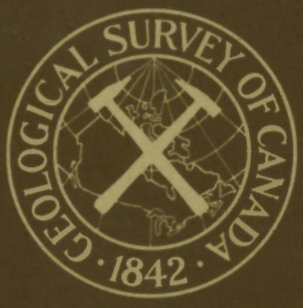

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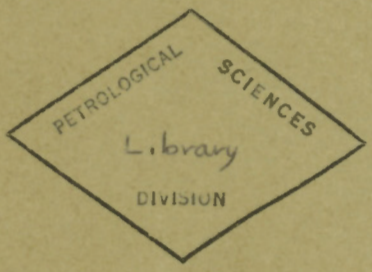

TRIASSIC STRATIGRAPHY, ROCKY MOUNTAIN FOOTHILLS, NORTHEASTERN BRITISH COLUMBIA

94 J AND 94 K

B. R. Pelletier

Price 50 cents

1960

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TRIASSIC STRATIGRAPHY, ROCKY MOUNTAIN FOOTHILLS, NORTHEASTERN BRITISH COLUMBIA

INTRODUCTION

This report is a preliminary account of the stratigraphy in the lower and middle Triassic rocks of the Rocky Mountain Foothills, northeastern British Columbia. Sections were measured along the western Foothills belt between Toad River to the north and Gatho Creek to the south. Some conclusions are presented from studies on primary current structures. Field work was commenced in the summer of 1959.

Assistance in the field was given by G.A. Bartlett, technical officer, and by C.W. Aubin and P.H. McGrath, student assistants. The author extends his thanks to R.H. Beattie of Hudson Hope, F.E. Madden of Ground Birch, T.O. Southwick and J.M. Burrows of Fort Nelson, and W.D. Hood of Fort St. John.

Earliest geological exploration in northeastern British Columbia was undertaken in 1888-89 by McConnell (1891)[1]. With the opening of the Alaska Highway west of Fort Nelson, a geological reconnaissance was made in 1943 along this new road by Williams (1944). Other geological investigations were carried out about the same time by Kindle (1944) who mapped the Toad and Liard rivers to the north; Hage (1944) who mapped in the vicinity of Fort St. John to the south; and McLearn (1945, 1946a, b, 1947a, b) who reviewed his studies on Triassic palaeontology of northeastern British Columbia and presented conclusions. Other contributions to the geology of the general area, especially the Peace River district, have been summarized by McLearn and Kindle (1950). In the summer of 1958, the writer completed a detailed map of the Tetsa River area (Pelletier, 1959). A compilation and interpretation of subsurface stratigraphy of the Triassic was made by Hunt and Ratcliffe (1959).

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STRATIGRAPHY

The Triassic of the Liard River valley of northeastern British Columbia was subdivided by Kindle (1944) into a lower and an upper division called the Grayling and Toad formations respectively.

Kindle proposed the term Grayling for a "series of soft, laminated, friable grey shales" occurring on the Liard and Grayling rivers, and he designated the cliff exposures on the Grayling River as the type section. The beds overlying the Grayling formation comprise "brown and black, platy shales and siltstone, sandstone and limestone", and were assigned to the Toad formation with type localities on the Toad River 2 miles south of the Liard, and on the Liard River between Hell Gate and Garbutt Creek. The contact between the formations was found to be conformable. Later, (see McLearn, 1946, 2nd ed., app.). Kindle divided the Toad formation into an upper and lower formation. The name 'Toad' was retained for the siltstones, sandstones, and shales in the lower part of the original formation, and the name 'Liard' was proposed for the upper part which included "the more massive beds of grey sandstones and grey limestones" exposed along the Liard River at Hell Gate.

Correlation of the Triassic formations is based on faunal zones. However, the main sandstone and siltstone ledge-makers can be readily traced by means of aerial photographs. The Grayling is sparsely fossiliferous but cf. Claraia stachei Bittner was collected by Kindle on the Grayling River a mile north of the Liard. The Beyrichites-Gymnotoceras zone is especially characteristic of the Toad formation. Along the Liard River below the mouth of the Toad, Kindle collected a Wasatchites fauna from the Toad formation 300 feet below the Beyrichites-Gymnotoceras zone. The Nathorstites zone is the most characteristic fossil zone of the Liard formation. Terabratulids, spiriferinids, and grypheids are also found in the Liard but below the Nathorstites zone.

The Triassic disconformably overlies bedded chert of Permian or Pennsylvanian age (Sutherland, 1958, p. 36) and, in turn, is overlain disconformably by the fissile, non-calcareous, dark grey shales of the Cretaceous. These shales may belong to the Garbutt or Buckinghorse formations of the Lower Cretaceous Fort St. John group.

The outcrop area of the Triassic (see Fig. 1, inside back cover) is bounded on the east by lowlands underlain by folded Lower Cretaceous shales, and on the west by folded and faulted Palaeozoic strata. Within the main Triassic belt, several Palaeozoic culminations are present in the form of compound anticlines that expose late Palaeozoic chert, limestones, shales and sandstones in their cores. Several of the synclinal valleys in the Triassic are occupied by Cretaceous shales.

Triassic formations generally outcrop in northwesterly trending valleys and ridges. The physiography is mainly controlled by northwesterly trending folds and faults, and to a lesser degree by erosion of the softer underlying beds along those trends. Several minor river-systems transect the various belts of outcrop, namely the Toad, Snake, Dunedin, Tetsa, Chischa, Chlotapecta, Tuchodi, and Gatho.

