GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 61-8

TRIASSIC STRATIGRAPHY OF THE ROCKY MOUNTAINS AND FOOTHILLS NORTHEASTERN BRITISH COLUMBIA

94 K and N (parts of)

(Report and 1 figure)

B. R. Pelletier

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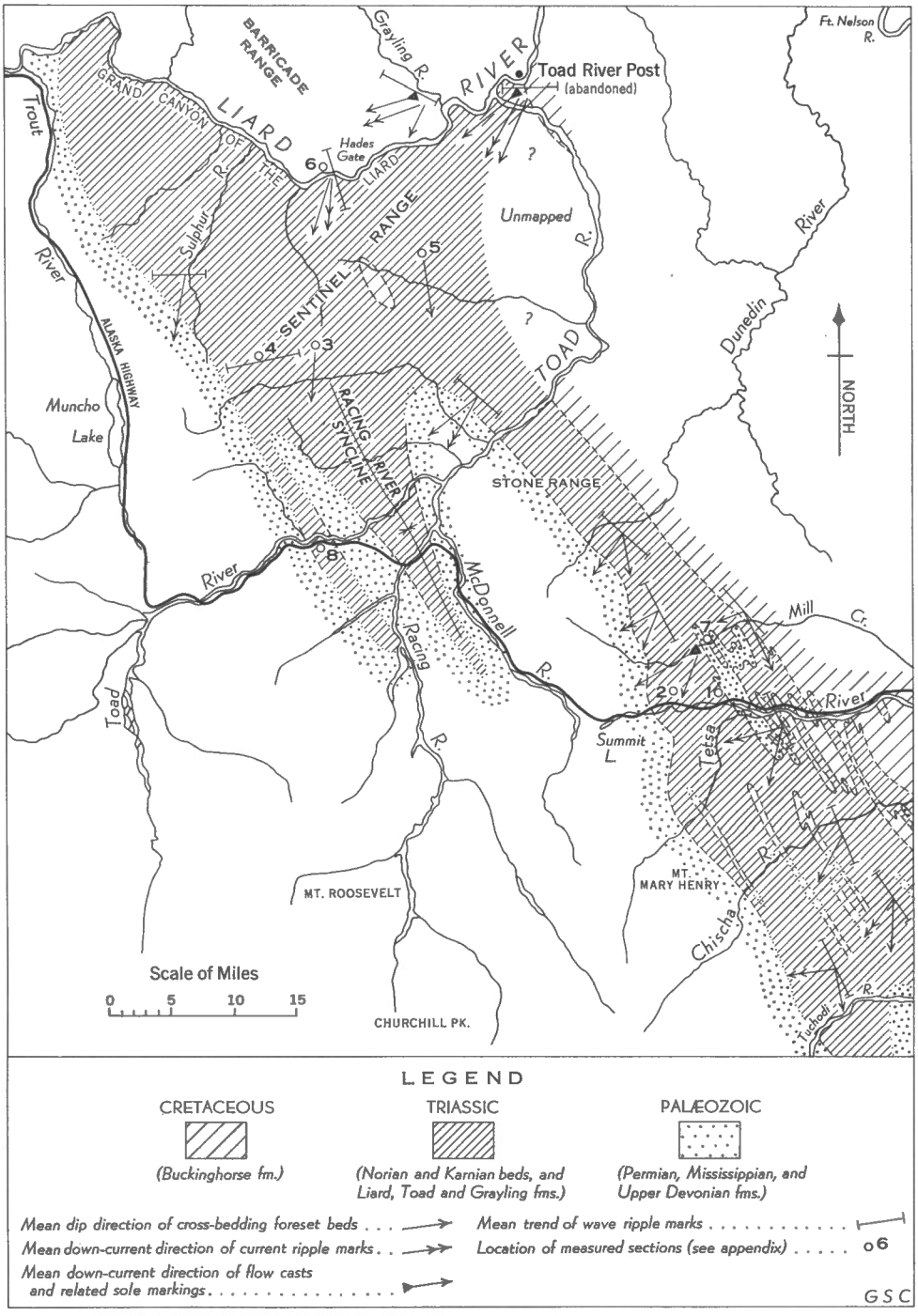

Figure 1. Map of foothills belt, northeastern British Columbia showing outcrop of Triassic rocks, sedimentary trends and location of stratigraphic sections

TRIASSIC STRATIGRAPHY OF THE ROCKY MOUNTAINS AND FOOTHILLS, NORTHEASTERN BRITISH COLUMBIA

INTRODUCTION

This study began in the summer of 1959 (Pelletier, 1960)[1]. During the 1960 field season, sections were measured along Liard River; in the Foothills between Toad and Liard Rivers and as far west as Sentinel Range; on upper Dunedin River; and on hills on either side of the Alaska Highway between mile-posts 383 and 428 (Fig. 1). The stratigraphy, lithology, outcrop distribution, and physiography are described in the previous (1960) report. This report contains additional sections and sedimentary studies, with further conclusions on source area and sedimentation. The faunas are being studied by E. T. Tozer who has prepared a separate report on the palaeontology (Tozer, 1961) and is responsible for the fossil identifications given here.

