the mouth of Toad River to a point 4 miles west of the mouth of Beaver River. There, the plateau is reduced to a maximum elevation of 500 or 600 feet above the river and the scarp is breached by Liard River flowing easterly across it. North of the Liard the scarp continues northeasterly for many miles. It was seen half a mile up Crow River, and the Beaver crosses it 15 miles north of the Liard. It is the outstanding topographic feature of the district, extending as it does for over 50 miles to the northeast across the map-area. The topmost beds of the scarp are invariably comprised of conglomerate of the Fort Nelson formation. The conglomerate and underlying sandstone and shale beds have a common northeast strike and dip from 10 to 40 degrees southeast to form the west limb of a major syncline, the conglomerate beds along Fort Nelson River forming the east limb, with the synclinal axis striking northeast somewhere along the course of the lower part of Dunedin Creek and along the valley of the Liard north from Nelson Forks.

The following section was measured across the Fort Nelson formation on the east side of Liard River, opposite the mouth of Scatter River, where the scarp rises to an altitude of 2,220 feet above the river. The bottom of the section is 1,660 feet above the river, where the Fort Nelson formation conformably overlies Lower Cretaceous shales of the Lépine formation.

Top of Section	Thickness Feet
Conglomerate; clean, well-washed beds	325
Sandstone, clean, coarse, yellow	15
Shale, dark	20
Sandstone and shale, interbedded	40
Conglomerate, massive	30
Sandstone, coarse, yellow, crossbedded	15

	Thickness Feet
Sandstone and shale, interbedded	25
Conglomerate, massive, mostly grit size	20
Sandstone, coarse, yellow	40
Total thickness	560

A 6-foot band of shale interbedded with the main conglomerate member on the north side of Beaver River contains a few fossil leaves, but these are too poorly preserved to be of value for age determination. Fossil leaves were also obtained at the top of the formation on the north side of Liard River, but are not diagnostic. The position of the Fort Nelson formation, capping as it does over 4,500 feet of Lower Cretaceous shales and sandstones and lying immediately below shales and sandstones containing Upper Cretaceous fossils, suggests that the conglomerate may mark the beginning of Upper Cretaceous sedimentation. If so, this formation may be the northern equivalent of the Dunvegan sandstone.

Upper Cretaceous sandstones and shales that overlie the Fort Nelson formation outcrop along the east side of Beaver River from 4 to 12 miles north of the Liard. Coarse and fine, loosely consolidated sandstone and dark shale beds, with a few thin beds of hard, rusty shale, are exposed in banks rising to as much as 300 feet above the river. They contain a few scattered concretions, and some beds contain an abundant fossil fauna. Pyrite from the hard shale beds has supplied acid that has destroyed much of the carbonate fossil remains of adjoining beds. In many places along the river there is over 100 feet of soft, grey, laminated clay shale containing rusty, fossiliferous concretions. The clay shale grades upward into poorly cemented sandstones. These beds strike north to northeast and dip 2 to 3 degrees east to southeast. A ridge of similar rock outcrops on the north side of Liard River, 9 miles northwest of Nelson Forks. The ridge is roughly 500 feet high, with 200 feet of sandstone, shale, and thin conglomerate beds exposed on the south slope close to the water. The beds strike north and dip 2 to 3 degrees east. Other exposures were observed on the south bank of Liard River west of the mouth of Dunedin Creek and are flat lying.

Fossils collected from the west side of a prominent hill east of Beaver River, 6 miles north of the Liard, were identified by F. H. McLearn as including Oxytoma, Pteria, Goniomya, Scaphites ventricosus, and Inoceramus pontoni, and as representing the Upper Cretaceous, Scaphites ventricosus zone.

Several loose pieces of bituminous coal from a seam at least 6 inches thick were found near the top of the hill, a short distance above the place where the fossils were collected.

Later Upper Cretaceous. On the east side of Liard River, 12 miles below the mouth of the Fort Nelson, there is a prominent hill of sandstone and shale from which a large Inoceramus was collected by M. Y. Williams, in 1922, on his trip to Mackenzie River (Williams, 1922). This fossil is

reported by F. H. McLearn to be Inoceramus cf. tuberculatus Woods. The fauna is equivalent to that found in the upper part of the Upper Alberta shale in southwestern Alberta. The Scaphites ventricosus zone (McLearn, 1937) occurs there in the lower part of the Upper Alberta shale.

As these Upper Cretaceous beds are exposed in hills that rise to 500 feet above the river, and as the strata have an easterly dip, it would appear that the formation may exceed 1,000 feet in thickness.