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	
	Middle Triassic	Liard 0-300	Massive, grey, calcareous sandstones, minor grey limestones and dark grey siltstones	Nathorstites
		Toad 600-1,600	Massive grey calcareous siltstones and mudstones, minor sandstone and limestone, platy shales and siltstones	Beyrichites-Gymnotoceras Wasatchites
	Lower Triassic	Grayling 1,200-1,500	Chiefly platy, dark grey, calcareous siltstones and mudstones; minor limestones; interbedded shale and 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	

Grayling Formation

The Grayling is exposed along all major rivers crossing the Foothills, but no complete section was found at any single location. Descriptions of sections measured at Ram Creek, Snake Creek, and Chischa River are given in the Appendix (sections 1, 2, 6, 7). The soft mudstone and shale sequences of the Grayling formation are recessive and where they occur as anticlinal cores, northwesterly trending valleys have formed.

The lower contact of the Grayling is disconformable and the black, fissile, non-calcareous shale rests upon dark bluish grey, blocky chert of Permian(?) age. In the lower part, the Grayling consists of black shales interbedded with thin- and medium-bedded sandstones. The shales may occur in intervals several feet thick. Higher in the section they are calcareous and, in the upper part, may be interspersed with 10- to 20-foot ledges of massive dark grey siltstone and mudstone with minor thin-bedded dark grey limestone. Shales in the upper part of the formation are platy and consist partly of siltstone and fine sandstone laminations. The upper contact of the Grayling is gradational and drawn at the base of the lowest, massive siltstone ledge-former of the Toad formation. This resistant Toad unit is generally about 70 feet thick but may be less.

Total thickness of the Grayling is about 1,500 feet in the western part of the Triassic belt. This figure is computed from partial sections which give about 500 feet of sandstone and interbedded non-calcareous shale in the lower part on Snake Creek, and about 1,000 feet of calcareous shale and platy siltstone in the upper part on Ram Creek. On lower Chischa River and lower Chlotapecta Creek, the Grayling is estimated to be 1,200 feet thick, although the basal sandstone beds are mostly concealed or may even be absent. The formation accordingly appears to be somewhat thinner in the east.

Ripple-marks and associated crossbedding are prominent in the lower, more sandy beds. The wave-ripple marks, which presumably form parallel to shore, suggest northwesterly trending shorelines east of the outcrop area during Lower Triassic time. On the basis of the westerly dip-direction (corrected for folding) of crossbedding foreset beds, sedimentary transport to the west and southwest is inferred. The presence of pelecypod impressions and shell fragments indicates a marine environment of deposition, and probably well offshore as further indicated by the finely laminated shales.

Toad Formation

Complete sections of the Toad formation are well exposed along the higher ridges especially where draws incise the scarp faces. Other sections occur along smaller rivers where the valleys are narrow. Sections described in the Appendix (sections 1 to 9) include those measured on Ram Creek, Snake Creek, Dunedin River, Tetsa River, Chischa River, Chlotapecta Creek, Tuchodi River, and Gatho Creek. On hillsides the Toad formation is generally recessive except for the upper and lowermost parts which consist of hard siltstone and sandstone ledge-formers.

Both contacts of the Toad formation are gradational. The lower contact is placed at the base of the lowest massive siltstone ledge, which in several sections contains small, elongated, black silicified nodules. The lower part of the Toad formation consists mainly of thick-bedded, dark grey calcareous siltstones, and minor dark grey calcareous shales. Thin, dark grey limestone is interbedded with the siltstone and shale, but in very minor amounts. The middle Toad is generally recessive and consists of massive, dark grey calcareous siltstones, minor calcareous shales, and a few thin fossiliferous limestone beds. These intermediate shales and siltstones comprise the typical Toad facies. In the upper part, thick-bedded calcareous sandstone ledges separated by intervals of soft, dark grey siltstones pass gradationally into a Liard-type sandstone. The contact with the overlying Liard formation is taken at the base of a thick sandstone ledge. The uppermost 70 to 80 feet of the Toad is recessive and generally concealed on hillside sections, but where exposed along river sections it may be seen to consist of soft, dark grey siltstone.

Thickness varies most significantly in an east-west direction. In the western section along Chischa River, the Toad is about 1,600 feet thick. Ten miles to the east, it thins rapidly to less than 800 feet.

Primary current-features such as crossbedding and current-ripple marks indicate that the direction of sedimentary transport was to the west and southwest. Trend of the ripple-marks indicates that the shorelines trended northwesterly. In some of the highly crossbedded layers in the uppermost Toad, both planar and festoon crossbedding are present. The assemblage of ripple-marks, burrows, and shells, together with festoon bedding, suggests that the deposits are marine and probably offshore bars. On the evidence of fossils and primary structures, a marine, near-shore environment of deposition is suggested for the upper part of the formation and farther offshore environment for the lower part.

Liard Formation

The Liard formation is well exposed along ridge-tops and steep river-banks. The most complete sections, however, are found at river level where both upper and lower contacts may be seen. Sections described in the Appendix (sections 2 to 9) are those measured on Snake Creek, Dunedin River, Tetsa River, Chischa River, Chlotapecta Creek, Tuchodi River, and Gatho Creek.

The lower beds of the Liard are gradational with the finer-grained, darker sandstones of the underlying Toad formation. Sandstones of the Liard consist of well-washed, medium-grained quartz cemented by calcite. The rock is medium grey and weathers yellowish orange and brown. Minor grey siltstones and shales occur in recessive intervals between the massive sandstones. Limestone is present as thin- and medium-bedded layers in the sandstones. It is less than 4 feet in total thickness in the eastern sections, but progresses to more than 10 feet in the west. The upper Liard consists of dark grey to black sandstone and limestone which weather orange; on hill-top exposures these beds may have a rough, bleached appearance. Minor

salt casts, solution breccias, vugs and stylolites are present. The upper Liard may be equivalent to the Charley Lake formation of the Ft. St. John region (Hunt and Ratcliffe, 1959, p. 576). The Liard formation is disconformably overlain by black shales of the Lower Cretaceous.