Thanks are extended to G. L. Goruk who served as field assistant, and to E. Gardner of Fort Nelson who operated the river-boat on Fort Nelson and Liard Rivers. The writer was joined in the field by E. T. Tozer whose preliminary identifications of the fossils greatly aided the field study. C. E. Andrews of Fort St. John assisted Tozer, mainly, and the writer in the field.

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[1] Names and dates in parentheses refer to publications listed in the References.

Table of Formations

Era	Period or Epoch	Formations and Thickness (feet)	Lithology	Faunal Zones
Mesozoic	Lower Cretaceous	Garbutt or Buckinghorse 2,300	Dark grey, fissile, non-calcareous shales with lower concretionary zone	
	Upper Triassic	Unnamed post-Liard beds 650-1,200	Limestone, sandstone, and massive siltstone	Pseudomonotis Halobia
	Middle Triassic	Liard 0-600	Massive, grey, calcareous sandstones, minor grey limestones and dark grey siltstones	Nathorstites
		Toad 600-3,000	Massive, grey, calcareous siltstones and mudstones, minor sandstone and limestone, platy shales and siltstones	Gymnotoceras-Beyrichites Wasatchites
	Lower Triassic	Grayling 850-1,400	Chiefly dark grey, non-calcareous shales and minor siltstones and limestones; interbedded thin sandstone in lower part	Claraia stachei
Palaeozoic	Permian-Pennsylvanian(?)	165	Thick-bedded, blocky, dark bluish grey to black chert	
	Mississippian	Kindle	Sandstone, limestone and black shale	

GENERAL STATEMENT

The sections measured in 1959 and 1960 (see Appendix) serve as control in establishing stratigraphic and, partly, geographic limits to the Triassic formations in northeastern British Columbia. The Triassic beds rest disconformably upon chert of Permian age and are overlain disconformably by lower Cretaceous shale. The formational contacts within the Triassic system are gradational.

The Triassic formations—the Grayling, Toad, and Liard (the only named formations)—can be recognized lithologically in the Foothills from the mouth of Toad River west across strike to the mouth of Racing River, the site of the axis of the Racing River syncline which trends parallel with the regional strike. Still farther west, new, younger, unnamed units occur. These units are equivalent to part of the proposed Schooler Creek group (see Hunt and Ratcliffe, 1959 p. 571, and McLearn, 1921). Changes in facies occur within a few miles in the direction across strike, although along strike a given facies may persist for scores of miles and at the same stratigraphic level.

In the eastern sections, Triassic rocks occur in their entirety between the disconformable boundaries of the underlying Permian chert and the overlying Cretaceous shales, and are less than 4,000 feet in thickness. To the west the Triassic system becomes thicker and may reach an estimated 6,000 feet in the Racing River area. Farther west, the Triassic appears to be thinner but neither the overlying Cretaceous nor the underlying Permian contacts were observed, so that it was not possible to establish an overall thickness in this area.

The decrease in thickness east of the Racing River syncline is due partly to pre-Cretaceous erosion, and possibly partly to eastward convergence of the formations. Erosion is exemplified in sections along Liard River by the disconformable, lower Cretaceous contact, which occurs as follows: 600 feet above the contact between the Toad and Liard formations 4 miles west of Hades Gate; only 300 feet above the Toad-Liard contact 5 miles east of Hades Gate; and somewhere in the upper Toad formation below Toad River, where the Liard formation is absent. A similar decrease in thickness, due to erosion, is seen in sections along the Alaska Highway. The disconformable lower Cretaceous contact occurs 550 feet above the Toad-Liard contact at mile-post 485.5, 280 feet above this contact at mile-post 482.5, 20 feet above the same contact at mile-post 374, and within the upper Toad formation at mile-post 372 where, again, the Liard is absent.

GRAYLING FORMATION

The Grayling formation consists of non-calcareous, flaky shales with minor thin, interbedded sandstones in the lower part. Small-scale crossbedding, ripple-marks, and sole markings such as fluting, grooves, and flow casts occur throughout the sandstone. These primary sedimentary structures indicate that sedimentary transport took place in a southwesterly direction. The presence of ammonites and the pelecypod Claraia stachei indicate a marine environment of deposition for the Grayling formation during the Scythian epoch (McLearn, 1945). This formation is persistent in widely scattered areas such as at Tetsa, Dunedin, Toad, Grayling, and Liard Rivers, at mile-post 427.5 on the Alaska Highway, and in the core of an anticline along a gravel road north of Toad River about 2 miles east of Sentinel Range. The Grayling formation has an estimated thickness of more than 1,300 feet on Liard River about 3 miles above Grayling River; it decreases to about 800 feet in the area of upper Dunedin River 40 miles south of Liard River. No observations on thicknesses east or west of the above sections were made, but Hunt and Ratcliffe (1959 p. 570) showed a progressive decrease in the combined thickness of the Grayling and Toad formations in the subsurface to the east.

TOAD FORMATION

The Toad formation consists of calcareous, dark grey, platy siltstones and shales, which alternate with sequences of calcareous, dark grey, massive siltstones up to several hundred feet thick. Some fine-grained sandstones are present in the upper part and contain crossbedding and ripple-marks, that both indicate a north-westerly trending shoreline and sedimentary transport to the southwest. The formation is characterized, particularly in the eastern sections, by Gymnotoceras-Beyrichites and Wasatchites. Fossils are rare in the western sections except in the lower part of the formation. The Toad is upper Scythian and Karnian in age in the eastern Foothills where fossil occurrences give evidence of these ages.