Pleistocene

Boulder clay hills 100 feet high are common along Fort Nelson River. Back from the river 1 or 2 miles many hills rise to 200 feet, and these likewise may be wholly comprised of boulder clay. Less prominent deposits of boulder clay were noted along Liard River as far up as the escarpment west of Beaver River, and along this river at intervals as far upstream as Merrill Mountain. Deposits of boulder clay seen along Brimstone Creek, 3 miles north of the Liard, contain boulders of limestone and sandstone up to 10 feet in diameter. As the gravel bars along the rivers are formed to a large extent from reworked boulder clay deposits they contain many pebbles and boulders from distant areas, most conspicuous of which are pink granite and granite porphyry boulders. The occurrence of well-worked gravel deposits 100 feet above Liard River overlying the Grayling formation west of Toad River suggests that the swift waters of the Liard have eroded their bed to a depth of 100 feet or more since the glacial age.

STRUCTURE

A major syncline that runs northeast down Liard River Valley forms the largest structural feature of the area. The high Cretaceous escarpment along the east side of Toad and Liard Rivers and west of Beaver River forms the west limb of the syncline, and similar rocks along Fort Nelson River form its east limb. The Cretaceous rocks along the Fort Nelson dip only 2 to 3 degrees westerly, but in the escarpment along the west limb of the syncline the dip is generally from 10 to 30 degrees easterly. The axial plane of the syncline trends northwesterly for over 15 miles about midway between Toad and Fort Nelson Rivers down the upper part of Dunedin Creek Valley, then swings gradually north and then northeasterly into Liard Valley and probably lies a few miles west of Liard River for a distance of over 30 miles northeast from the mouth of the Fort Nelson.

On the west side of Liard River, from Grayling River north to the Beaver, a belt of comparatively gently folded rocks occupies an area 10 to 15 miles wide. Farther west the rocks are more closely folded and faults of small displacement are associated with the folds. A comparatively strong fault crosses the Liard a mile west of the mouth of Brimstone Creek. An escarpment that is thought to be a fault scarp was noted on the photographs of Crow River Valley. The escarpment runs northeast almost to Beaver River from the southerly bend of Crow River 22 miles west of its mouth. It strikes towards the Dickie Mountain anticline. The west limbs of most of the folds in the district dip more steeply than those on the east.

Toad Anticline

A cross-section of a composite or major anticlinal fold of Triassic and Lower Cretaceous strata is exposed for 12 miles along Liard River between the mouths of Brimstone and Garbutt Creeks. The northeast limb of the anticline is exposed for 4 miles up Toad River from the Liard. The beds on the northeast limb, where examined on both Liard and Toad Rivers, strike northwest and dip from 20 to 30 degrees northeast. The beds on the southwest limb, east of Brimstone Creek, dip from 45 to 75 degrees southwest. Numerous, small, anticlinal folds are superimposed upon the major fold, particularly towards its centre between Graybank Creek and Grayling River. The axial plane of the major fold strikes northwest and is believed to lie about a mile east of the mouth of Grayling River. The extent of the Toad anticline north and south from Liard River has not been determined, but judging from the topography the Toad formation might be expected to close 12 or 15 miles south of the mouth of Toad River, and probably closes about 20 miles northwest of the Liard where other anticlinal structures swing northeast across its path up the valley of Grayling River.

Scatter River Monocline

The Cretaceous rocks along Liard River near the mouth of Scatter River dip from 10 to 30 degrees east. Commencing 1½ miles west of the Liard, the beds along Scatter River dip less and less steeply to the east. From 2 to 8 miles west of the Liard the Scatter formation is flat lying. The resulting terrace structure might form a possible trap for petroleum if it were present in the underlying rocks.

Beaver River Anticline

The Fort Nelson formation dips southeast between 30 and 35 degrees where Beaver River crosses it 18 miles upstream from the Liard. The underlying Lépine shale and Scatter formation also dip southeast for a distance of 2 miles northwest along Beaver River from the conglomerate escarpment. A little farther northwest the beds are horizontal, and for the succeeding 5 miles the Scatter formation dips about 3 degrees northwesterly.

Dickie Mountain Anticline

Merrill Mountain, the first encountered on the trip up Beaver River, lies on the north side between 38 and 41 miles upstream from the Liard, and Dickie Mountain is the next one to the northwest, between 42 and 47 miles upstream. Dickie Mountain trends northeast and forms the southeast limb of an anticline, both limbs of which appear to dip from 15 to 25 degrees, respectively, to the southeast and northwest. A study of air photographs reveals that the axial plane of Dickie anticline extends south almost as far as the small northerly bed in Beaver River 47 miles upstream from the Liard, and that it extends northeast to La Biche River. Exploration during the past season was carried only as far as Merrill Mountain. The strata on both Merrill and Dickie Mountains dip from 10 to 20 degrees southeast, and as Merrill Mountain is comprised of Permian strata with Carboniferous beds at its base, it may be assumed that Dickie Mountain is comprised of Carboniferous or older beds.