The upper Liard increases in thickness from 4 feet in eastern exposures on the Tetsa River, to more than 50 feet in western sections on Chlotapecta Creek. It is present in all complete sections of the Liard to the south, and appears to thicken in a southwesterly direction. Thickness variation of the Liard is greatest in an east-west direction. In the western sections the formation is more than 300 feet thick. Ten miles to the east in river sections opposite mile-post 374 on the Alaska Highway, it is 25 feet thick. Two miles farther to the east, the Liard is absent and lower Cretaceous shales lie disconformably upon massive dark grey siltstones of the Toad formation. Much of this abrupt eastward thinning is due to pre-Cretaceous erosion, and some is due to eastward convergence and minor disconformities. The eastern limit of the Liard formation extends northwesterly and southwesterly across the Alaska Highway near mile-post 372, and cuts obliquely across the structural trend of the Foothills.

Primary current-structures such as coarse-scale crossbedding, festoon bedding, current- and wave-ripple marks occur throughout the sandstones. These indicate northwesterly trending shorelines, and a probable direction of sedimentary transport to the southwest. Arthrophycus-like forms occur along many bedding planes and are included in an assemblage of near-shore features such as primary current-structures, burrows, macerated shells, thin beds of pebbles and minor disconformities. Lower Liard sandstones with these characteristics are presumed to be offshore bars. Upper Liard beds have many features characteristic of an evaporite sequence.

History of Sedimentation

Primary current-structures indicate that the source region lay to the east and northeast of the area. Sediments were transported in a general southwesterly direction across a shore zone which trended northwesterly (Fig. 1). The site of deposition as outlined by the thickness trends also extended northwesterly, but appears to have trended more easterly in the southern part of the area. This change in trend is inferred from a change in the current direction toward the south in the Tuchodi River - Gatho Creek area. More than 3,500 feet of Triassic sediments accumulated in the western part of the depositional area, and at least 2,000 feet in the vicinity of the eastern Foothills (Fig. 1). The rapid thinning across 15 miles of the depositional area is partly due to post-Liard erosion of the Liard and uppermost Toad.

In gross lithology the clastic sediments of the Triassic become progressively coarser from bottom to top of the section. Shales, mudstones and minor siltstones of the Grayling pass gradationally into the shales, siltstones and fine-grained sandstones of the Toad. The uppermost Toad sandstones pass gradationally into the major, coarser-grained sandstones of the Liard. Thickness of crossbedding also varies progressively from bottom to top of the section. Average thickness of

Grayling crossbedding is 1 inch; of the Toad, 5 inches, and of the Liard, 9 inches. Another apparent change from bottom to top of the Triassic section is an apparent facies shift. Grayling deposition was relatively deeper marine; Toad deposition was closer to shore with minor offshore bars forming; Liard deposition was mostly shallow marine, and perhaps continental in the uppermost part. Although the facies shift appears to progress without interruption, the presence of minor disconformities, pebble beds, and the alternation of sandstone and finer clastics indicate numerous withdrawals and advances of the sea during Triassic time.

The coarsening of gross lithology and sedimentary structures from bottom to top of the section, and the occurrence of near-shore facies over deeper marine facies together with sedimentary transport to the southwest suggest that the shore zone and the entire sedimentation system occurred in successively westerly areas during Triassic time. These factors further suggest that the deposits of a given lithology which formed in these successively westerly areas concomitantly occupied stratigraphically higher positions in the section.

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). Such reservoir sands are deposited in the form of discontinuous sheets and lenses capped by shale, and form an integral part of the sedimentation system. As part of this system, the sandstones must have been deposited in successively westerly areas and have occupied progressively higher stratigraphic positions in the section. The trend of the sandstone bars, based on their parallel position with the presumed trend of the ancient shoreline, is northwesterly. It may be profitable to extend exploration of proven fields along such trends.

- APPENDIX -

Section 1. Located in draw on hillside east of Ram Creek, 2 miles southeast of Toad River Junction.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Liard Formation		
12	Covered interval, recessive unit at top of hill; may be upper Liard; thickness estimated	200	2,409
11	Sandstone and siltstone, dark and medium grey and weathering yellowish grey to brown; sandstone is fine grained, and thick bedded; minor black limestone occurs in sandstones; abundant brachiopod and ammonite fauna (Nathorstites), also dinosaur bones; unit is a ledge-maker	162	2,209
	Toad Formation		
10	Covered interval, recessive	241	2,047
9	Sandstone, medium to dark grey and weathering yellowish brown, medium- to thick-bedded; 1.5-foot calcite vein present; unit forms ledge	43	1,806
8	Siltstone, dark grey and weathering yellowish orange, thin-bedded and platy; unit is recessive	74	1,763
7	Siltstone, dark grey and weathering yellowish grey and brown, soft, massive, recessive	62	1,689
6	Sandstone, dark grey and weathering yellow-grey, fine-grained, massive; lower 76 feet is recessive, upper part forms ledge	161	1,627
5	Sandstone, dark grey and weathering yellowish grey, fine-grained, thick-bedded; ledge-maker	44	1,466

Section 1 (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
4	Sandstone and siltstone, dark grey and weathering yellowish grey, soft, fine-grained; thick-bedded in upper third but remainder is platy; some medium-bedded sandstone is interbedded in lower part; beds are flaggy toward base; unit is generally recessive throughout	201	1,422
3	Siltstone, dark grey and weathering yellowish grey, massive; basal ledge of Toad	64	1,221
	Section measurement continued 1 mile downstream at anticlinal core.		
	Grayling Formation		
2	Covered interval, probably weathered out shales and siltstones, recessive	71	1,157
1	Siltstones and shale, dark grey to black and weathering dark grey, platy, with minor 1- to 2-inch sandstone beds, small-scale crossbeds and ripple-marks present, pelecypods at 840 feet	1,086	1,086
	Section ends in core of anticline exposed at creek level.		