The thickness of the Toad formation increases from 1,200 feet near the mouth of Toad River, to more than 2,000 feet about 9 miles to the west; it reaches an estimated maximum of 3,000 feet in the Racing River area. Farther west the formation becomes thinner. At mile-post 427.5 it is 1,388 feet thick, or, with the addition of a transitional interval of 174 feet (see Appendix, sec. 8, units 7 and 8), it has a maximum thickness of 1,562 feet. The Toad formation is unknown at Sulphur Creek but is presumed to be thinner there.

LIARD FORMATION

The Liard formation consists of dark grey, massive siltstones, and fine- to coarse-grained, grey, massive sandstones with minor interbeds of thick grey limestone. A shallow-water facies in the sandstone is characteristic of the Liard. Festoon bedding, crossbedding, ripple-marks, scour features, and coquinoid layers are present. The sedimentary structures again indicate a southwesterly transport of sediments. A Ladinian age is assigned to the Liard formation based on the occurrence of Nathorstites at one or more stratigraphic levels. Variation in thickness of the formation is partly due to erosion. However, 270 feet was measured 9 miles west of the mouth of Toad River on Liard River, and 600 feet at a section on Liard River 4 miles west of Hades Gate. In the Racing River area, the typical Liard formation is difficult to recognize lithologically, so that thickness estimates are unreliable; about 400 feet of it is present in 'Sheep Mountain' (see Appendix, sec. 3). In the mountain ranges less than 7 miles to the west, the Liard is absent, and it is not known in any of the more westerly localities.

UNNAMED POST-LIARD BEDS

These beds consist of undivided upper Triassic units which are equivalent to the Triassic formations of that age in the areas of Peace and Halfway Rivers. They comprise medium to light grey limestone and sandstone, with darker siltstones and limestones in the upper beds. Several bioclastic units occur throughout the limestone but these are generally thin. A few crossbeds and ripple-marks suggest southwesterly transport of sediments. The post-Liard beds occur in the upper part of the Racing River syncline and are characterized by the fossils Sirenites and Halobia. To the west are younger beds, which contain the pelecypod Monotis subcircularis as typified in areas west of Sulphur Creek.

The entire thickness of the post-Liard beds is not known as no section was complete. In all sections, the lower Cretaceous, which presumably overlies them, is absent—in fact, there is no definite upper boundary. In the Racing River syncline, these beds appear to be about 950 feet thick; about 6 or 7 miles to the west they are about 1,150 feet thick; at mile-post 428 they are between 300 and 600 feet thick, and presumably thinner to the west. There are no occurrences of these younger beds east of the Racing River syncline in the vicinity of Liard, Toad, and Tetsa Rivers.

HISTORY OF SEDIMENTATION

The widespread occurrences of primary sedimentary current structures throughout the area and over many intervals of the section have permitted some conclusions to be reached on the direction of sedimentary transport. Oscillation or wave-type ripple-marks, which presumably formed in positions parallel with the shore, trend northwesterly and indicate that ancient shorelines extended in a northwest-southeast direction. Current-ripple marks with their steep slope dipping southwesterly, and crossbedding with foreset beds also dipping southwesterly, indicate a direction of sedimentary transport to the southwest and suggest a probable source area to the northeast (Fig. 1). Flow casts, which occur on the underside of sandstone beds, are evidence of the passage of heavy, mud-laden water down a submarine slope of unknown but presumably shallow gradient. In some cases, the up-current ends of the spatulate protuberances of the flow casts can be distinguished, and these indicate a southwesterly course for the ancient currents.

Certain facies such as the shallow-water sandstones of the upper Toad formation at the mouth of Toad River, various sandstones of the Liard formation several miles to west, and the interbedded sandstones of the unnamed post-Liard beds at 'Sheep Mountain' again to the west, occur as separate tongues or wedges that occupy successively higher stratigraphic positions in the section. Such an apparent migration of facies suggests progressively southwesterly occurrences of similar depositional sites as the Triassic period advanced. The apparent shift in facies resulted in a fine-grained, offshore facies, succeeded by a coarser-grained, inshore facies, thus suggesting repeated or continued uplift during Triassic time. Several erosional unconformities suggest that the uplift was episodic rather than continuous. The uplift occurred in the east as the above facies shift is westerly.

Oil and gas occurrences in the subsurface Triassic east of the Foothills are reported to be in offshore bars or lenses (Hunt and Ratcliffe, 1959, p. 566). This shallow-water facies is an integral part of the sedimentation system, and occurs in trends that extend for great distances along strike. Sedimentary traps for petroleum or natural gas may follow similar trends as they, too, are an integral part of the sedimentation system. If subsurface trends of the Triassic parallel those occurring in the Foothills, then a broad area east of the Foothills and extending over much of northeastern British Columbia appears promising for the development of natural gas and petroleum. Exploration of known reservoirs along such trends may prove the value of much of this area.