Beavercrow Mountain Anticline

A prominent mountain ridge that extends 30 miles southwest from Beaver to Crow Rivers at a point 53 miles upstream from the Liard is named Beavercrow Mountain. This mountain forms the southeast limb of a prominent anticline that has been named the Beavercrow Mountain anticline. The structure has not been visited, but photographs of it show that the beds of Beavercrow Mountain strike northeast and dip between 10 and 30 degrees southeast. The west side of the mountain is marked by a steep escarpment. From 2 to 4 miles west of the escarpment, the northwest limb of the anticline is marked by prominent hills the strata of which dip from 35 to 85 degrees towards the northwest. Beaver River swings north around the north end of this anticline at a point 55 miles upstream from the Liard. As the dip of the beds on the west limb of the anticline are the steeper, the axial plane will have a pronounced southeast dip.

Other Anticlines

A major anticlinal fold that crosses Grayling River 27 miles northwest of the mouth of Grayling River was traced with the aid of air photographs for over 25 miles north into Crow River Valley. It probably continues farther north, and the axis is thought to lie 1 or 2 miles west of Larsen Lake. The beds to the east of the axial plane dip at comparatively low angles to the east. They are comprised of resistant rocks that form a high plateau between Crow and Grayling Rivers, due south of Larsen Lake. The strata on the west side of the axial plane are not as well exposed, but in general these rocks appear to dip from 25 to 85 degrees west.

Photographs of the east-flowing part of La Biche River, between 25 and 30 miles upstream from the Liard, show that here the La Biche cuts across a prominent mountain ridge that runs northeast for 10 miles and then due north to beyond the map-area. The ridge is comprised of resistant rocks that extend southwest from the La Biche towards Beaver River, and that appear to be a northerly continuation of the Scatter formation seen on Beaver River. It represents a major anticlinal structure, the axial plane of which runs northeast across La Biche River and then swings due north. The limbs of the fold dip 30 to 50 degrees southeast and northwest at La Biche River, but towards the southwest the folding becomes gradually less pronounced and in 5 or 6 miles the mountain merges with the hilly plateau country of Beaver River Valley. The anticline that crosses Beaver River 20 miles upstream from the Liard is probably the one that crosses La Biche River, so that it may exceed 30 miles in length.

Air photographs show a well-defined symmetric anticline striking southwest for 12 miles between Scatter and Grayling Rivers, 25 miles west of the mouth of Scatter River. Near Scatter River the limbs of the fold dip about 10 degrees northwest and southeast. Farther southwest, towards Grayling River, they dip at increasingly steep angles that appear to reach, and in some places to exceed, 45 degrees. The structure has not been visited.

OIL POSSIBILITIES

The black marine shales of the Toad formation are possible source beds for petroleum. The impure limestones of this formation give off a petroliferous odour on freshly broken surfaces. Limestone, shales, and sandstones of Silurian and Devonian age are indicated by M. Y. Williams as outcropping along Toad River 25 miles south of Hell Gate and along the Alaska Highway 25 miles west of Hell Gate. It is probable that these rocks also underlie much of Nelson Forks area, and if so may also represent source beds of petroleum. The Lower Cretaceous marine shales of Garbutt, Scatter, and Lépine formations may contain sufficient organic remains to be regarded as possible source beds.

Many of the sandstone beds of the Permian section examined on Beaver River are comparatively porous, and where capped by shale beds could act as reservoir rocks. Some of the impure sandstones of the Toad formation may also be sufficiently porous to aid local oil concentration. The sandstones of the Scatter formation are generally more permeable than the older rocks and under suitable conditions might likewise comprise favourable beds for oil accumulation. Some of the sandstones and grit conglomerate horizons of Fort Nelson formation are also quite porous. In places the lower lenticular beds might form stratigraphic traps where they wedge out on the arms of folds.

No oil seepages were noted during the past season, but they may yet be found when exploration along the numerous anticlinal folds is carried out. Gas escaping from a spring a few feet from the east bank of Brimstone Creek, 3 miles north of the Liard, is believed to be mostly carbon and sulphur dioxide, as it could not be ignited. Sulphurous fumes were noted escaping from strata along the anticlinal axial planes of small folds on both Lépine and Crusty Creeks.

The area is situated favourably with respect to possible source rocks and structures that aid accumulation of oil, but the actual presence or absence of oil in the area has not been established and can only be determined by further work.