Section 2. Located in draw on east face of most easterly Palaeozoic ridge, 1/2 mile north of Snake Creek at headwaters.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Grayling Formation		
	Upper contact of Grayling not exposed		
12	Siltstone and shale, dark grey and weathering dark grey, soft, calcareous, uniformly platy and well laminated, recessive	360	1,508
11	Partly covered interval, platy siltstone and shale, dark grey and black and weathering dark grey, calcareous, recessive	335	1,148
10	Siltstones and shales as in units 12 and 11, recessive	29	813
9	Covered interval	225	784
8	Shale, black and weathering dark grey and orange-rusty-brown, non-calcareous, fissile; minor 1-inch interbedded sandstone flags (less than 20%)	125	559
7	Covered interval, recessive	45	434
6	Shale and interbedded sandstone as in unit 8, recessive	125	389
5	Covered interval, non-calcareous black shale in talus, recessive	89	264
4	Sandstone and interbedded shale as in units 8 and 6; sandstone is mostly flaggy and occurs near base (10 feet total) and is calcareous; beds weather rusty brown, recessive	48	175
3	Sandstone, dark grey and weathering light yellowish brown, fine- to medium-grained; beds thin and medium and interbedded with fissile, non-calcareous black shale; sandstone forms ledge	68	127

Section 2. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
2	Shale, black and weathering orange-brown, soft, non-calcareous, fissile, recessive	19	59
1	Shale, black and weathering orange-brown, hard, platy; forms ledge This unit is the base of the Grayling. It is in disconformable contact with the bluish grey, blocky chert of Permian or Pennsylvanian age.	40	40

Section 3. Located on hill off north bank of Snake Creek about 3 miles east of most easterly Palaeozoic ridge at the Rocky Mountain front.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Upper contact of Liard is not present here. There is an overlying covered interval on the dip slope which was not measured; probably less than 20 feet.		
	Liard Formation		
12	Sandstone, brownish grey and weathering yellowish orange, coarse-grained, quartzose, medium-bedded, somewhat foggy; minor black shale interbeds present; concretions, cross-bedding, worm burrows or unknown trails, and ripple bedding prominent; unit forms ledge on hill-top	29	729
11	Covered interval, estimated thickness over shoulder underlain by beds with constantly changing attitudes; maximum figure is 65 feet, minimum is 35 feet; interval is recessive	65	700
10	Sandstone, dark grey to brown and weathering yellowish grey and brown, medium-grained, generally medium-bedded but may be thicker, ledge-former	26	635
9	Covered interval, recessive	7	609
8	Sandstone, dark grey and weathers orange and grey, medium-grained, massive, ledge-former	6	602
7	Covered interval	7	596
6	Sandstone, dark grey and weathering yellowish and reddish brown, medium-grained, massive with minor medium-bedded layers; concretions and cross-bedding present; ledge-former	150	589
	This is taken as the basal unit of the Liard; conformable contact with the Toad formation.		

Section 3. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Toad Formation		
5	Sandstone and siltstone, dark grey and weathering yellow and grey, striped appearance on hill face, fine-grained, calcareous, contain worm burrows, ripple-marks, fine crossbedding and minor scour, recessive	44	439
4	Siltstone, dark grey and weathering dark grey, calcareous, massive, forms ledge	10	395
3	Siltstone, dark grey to black and weathering dark grey, soft, calcareous, massive, minor flags, recessive	100	385
2	Siltstone, dark grey and weathering yellowish orange, hard, calcareous, platy and flaggy, forms ledge	57	285
1	Siltstone, dark grey and weathering yellowish orange and dark grey, soft, calcareous, flaggy and medium-bedded, recessive	228	228

Lower part of section concealed by overburden on hillside. There may be 400-500 feet or more of lower Toad not exposed.

Section 4. High hill about 1 mile north of Dunedin River near headwaters. Section measured on west face.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	There is no Cretaceous on top of hill. Upper contact of Liard is missing.		
	Liard Formation		
22	Sandstone, dark grey and weathering brown, medium-grained quartz with calcareous cement, soft, massive, numerous ammonites in concretions, Nathorstites fauna; concretions are epigenetic and mostly sandstone with high lime content; unlike so-called "cannon-ball" concretions of other units; unit is recessive	84	2,235
21	Sandstone, dark grey with light brown and orange weathering, fine-grained, calcareous, massive generally, forms ledge	43	2,141
20	Sandstone, with minor interbedded limestone, dark brownish grey and weathering light brownish grey, massive and thick bedded; Gryphea and terabratulids present; some "recessed" calcareous concretions which have weathered into low relief; unit is recessive	76	2,098
19	Sandstone, platy and thin-bedded; fine crossbedding on a small scale, and thinly laminated beds present in lower 6 feet; unit forms a ledge but lower 6 feet is recessive	19	2,032
18	Sandstone, medium grey and weathering yellowish brown and grey, medium-grained, calcareous, ledge-former	21	2,013
17	Covered interval, recessive	70	1,992
16	Sandstone, dark brownish grey and weathering light brownish grey and yellowish grey, medium-grained, calcareous, thick-bedded; some flaggy units present are finely crossbedded; "cannon-ball" concretions present weather into low relief; beds form ledge	42	1,922

Section 4. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	This unit is taken as basal Liard		
	Toad Formation		
15	Covered interval, recessive	70	1,880
14	Covered interval, steep drop, no outcrop	22	1,810
13	Partly covered interval, sandstone, dark grey to brown and weathering light yellowish brown, white staining, fine-grained, soft, calcareous, medium-bedded, recessive	19	1,788
12	Partly covered interval, siltstone chiefly and fine-grained sandstone, dark grey and weathering yellowish grey with white coating, calcareous, thick-bedded, ammonites present (Gymnotoceras-Beyrichites fauna); most of the unit is exposed; interval is recessive	201	1,769
11	Sandstone, dark grey and weathering yellowish grey, fine-grained, calcareous, concretions at base weathering in low relief; minor shale content and finely crossbedded sandstone in lower 20 feet; unit is ledge-former	84	1,568
10	Siltstone and fine-grained sandstone, dark grey, soft, calcareous, medium-bedded, recessive	209	1,484
9	Sandstone, medium grey and weathers yellowish brown, fine grained, hard, massive, ledge-maker	24	1,275
8	Siltstone and minor fine-grained sandstone, dark grey, thick-bedded but platy at the base of each sandstone bed	130	1,251
7	Siltstone, black and weathering grey and yellowish grey, beds mostly platy, recessive	140	1,111