APPENDIX

Section 1. Hill on north side of Alaska Highway opposite bridge at mile-post 382.5.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Liard Formation		
21	Sandstone, dark grey and weathering medium brownish grey; fine- to medium-grained, calcareous; irregularly laminated; laminations occur in thick-bedded aggregates; ledge-former	12	1,650
20	Covered interval, recessive	13	1,638
19	Sandstone, medium to dark grey and weathering brownish grey; fine- to medium-grained, calcareous; massive but internally laminated; ledge-former; Nathorstites, Ostrea and terebratulids present, also small gastropods and bones of marine reptiles	56	1,625
18	Covered interval, recessive	10	1,569
17	Sandstone, medium grey and weathering grey and orange-brown; calcareous; thick-bedded; ledge-former; Nathorstites present	22	1,559
16	Covered interval, recessive	6	1,537
15	Sandstone, dark to medium grey and weathering orange-brown and grey; fine-grained, calcareous; massive; ledge-former; recrystallized ammonites and brachiopods present	115	1,531
14	Covered interval, recessive	19	1,416

Unit	Lithology	Thickness (feet	Height Above Base (feet)
13	Sandstone, dark to medium grey and weathering orange-brown and grey; concretionary; medium-bedded, small-scale crossbedding; ledge; terebratulids present	30	1,397
	Toad Formation		
12	Covered interval	220	1,367
11	Sandstone, dark grey and weathering pale orange-brown; fine-grained, calcareous; thick-bedded, thin crossbedded layers; ledge	20	1,147
10	Siltstone, outcrop at 26-foot mark extending below for 20 feet; siltstone, dark grey and weathering dark brownish grey; thick-bedded to massive. Unit partly covered and recessive	57	1,127
9	Sandstone, dark grey and weathering brownish grey with some light yellowish grey; fine-grained, calcareous; small-scale crossbedding, thin-bedded and somewhat flaggy; ledge-former	121	1,090
8	Siltstone and minor shale, black and weathering dark grey; some fine-grained, calcareous sandstone; thin-bedded. Unit partly covered and recessive	41	969
7	Siltstone, dark grey to black and weathering brownish and yellowish grey with considerable white coating; calcareous; somewhat soft at base where it passes into a recessive, covered interval; beds generally massive and form ledge	95	928

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
6	Covered interval, recessive; presumably underlain by soft, black siltstones	73	833
5	Siltstone and minor limestone, black and weathering dark brownish grey and yellowish grey; medium- and thick-bedded; upper 55 feet forms ledge; lower 25 feet recessive	80	760
4	Siltstone, dark grey to black and weathering dark brownish grey; calcareous; massive; ledge-former	125	680
3	Siltstone, black and weathering dark grey with white coating; calcareous; thick-bedded. Unit partly covered, about 40% concealed; recessive	178	555
2	Siltstone, dark grey and weathering brownish grey; calcareous; massive; ledge-former	162	377
1	Siltstone, black and weathering brownish grey; calcareous, hard; thick-bedded but internally divided by laminations and thin beds; these beds alternate in thick units with softer black, calcareous siltstone; soft siltstone also laminated; toward base, softer beds become platy and shaly. Unit is recessive	215	215

Section ends at nose of anticline.

Section 2. North end of hill 2 miles north of mile-post 385.5 on Alaska Highway.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Liard Formation		
21	Sandstone, dark greyish brown and weathering dark grey; medium-grained, calcareous; thick-bedded; ledge; Nathorstites and Daonella present; fossils occur in thick limestone pods	63	946
20	Covered interval, recessive	7	883
19	Sandstone, dark brown to grey and weathering brown and grey; fine-grained, calcareous; thick-bedded; ledge. Unit partly covered, about 80% concealed	68	876
18	Sandstone and limestone, dark grey and weathering medium grey; sandstone is calcareous, fine-grained and thick-bedded; limestone is fine-grained, thick-bedded, and inter-bedded with the sandstone; ledge	15	808
17	Sandstone, dark brown to grey and weathering dark brown; medium-grained, calcareous; thick-bedded. Unit partly covered, about 30% concealed; recessive	56	793
16	Sandstone, dark grey and weathering orange-brown; fine- to medium-grained, calcareous; medium-bedded generally but some beds are thicker at top; crossbedded; ledge	42	737
15	Covered interval, recessive; dark grey, calcareous siltstone in talus	46	695

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
14	Sandstone, dark grey and weathering orange-brown; medium-grained, calcareous; massive; ledge; Nathorstites present in upper beds	33	649
13	Covered interval, recessive	22	616
12	Sandstone, dark grey and weathering brownish grey; medium-grained, calcareous, concretionary; massive; Ostrea and Terebratulids present; lower 40 feet recessive, upper part forms ledge	119	594
	Toad Formation		
11	Sandstone, dark grey and weathering dark brownish grey; minor interbedded limestone; sandstones are calcareous and fine grained; upper 6 feet finely laminated and crossbedded; beds generally massive; unit forms ledge	86	475
10	Covered interval, recessive	37	389
9	Sandstone, dark grey and weathering brownish grey; fine-grained, calcareous; crossbedded, finely laminated; beds massive; ledge	36	352
8	Covered interval, recessive	20	316
7	Sandstone, dark grey and weathering brownish grey; fine-grained, calcareous; finely laminated in medium-bedded units; small-scale crossbedding; ledge-former	33	296
6	Covered interval, recessive; soft, platy, calcareous, dark grey siltstone in talus	33	263

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
5	Sandstone, dark grey and weathering orange-brown; fine-grained, calcareous; small-scale crossbedding, thin- and medium-bedded; ledge-former	31	230
4	Covered interval, recessive	21	199
3	Sandstone and siltstone, dark grey and weathering brownish and yellowish grey; sandstone is very fine grained and in thin laminations; some cross-bedding, beds massive; ledge-former	53	178
2	Covered interval, recessive	46	125
1	Siltstone, dark grey and weathering dark grey and brownish grey; calcareous; massive; ledge-former	79	79
	Base of section concealed by overburden.		