Section 4. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
6	Sandstone, medium grey and weathering yellowish grey, fine-grained, calcareous, mostly thick-bedded, forms ledge	45	971
5	Siltstone, dark grey and weathering orange-brown, soft, slightly calcareous, minor fine-grained sandstone content, recessive	46	926
4	Sandstone, dark grey and weathering dark yellowish orange-brown, fine-grained, highly calcareous, medium-bedded, numerous current-markings	24	880
3	Sandstone, dark grey and weathering dark grey, somewhat silty, slightly calcareous, massive; at base of unit beds are siltstone	256	856
	Base of Toad is drawn arbitrarily at this unit; although platy beds occur in the upper part of the section, they become more important in the lower part where the section contains the typical Grayling facies.		
	Grayling Formation		
2	Siltstone and shale, black and weathering dark grey with white staining, very calcareous, somewhat sandy in places, beds platy to well-laminated	362	600
1	Siltstone, dark grey to black and weathering dark grey with whitish coating, slightly calcareous; upper third is massive, lower part is finely laminated	238	238

Base of section is in core of anticline

Section 5. Located on west flank of anticline on south bank of Tetsa River opposite mile-post 374.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Vertically dipping Cretaceous shales containing ironstone concretions; beds disconformably overlie Liard formation.		
	Liard Formation		
14	Sandstone and interbedded limestone; upper 5 feet contains dark grey to black sandstone and limestone weathering orange; sandstone is medium grained and medium bedded; lower 15 feet consists of sandstone, medium-grey and weathering yellowish grey. At mile-post 375, this unit contains chert-pebble conglomerates, and opposite mile-post 373 on south bank of Tetsa, solution breccias are common. At the present outcrop, this unit is taken as the base of the Liard.	20	1,043
	Toad Formation		
13	Sandstone and siltstone, dark grey and weathering orange-brown, fine-grained, soft, calcareous and thin-bedded; beds are mostly flaggy; unit is recessive	19	1,023
12	Sandstone, dark grey and weathering light yellowish grey, fine-grained, minor coquinoid limestone less than 6 inches thick with mostly crinoidal fragments; beds generally thick; ledge-former	88	1,004
11	Siltstone and sandstone, dark grey and weathering light yellowish grey and black, fine-grained, thin- and medium-bedded, recessive	19	916
10	Sandstone, dark grey and weathering light yellowish grey, fine-grained, concretions weathering low, thick-bedded, ledge-former	29	897

Section 5. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
9	Sandstone and siltstone, dark grey to black and weathering dark grey, fine-grained, thin-bedded and flaggy, recessive	32	868
8	Sandstone, minor platy siltstone and shale, dark grey and weathering dark, fine-grained, sandstone is thin- and medium-bedded and forms a ledge in the upper part; lower 16 feet is recessive due to predominance of soft shale and siltstone	30	836
7	Siltstone and fine-grained sandstone, dark grey and weathering dark brownish grey; middle 15 feet is recessive due to predominance of platy siltstone, otherwise unit forms a ledge	45	806
6	Siltstone and fine-grained sandstone, dark grey and weathering light yellowish grey, medium- to thick-bedded, ledge-former	40	761
5	Covered interval, recessive	13	721
4	Siltstone, dark grey and weathering grey and yellowish grey, thick-bedded but internally divided by thin-bedded and platy units, recessive	255	708
3	Siltstone, dark grey and weathering dark grey to black; minor dark grey, thin limestone containing ammonites and pelecypods about 15 feet from top; alternating hard and soft aggregates present throughout; recessive	137	453
2	Siltstone, dark grey to black and weathering light yellowish grey and dark grey, contains black, silicified, nodules about 1 inch long; ledge-former; unit is taken as the basal Toad	45	316

Section 5. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Grayling Formation		
1	Siltstones and shales, black and weathering dark grey to black, calcareous, platy, soft, recessive	271	271

Base of section in core of anticline.

Section 6. Section at east entrance of canyon on Chischa River, 10 miles west of Muskwa River.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Top of section is contact between Cretaceous black shales and underlying Liard sandstones. Contact is disconformable.		
	Liard Formation		
15	Sandstone, dark grey to black and weathering orange, thin-bedded, slightly recessive	11	1,659
14	Sandstone, dark grey and weathering light yellowish orange, medium- to coarse-grained, massive to medium-bedded but generally thick, crossbedded, ledge-former	42	1,648
	This unit is taken as the basal Liard.		
	Toad Formation		
13	Sandstone and siltstone, dark grey and weathering sooty black and grey, thin-bedded, soft, recessive	8	1,606
12	Sandstone, dark grey and weathering yellowish grey, fine-grained, massive, ledge-former	15	1,598
11	Sandstone, dark grey and weathering medium grey and yellowish grey, medium- to thick-bedded, internally, beds are finely laminated; fossils highly recrystallized; ledge-former	80	1,583
	There is a 1-foot layer of platy dark grey siltstone at top which separates both ledges; at 23 feet from the top, a massive sandstone ledge appears and is 13 feet thick; then finely laminated beds continue although bedding is generally thick throughout.		

Section 6. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
10	Sandstone and siltstones, dark grey and weathering dark grey and yellowish grey, generally medium-bedded or thicker; incipient concretions 6 to 10 inches in diameter appear at top, and bedding passes through them; some recrystallized fossils At 45 feet from top, 6-inch to 3-foot aggregates of black platy siltstones appear and are recessive, thus giving alternate ledges--about 3 of them--up to 15 feet thick with a major 10-foot ledge at base; some thin-bedded limestone (less than 1%).	127	1,503
9	Sandstone, dark grey and weathering medium grey, fine-grained, recessive Rock has sooty appearance, is finely laminated, and is soft and platy; some medium- to thick-bedded sandstones are interbedded; at 33 feet from top, ammonite impressions occur and are similar to those in outcrop opposite mile-post 370 on south bank of Tetsa River where Liard is absent.	61	1,376
8	Siltstone and fine-grained sandstone, dark grey and weathering yellowish grey and medium grey, thick-bedded with minor thin-bedded dark grey limestone; at 13 feet from top, prolific ammonite fauna occurs; unit forms ledge	42	1,315
7	Siltstone and fine-grained sandstone, continuation of above ledge, but beds are well-laminated; dark grey and weathering medium grey; large concretions present; prolific ammonite and pelecypod fauna present at 41, 48, and 55 feet from top; minor platy siltstones present in lower 30 feet but only 20% of unit	73	1,273

Section 6. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
6	Siltstone and fine-grained sandstone, continuation of ledge; beds are dark grey; pebble beds with pebbles of dark grey sandstone and siltstone up to 3 inches in diameter occur at top; several beds contain black silicified and cherty nodules, generally crystalline and up to 2 inches long; ammonites at 9 and 38 feet from top	94	1,200
	Black platy siltstones occupy about half the unit, thus making it more recessive than overlying one; platy beds alternate rhythmically with thicker sandstone beds		
5	Siltstone, dark grey and weathering medium grey, small black siliceous nodules present; this unit is considered to be the base of the Toad	56	1,106
	There is a 9-foot ledge at base, above which lies 7 feet of platy siltstone; contact is transitional and is arbitrarily placed at the base of the lowest ledge in this thick-bedded and massive siltstone unit. It is possible that the beds containing ammonite impressions about 200 feet below this unit are also Toad. This would give about 800 feet total thickness for the Toad		
	Grayling Formation		
4	Siltstone and shale, black and weathering dark grey, soft, calcareous, platy and finely-laminated	804	1,050
	Whitish coating is common; at 7 feet, worm burrows occur; at 197 feet from top, there are poorly preserved ammonite impressions. From 311 feet to base of unit, there are 6- to 12-inch beds of light grey sandstone weathering light yellowish grey; they occur at scattered intervals 3 to 25 feet apart and occupy 10% of this part of the unit.		

Section 6. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
3	Siltstone, dark grey and weathering light yellowish grey, massive, ledge-former	20	246
2	Siltstones and shales, black and weathering dark grey; minor interbeds of fine-grained sandstone, and numerous interbeds of dark grey siltstone with a considerable white coating and dark grey weathered surface	110	226
1	Siltstone, dark grey with considerable white coating and weathering dark grey and yellowish grey, medium- and thick-bedded	116	116

Section ends at anticlinal crest; syncline occurs up-creek a few hundred feet but no new section is apparent. Although continuous section to base was not observed, it is estimated that 150 feet at most is not exposed.

Section 7. West face of hill 1 mile north of Chlotapecta Creek and 10 miles east of Rocky Mountain front. Section measured at head of small creek and steep draw.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Section begins at top of hill.		
	Liard Formation		
12	Sandstone, dark grey and weathering orange, medium-grained, calcareous, thick-bedded, ledge-former	79	1,127
11	Sandstone, dark grey and weathering orange-brown, calcareous, thin-bedded and platy, or flaggy, recessive	39	1,048
10	Covered interval, recessive	48	1,009
9	Sandstone, dark grey and weathering orange and grey, medium-grained, massive ledge-former	73	961
8	Covered interval, recessive	5	888
7	Sandstone, dark grey and weathering orange and grey, medium-grained, thick-bedded, ledge-former This ledge is taken as the base of the Liard; it is very prominent.	43	883
	Toad Formation		
6	Covered interval, recessive	82	840
5	Sandstone, dark grey and weathering yellowish grey and orange, fine-grained, massive, ledge-former	55	758
4	Siltstone, black and weathering dark brownish grey and dark grey, massive, recessive	42	703

Section 7. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
3	Sandstone, dark grey and weathering yellowish grey and orange, massive but internally divided by thin beds and laminations; unit forms ledge, but lower 10 feet is recessive	37	661
2	Siltstone and fine-grained sandstone, dark grey and weathering dark brownish grey, massive and without laminations, ledge-former	29	624
1	Siltstones, dark grey and weathering dark grey with yellowish grey and white coating; prolific ammonite fauna, few pelecypods and orthocones at 270 and 300 feet from top in 6-inch, dark, impure limestones; rhythmic alternation of massive units of hard and soft siltstone gives outcrop a "ribbed" appearance; the lower 353 feet is well-laminated and platy in several intervals although beds are generally massive	595	595

Section ends in core of anticline. The lower siltstone ledge of the Toad is not exposed completely so that total thickness of the Toad is estimated to be at least 900 feet.