Section 3. Hill in Racing River syncline 12 miles south of Rapids of the Drowned, Liard River. So-called 'Sheep Mountain' of this area.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Unnamed Post-Liard Beds		
38	Sandstone, medium to dark grey and weathering dark brownish grey and orange-brown; fine-grained, calcareous; generally massive; ledge-former; impressions of Ammonites (Sirenites), pelecypods (Halobia), and brachiopods. At base is 5 feet of bioclastic limestone	165	4,297
37	Sandstone, medium grey and weathering medium grey; very fine grained, calcareous. Beds not exposed; rock breaks into cobble-size blocks; unit is recessive and concealed by talus blocks	51	4,132
36	Sandstone, light grey and weathering light grey; coarse-grained, calcareous; crossbedded, thick-bedded; ledge. At 140 feet from top, rhynchonellids are present; thin beds of bioclastic limestone in several places; at 140 feet, slope breaks and beds become recessive, are darker grey and weather light brownish grey; at 215 feet from top, beds continue as massive occurrences and are medium to coarse grained	245	4,081
35	Limestone, black and weathering medium grey; bioclastic and silty; thin-bedded; pectenoids and nautiloids present. Unit recessive	12	3,836

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
34	Sandstone, medium grey and weathering medium to dark grey and dark brown; medium- to fine-grained, calcareous; massive; generally a ledge-maker; basal 25 feet is recessive; possible nautiloids, and bioclastic limestone at 88 feet from base	231	3,824
33	Sandstone, medium grey and weathering dark grey and brownish grey; fine-grained, calcareous; massive; ledge; minor bioclastic limestone a few inches thick also present	93	3,593
32	Sandstone and siltstone, dark grey to black and weathering dark brownish grey; fine-grained, calcareous; minor 6-inch beds of black limestone in upper 30 feet; most bedding is massive but consists of laminations that commonly weather to platy slabs about 1/2 inch thick; some brachiopods, ammonites, and pelecypods of upper Triassic age present but deformed; ledge-former; irregular limestone beds present in lower 20 feet	154	3,500
	Liard Formation		
31	Sandstone, dark grey and weathering brownish grey; fine-grained, calcareous; massive but, due to weathering along laminations, beds break into 1-inch slabs; interval recessive	122	3,346
30	Siltstones and interbedded shales, dark grey and weathering light orange-brown; calcareous; platy; recessive	55	3,224

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
29	Siltstone, dark grey and weathering light orange-brown; calcareous; beds consist of massive aggregates of hard and soft siltstone laminations; recessive weathering soft beds alternate with resistant harder beds to give rock face a ribbed appearance	140	3,169
28	Sandstone, dark grey and weathering orange-brown; fine-grained, calcareous; laminated, massive bedding; ledge-former; Daxatina canadensis (Whiteaves), Daonella sp. present	21	3,029
27	Sandstone, dark grey and weathering orange-brown; fine-grained, calcareous; somewhat silty; laminated in massive aggregates; recessive	22	3,008
26	Sandstone, dark grey and weathering orange-brown; fine-grained, calcareous; massive; ledge-former	35	2,986
25	Siltstone, dark grey and weathering grey and orange-brown; calcareous; platy; recessive	15	2,951
24	Sandstone, dark grey and weathering orange-brown; fine-grained, calcareous; massive; ledge-former	30	2,936
	Toad Formation		
23	Siltstone, dark grey and weathering grey and orange-brown; calcareous; platy but in massive aggregates; recessive	40	2,906

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	(Toad formation transitional over next three or four units above.)		
22	Sandstone, dark grey and weathering dark yellowish grey; fine-grained; massive; ledge-former	50	2,866
21	Siltstone, dark grey and weathering yellowish brown; calcareous; platy; generally recessive; some platy aggregates are harder than others and tend to form ledges 6 to 10 feet apart in upper 80 feet	220	2,816
20	Covered interval, recessive; platy, dark grey, calcareous siltstone and shale in talus	132	2,596
19	Siltstone and shale, dark grey and weathering yellowish brown and orange; calcareous; platy; ledge-former	200	2,464
18	Siltstone and shale, black and weathering dark grey and yellowish brown; calcareous; laminated and breaking into thin platy beds; recessive; Daonella occurs 25 feet from top	159	2,264
17	Sandstone, dark grey and weathering light yellowish brown; fine-grained, calcareous; laminated in places with minor platy shales; generally massive; ledge-former	36	2,105
16	Siltstones and shale, black and weathering dark grey and yellowish brown; calcareous; platy; upper 80-feet forms ledge; at 54 feet from top, two thick beds of fine-grained calcareous sandstone occur and form	169	2,069