Section 8. Section on west face of hill 1 1/2 miles north of Tuchodi River, 5 miles east of Rocky Mountain front. Lower part of section was measured by offsetting along the bedding toward the south.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Liard Formation		
19	Sandstone, medium grey and weathering orange and grey; some thick limestone beds; unit generally thick-bedded with flaggy beds at base; Nathorstites fauna present; highly recrystallized; ledge-former Toward the north, it appears that higher beds may be present on hill-tops.	16	1,633
18	Covered interval, recessive	18	1,617
17	Sandstone, medium grey and weathering orange and grey, medium- to coarse-grained, and in places, a grit, massive, crossbedded; Gryphea and terabratulids present; minor coquinoid limestone, mostly crinoidal This unit is taken as the base of the Liard. It is a strange ledge-former.	79	1,599
	Toad Formation		
16	Sandstone, dark grey to black and weathering dark brownish grey, thin- and medium-bedded, recessive	78	1,520
15	Sandstone, dark grey and weathering yellow and orange, fine-grained, massive, crossbedding prominent in some layers, ledge-former	41	1,442
14	Covered interval, recessive	178	1,401

Section 8. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
13	Sandstone, dark grey and weathering yellowish grey and orange, fine-grained, massive; poorly preserved ammonite and pelecypod impressions (Beyrichites(?) fauna); ledge-former	62	1,223
12	Covered interval, recessive	34	1,161
11	Siltstone and fine-grained sandstone, dark grey and brown weathering, brownish grey, thick-bedded, generally recessive with small ledge (few feet) at top	82	1,127
10	Siltstone and fine-grained sandstone, dark grey and weathering brownish grey, massive, ledge-former but lower 15 feet is recessive	74	1,045
9	Siltstone and minor limestone interbeds, dark grey to black and weathering brownish grey, poorly preserved ammonites, massive, ledge-former	42	971
8	Covered interval, recessive	33	929
7	Siltstone, black and weathering dark grey and brown, soft, massive; lower 10 feet is recessive, upper 10 feet forms ledge	20	896
6	Covered interval, recessive	42	876
5	Sandstone, dark grey and weathering brownish grey to yellowish brown; medium-bedded and divided internally by fine laminae	19	834
4	Partly covered interval, recessive	183	815

Section 8. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Long, lateral shift in measuring made here parallel to bedding; measurements continued about 1/3-mile south; about 20 feet of rock exposed near middle and upper thirds; fine-grained sandstone and siltstone, dark grey and weathering yellowish brown (some red, oxidized iron present but this may be effects of fire).		
3	Siltstone, black and weathering dark grey with some yellow and white coating, soft, massive and thick-bedded with fine laminations, recessive	340	632
2	Siltstone, dark grey to black and weathering dark grey with yellow and white coating; thick-bedded soft units rhythmically alternating with similar hard ones give outcrop a "ribbed" appearance; unit is recessive	133	292
1	Siltstone, dark grey to black and weathering dark brownish grey and dark grey, recessive	159	159
	Section ends at ground-level. This unit is close the base of the Toad; probably not more than 100 feet would be Toad.		

Section 9. Section at eastern range of Foothills on Gatho Creek. Upper part measured at river-level; lower part measured on east face of hill after making offset along strike north from river-level.

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Section begins at river-level, black shale of Cretaceous disconformably overlying Triassic sandstones.		
	Liard Formation		
17	Sandstone, dark grey and weathering rusty orange, fine-grained, flaggy and medium-bedded, recessive	34	2,323
16	Sandstone and limestone, black and weathering orange with some green staining; stylolites, concretions, and salt casts present; limestone is minor and interbedded; beds medium to thick and generally with irregular bedding surfaces; ledge-former	113	2,289
15	Sandstone, dark grey and weathering dark grey, fine-grained, beds thick but are internally well-laminated and may be platy, soft and recessive	13	2,176
14	Sandstone, medium grey and weathering orange and light grey, coarse-grained, thick-bedded, ledge-former	111	2,163
13	Sandstone, dark grey and weathering dark grey, thin-bedded and flaggy, Nathorstites poorly preserved, recessive	14	2,052
12	Sandstone, dark grey and weathering orange and grey, fine-grained, generally massive with some thick beds, ripple-marked, large-scale crossbedding, minor limestone, Gryphea at 82 feet from top, ledge-former	92	2,038
	This unit is taken as base of Liard. It forms a very prominent ledge.		

Section 9. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Toad Formation		
11	Sandstone, dark grey and weathering dark yellowish grey, fine-grained, thin-bedded, wispy crossbedding (small-scale), recessive	22	1,946
10	Sandstone, light grey and weathering yellowish orange and grey, fine- to medium-grained, massive, ledge-former	59	1,924
9	Siltstone and mudstone, black and weathering black with white coating, medium-bedded, recessive	31	1,865
8	Sandstone, dark grey and weathering dark yellowish grey to brownish grey, fine-grained, prominent ledge in upper 20 feet, beds massive, remainder is recessive and medium-bedded	92	1,834
7	Siltstone, dark grey and weathering dark grey with yellowish white coating, thick-bedded; ledge in upper 40 feet, remainder is recessive	126	1,742
6	Siltstones and minor impure limestones, dark grey and weathering dark grey, thick-bedded, ledge-former	42	1,616
5	Siltstone, dark grey and weathering dark grey and yellowish brown and grey; rhythmic alternation of hard and soft siltstone aggregates in thick-bedded units; black; silicified nodules present in hard beds and about 1 inch long; recessive; outcrop has ribbed appearance, recessive	61	1,574
4	Siltstone, dark grey and weathering dark grey, massive but finely laminated and breaking into platy units, recessive	230	1,513
3	Siltstone and shale, dark grey and weathering brown, massive and platy beds, recessive	240	1,283

Section 9. (cont.)

Unit	Lithology	Thickness (feet)	Height Above Base (feet)
	Section ends at core of overturned anticline; this unit of shale and siltstone is similar to the Grayling and is presumed to lie near the base of the Toad. The 240 feet is estimated and is arbitrarily taken as the base of the Toad. The contact is concealed.		
	Grayling Formation		
2	Covered interval, recessive	500	1,047
	Between the lowest outcrop of Toad in anticlinal core on north bank of Gatho Creek and Grayling exposures on south bank, there is an estimated gap of 500 feet. This is based on structural position of the exposures, assuming a northerly low-plunging anticline occurs as the major structure.		
1	Siltstones and shales, black and weathering dark grey, platy, recessive	543	543
	These beds occur on south bank of Gatho Creek about 1 mile southwest of unit 3.		

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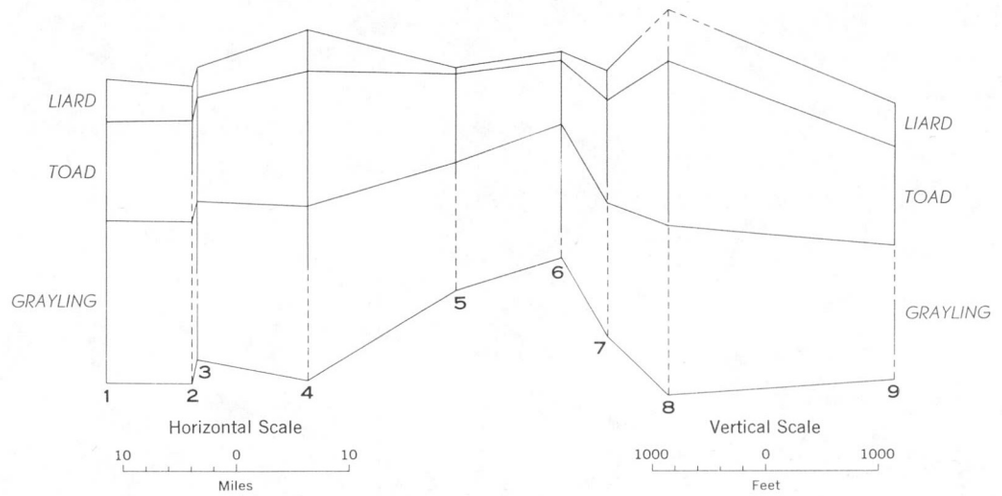

Dashed lines indicate assumed thickness of concealed intervals. Datum for the base is the top of the Permian chert.

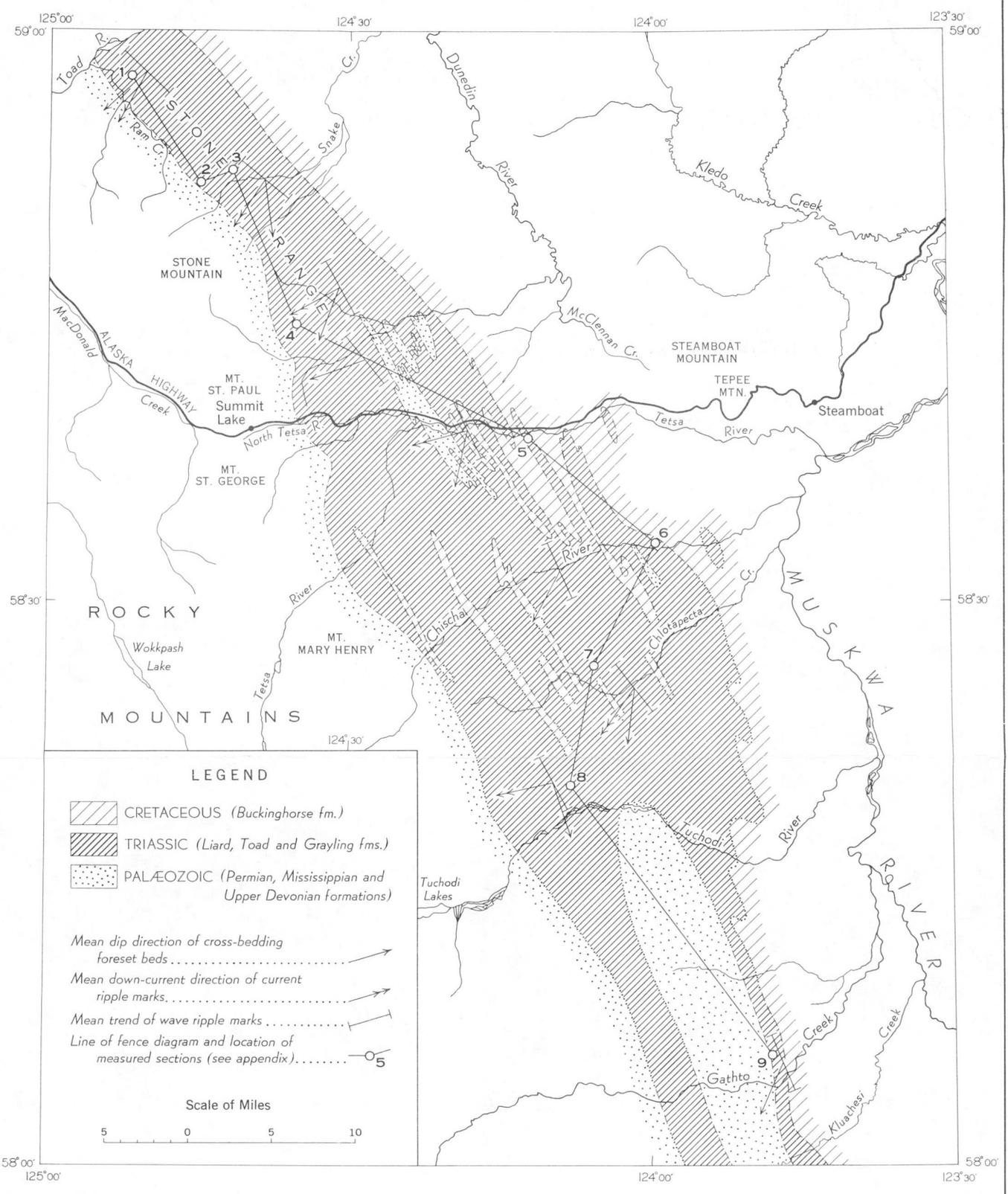

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Figure 1. Map of foothills belt, northeastern British Columbia showing outcrop of Triassic rocks, sedimentary trends and location of sections with fence diagram showing thickness variations of Triassic formations