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	small ledge to 80-foot mark, but most of ledge consists of platy siltstone and shale; sandstone exhibits considerable soft-sediment slump features such as folds and breccia-tion, which continue in various parts of unit to base; lower part recessive		
15	Sandstone, dark grey and weathering yellowish brown; calcareous; platy; ledge-former; ammonite and pelecypod fragments present	64	1,900
14	Covered interval, recessive; some platy shales in talus	37	1,836
13	Sandstone, dark brownish grey and weathering yellowish brown and grey; fine-grained, calcareous; finely laminated in massive beds; ledge-former	13	1,799
12	Covered interval, recessive	120	1,786
11	Sandstone, dark grey and weathering yellowish brown; fine-grained, calcareous; beds somewhat platy but in massive aggregates; ledge-former; minor thin-bedded limestone also occurs	13	1,666
10	Covered interval, recessive; some soft platy siltstone and shale in talus	41	1,653
9	Siltstone and shale, dark grey and weathering dark grey and light yellowish brown; platy; weak ledge-former	11	1,612
8	Covered interval, recessive; some platy shales and small 10-foot ledge at 50 feet from top	145	1,601

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
7	Siltstone and shale, dark grey and weathering dark, yellowish grey; calcareous; finely laminated and platy; recessive; 4 feet of sandstone at 175 feet to form small ledge; shale and siltstone continue to base	509	1,456
6	Shales and siltstone, dark grey and weathering dark grey; calcareous; recessive. Interval about 40% concealed. Ammonite impressions, cf. Parapopanoceras in talus	80	947
5	Shales and siltstones, dark grey and weathering dark grey; somewhat sandy, calcareous; mostly platy; recessive; massive 10-foot ledge of grey sandstone occurs 20 feet above base	275	867
4	Covered interval, recessive; black shales and siltstone in talus	54	592
3	Shale and siltstone, dark grey and weathering dark grey; calcareous; platy and laminated; minor ledges occur but unit is generally recessive	321	538
2	Covered interval, recessive	58	217
1	Shale and siltstone, dark grey and weathering dark grey and yellowish brown; calcareous; platy but commonly massive; small ledges occur in a few intervals	159	159
	Base of section concealed by talus.		

Section 4. Hill near headwaters of Eight Mile Creek, 10 miles southwest of Rapids of the Drowned, Liard River.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Unnamed Post-Liard Beds		
19	Limestone, dark grey and weathering medium grey; fine-grained, arenaceous; medium bedded; laminations and irregular bedding planes occur throughout unit; generally recessive but upper 10 feet forms ledge at peak of mountain	138	2,009
18	Limestone, dark grey to black and weathering dark brownish grey; dense, thick-bedded; ledge-former; irregular silicified masses and clusters several inches in extent occur throughout	60	1,871
17	Limestone, dark grey and weathering light grey; fine-grained; massive; recessive. On hill 1/2 mile north, ammonites and pelecypods collected from beds thought to be equivalent to this unit	86	1,811
16	Limestone, light grey and weathering light grey; fine-grained; clusters of silica weathering out in relief; massive; ledge-forming. On hill 1/2 mile north, Discotropites sp., Juvavites sp. and other ammonites, and Halobia sp. collected in beds thought to be equivalent to this unit	48	1,725
15	Limestone, medium grey and weathering dark grey; medium-grained; minor bioclastic beds present; some black chert occurs as pods and stringers a few inches long; massive; recessive	102	1,677

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
14	Limestone, light grey and weathering light grey; fine-grained; partly bioclastic; thick-bedded; ledge-former	36	1,575
13	Sandstone, dark grey and weathering dark brownish grey; fine-grained, calcareous; massive; recessive	16	1,539
12	Limestone, light grey and weathering light grey; fine-grained; bioclastic in part; thick-bedded; ledge-forming	56	1,523
11	Sandstone, dark grey and weathering medium grey and medium brownish grey; fine-grained, calcareous; medium-bedded; ledge-forming	80	1,473
10	Sandstone, medium grey and weathering medium brownish grey; fine-grained, calcareous; thick-bedded; ledge-forming	20	1,393
9	Sandstone, medium grey and weathering medium brownish grey; fine-grained, calcareous; thin-bedded; recessive	98	1,373
8	Sandstone, medium grey and weathering light brown and medium grey; fine-grained, calcareous; laminated in massive aggregates; ledge-forming	143	1,275
7	Sandstone, dark grey and weathering medium grey and light brownish grey; medium- to fine-grained, calcareous; laminated and breaking into thin platy beds; recessive; wave-type ripple-marks present on small scale	126	1,132
6	Sandstone, dark grey and weathering medium grey and brown; fine-grained and silty, calcareous; beds	146	1,006

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	somewhat platy and laminated and generally thin-bedded; not a pronounced ledge-former; at 40 feet from the top, Halobia occurs in siltstone and shale; most of lower beds (100 feet or more) consist of platy siltstone and shale		
5	Covered interval, recessive; platy shale and siltstone in talus	220	860
4	Sandstone, dark grey and weathering medium grey; medium- to fine-grained, calcareous; laminated, medium- and thick-bedded; ledge-forming	22	640
3	Covered interval, recessive; concealed by vegetation	542	618
2	Siltstone, black and weathering dark grey; calcareous; platy; ledge-former; ammonite impressions, thought to be of Ladinian age (Liard equivalents)	26	76
1	Sandstone and siltstone; dark grey and weathering dark brownish grey; fine-grained, calcareous; massive, ledge-former. Unit occurs at base of hill on southeast flank about 1 mile north of upper limestone beds in this section		
	Base is concealed.		

Section 5. High flat-topped hill 10 miles southeast of Hades Gates, Liard River.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Liard Formation		
21	Sandstone, medium grey and brown, and weathering brown with white coating; medium-grained, calcareous; massive; ledge, but lower 5 feet slightly recessive; concretionary; large concretions up to 16 inches in diameter are calcareous and weather in low relief	21	1,017
20	Sandstone, dark grey and weathering medium brownish grey and orange; fine-grained, calcareous; laminated, beds platy; ledge-forming	26	996
19	Covered interval, recessive	5	970
18	Sandstone, dark grey and weathering dark brownish grey; fine-grained, calcareous; laminated, medium-bedded; ledge-forming	4	965
17	Covered interval, recessive	31	961
16	Sandstone, dark grey and weathering dark brownish grey; fine-grained, calcareous; massive; ledge-forming	40	930
15	Covered interval, recessive	19	890
14	Sandstone, dark brownish grey and weathering light yellowish brown; fine-grained, calcareous; thick-bedded; Nathorstites and terebratulids occur in limestone pods and beds; upper 10 feet forms a ledge; lower part recessive	34	871

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
13	Sandstone, dark grey and weathering light brown; medium- to fine-grained, calcareous; massive; ledge-former; Nathorstites, Ostrea and terebratulids in limestone pods; lower 25 feet contains considerable small-scale festoon beds and crossbedding; a few large concretions also occur	97	837
	Toad Formation		
12	Covered interval, recessive	174	740
11	Sandstone and interbedded siltstone, dark grey to black and weathering dark brown; fine-grained, calcareous; thick-bedded; belemnites occur in uppermost 2 inches, pelecypods at 10 feet from top; a few concretions are present; upper 15 feet forms ledge, lower part recessive	26	566
10	Siltstone, dark grey and weathering dark brown; calcareous; massive; ledge-former	26	540
9	Covered interval, recessive; probably consists of soft siltstones and shale	24	514
8	Siltstone, dark grey to black, and weathering dark grey; somewhat sandy but generally very fine grained, calcareous; thick- and thin-bedded; ledge-forming	34	490
7	Covered interval, recessive; soft siltstone	16	456

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
6	Sandstone, dark grey and weathering yellowish brown; very fine grained, calcareous; massive; ledge-forming; pelecypods present	25	440
5	Siltstone, dark grey and weathering grey; calcareous; laminated, thin-bedded; recessive	30	415
4	Covered interval, recessive	70	385
3	Siltstone, black and weathering dark grey; calcareous; medium to massive bedding, generally massive; ledge-former; pelecypods in upper 2 feet, brachiopods at base	34	315
2	Covered interval, recessive; mostly soft, black, calcareous siltstone weathering dark grey, found in talus; blocks consist of thin- and thick-bedded siltstones	175	281
1	Siltstone, dark grey and weathering grey and yellowish brown with orange coating; calcareous; laminated in part, generally medium-bedded but some massive beds occur; ledge-former	106	106
	Base of section concealed.		

Section 6. Canyons 3 miles west of Hades Gates, north bank of Liard River.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Lower Cretaceous		
	Shale, black and weathering dark grey with considerable orange iron-staining; non-calcareous, flaky and soft; contact with underlying Liard formation appears to be structurally conformable		
	Liard Formation		
6	Sandstone, medium to dark grey and weathering dark grey and brownish grey; fine- to medium-grained, calcareous; beds massive; ledge-former; brachiopod coquina occurs 10 to 15 feet above base; Nathorstites and other ammonites occur in several beds and in concretions throughout the section. Upper 95 feet measured on east flank of anticline, remainder on west flank	112	406
5	Sandstone, medium to dark grey and weathering medium brownish grey; fine-grained, calcareous; medium- to thin-bedded; minor limestone; numerous shallow-water features; concretions; ledge-former; cross-bedding, current and wave ripple-marks; minor scour, worm trails and casts occur throughout; concretions are calcareous, up to 1 foot or more in diameter, and weather in low relief	56	294

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
4	Sandstone, dark grey and weathering dark grey; fine-grained, calcareous; minor limestone in 6-inch beds; thick-bedded; ledge-former	9	238
3	Sandstone and interbedded siltstone and shale, black and weathering dark grey with yellowish brown; calcareous; platy and thin-bedded; recessive; sandstone commonly occurs as 2- to 3-foot beds extending only 30 to 40 feet along strike	84	229
2	Covered interval, recessive	15	145
1	Sandstone, dark brownish grey and weathering medium grey and brownish grey; fine-grained, calcareous; massive; ledge-former; concretions up to 15 inches in diameter; ammonites including Nathorstites present. Ammonites generally prolific in upper part of unit; fossils in nodules at 18 to 22 feet from top and in beds 32 feet from top; 56 feet measured, remainder of unit estimated to core of anticline to east	130	130

Section 7. Dunedin River, 4 miles north of mile-post 380, Alaska Highway.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Toad Formation		
7	Siltstone and shale, black and weathering dark grey to black; calcareous; laminated, platy; occurs as slabs less than 1/2 inch thick; recessive; pelecypods throughout; Posidonia at 199 feet from top. This unit selected as basal Toad formation	231	1,112
	Grayling Formation		
6	Shale, medium grey and weathering dark grey with rust stains; non-calcareous, flaky; recessive; thin beds of sandstone at 10- to 20-foot intervals	141	881
5	Shale and sandstone; shale is medium grey and weathers to a dark grey with rust stains, non-calcareous, and flaky; sandstone is medium grey and weathers to a light yellowish brown, slightly calcareous to non-calcareous, fine-grained, and thin-bedded; ripple-marks and small-scale crossbedding; flow casts also common; recessive, but somewhat resistant in intervals occupied by sandstone; sandstone generally occupies less than 5% of the unit but some intervals may contain up to 25%; upper 54 feet is 50% sandstone	447	740

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
4	Shale, medium grey and weathering dark grey with rust stains; non-calcareous, flaky; recessive; about 5% of interval consists of thin-bedded sandstone	10	293
3	Sandstone, medium grey and weathering light yellowish brown; fine-grained, non-calcareous; small-scale current features such as scour, crossbedding, and ripple-marking; flow casts, grooves, and lineations present; resistant; flaky, grey, non-calcareous shale occupies less than 10% of interval	69	283
2	Shale and siltstone: shale is medium grey, weathers to dark grey, is non-calcareous, soft, and flaky; siltstone is dark grey, weathers to dark grey, is slightly calcareous and platy; platy siltstones and shales interbedded in 1- to 3-foot intervals; Claraia cf. stachei (Bittner) occurs at 81 feet and various ammonites at 97 from base; recessive. Minor thin-bedded sandstones occur in upper 10 feet and exhibit numerous current structures. Ammonites occur in limestone concretions, although most concretions in this interval are barren of fossils	194	214

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
1	Shale, medium grey and weathering dark grey with considerable rust stains; non-calcareous, flaky; deeply recessive. Unit is the basal Grayling. It forms a disconformable contact with the underlying chert; contact is exposed and accessible on both sides of river	20	20
	Permian (?) Chert		
	Base of section.		

Section 8. North side of hill opposite mile-post 427 and about 1/2 mile south of highway.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Unnamed Post-Liard Beds		
10	Siltstone, black and weathering dark grey, with some light yellowish brown; calcareous, platy; ledge-former; some medium-bedded nodular limestone inter-bedded in basal 10 feet; Halobia occurs 10 feet from top, and at different intervals lower in the unit; Karnian ammonites occur at 30, 50, and 100 feet from top, and more abundantly at base; fossils occur in a deformed, flattened state in the platy beds, but preservation is better in nodular limestone	132	1,854
9	Limestone, black and weathering dark grey and brownish grey; dense to fine-grained; medium- to thick-bedded; soft; recessive; interval partly covered in upper 90 feet, about 60% is exposed; between 96 and 108 feet, beds are massive and show soft sediment slump and brecciation; lower 50 feet forms steep ledge and limestone is separated by thin, 1-inch, black, shaly partings. Beds are possibly lowest Karnian. Liard formation is absent	160	1,722

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Toad Formation		
8	Siltstone, dark grey and weathering dark grey and yellowish brown; calcareous, platy; two thick beds near base where beds are somewhat sandy; ledge-former	90	1,562
7	Siltstone, dark grey and weathering dark grey and dark brownish grey; calcareous; black limestone stringers, about 1/4 inch wide and up to several inches long, lie parallel with bedding; bedding is massive and brecciated due to soft-sediment slumping; unit forms ledge but lower 10 feet is somewhat platy and recessive	84	1,472
6	Siltstone, black and weathering dark grey; calcareous; massive but internally divided by 1/2-inch platy units; 4-inch calcite bed or lense at base; ledge-former	18	1,388
5	Siltstone, black and weathering dark grey and black; calcareous; soft; massive; recessive	128	1,370
4	Siltstone, black and weathering dark grey mostly, with some yellowish brown; calcareous; black limestone stringers and blebs present; massive, but fractures into platy beds; ledge-former	118	1,242
3	Siltstone, black and weathering dark grey to black; calcareous; generally well laminated in thick-bedded and massive aggregates;	1,004	1,124

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	recessive; above siltstone aggregates are alternately soft and hard with soft rock weathering in low relief to give rock face a ribbed appearance. Unit resembles some Toad facies in eastern sections; between 170 and 200 feet, beds are massive and up to 20 feet thick; below 400 feet, platy units predominate but alternation of hard and soft units continues; Daonella occurs 510 feet from top; 780 feet was measured at principal draw and another 224 feet was added from partial section in draw on southwest face		
2	Covered interval, recessive; thickness estimated	100	120
1	Siltstone, black and weathering dark grey to black; calcareous; platy; ledge-former; Pseudomonotis occidentalis (Whiteaves) present	20	20
	Base of measured section		
	Covered interval, recessive. This interval not included in section, but it extends across strike to the highway where outcrops of the Grayling formation occur in road-cuts,		