58-10

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

PAPER 58-10

FERNIE MAP-AREA, WEST HALF, BRITISH COLUMBIA

82G W½

(Report and Map 20-1958)

By

G. B. Leech

OTTAWA
1958

Price, 50 cents

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CONTENTS

FERNIE MAP-AREA, WEST HALF
BRITISH COLUMBIA

INTRODUCTION

This preliminary report describes the north and east-central parts of Fernie map-area W 1/2. No previous geological maps of this area have been published except for the Cranbrook map-sheet (lat. 49° 30' to 49° 45'; long. 115° 30' to 116° 00') (Rice, 1937).[1] The report is based on one month's field work by the writer in 1956 and three months' work by the writer and R.L. Langenheim, Jr. in 1957. No new work was done in Cranbrook map-area.

[1]Names and dates in parentheses are those of references cited below.

Pack-trails exist in most major valleys in the Rockies part of the map-area and there are logging roads near the Rocky Mountain Trench and Elk River. In 1957, the Bull River road was open to the mouth of Galbraith Creek, a branch logging road gave access to the upper part of Tanglefoot Creek, and a logging road from the Elk River entered the headwaters of Sulphur Creek. The pack-horse trails are maintained chiefly for big game hunting. A trail up Galbraith Creek leads to the uplands known as "Top of the World", where it connects with trails from Wild Horse and Lussier Rivers and with a less-used trail on Coyote Creek. A trail cut in 1957 passes from the northeastern headwaters of Galbraith Creek to the mid-part of Quinn Creek, thence north to its head and on down Blackfoot Creek to White River. There is no trail on lower Quinn Creek. The Bull River valley is easy to travel as far as Quinn Creek, and the part above Narboe (Nelson) Creek is accessible from upper Elk River via Brûlé Creek. The Bull River and Galbraith Creek trails cross fords that are impassable in high water.

REFERENCES

Daly, R.A.
1912: Geology of the North American Cordillera at the Forty-ninth Parallel; Geol. Surv., Canada, Mem. 38.

Evans, C.S.
1933: Brisco-Dogtooth Map-Area, British Columbia; Geol. Surv., Canada, Sum. Rept. 1932, Pt. AII, pp. 106-176.

Henderson, G.G.L.
1954: Geology of the Stanford Range of the Rocky Mountains, Kootenay District, British Columbia; B.C. Dept. Mines, Bull. 35.

Leech, G.B.
1954: Canal Flats, British Columbia; Geol. Surv., Canada, Paper 54-7.

Rice, H.M.A.
1937: Cranbrook Map-Area, British Columbia; Geol. Surv., Canada, Mem. 207.

Schofield, S.J.
1915: Geology of Cranbrook Map-Area; Geol. Surv., Canada, Mem. 76.

Shepard, F.P.
1926: Further Investigations of the Rocky Mountain Trench; J. Geol., vol. 34, pp. 623-641.

Walker, J.F.
1926: Geology and Mineral Deposits of Windermere Map-Area, British Columbia; Geol. Surv., Canada, Mem. 148.

GENERAL GEOLOGY

TABLE OF FORMATIONS

Era	Period or epoch	Formation	Lithology
Cenozoic	Pleistocene and Recent		Till, gravel, sand, silt, alluvium
		Unconformity	
Mesozoic and(?) Cenozoic	Lower Cretaceous and(?) later		Monzonite, quartz monzonite granodiorite. Granodiorite (White Creek batholith)
		Intrusive contact	
Mesozoic	Triassic	Spray River formation	Dark siltstone and silty shale
		Not in contact	
Palaeozoic or Mesozoic	Devonian(?) or Cretaceous(?)		Shale, limestone; conglomerate, tuff, breccia; greenstone
		Not in contact	
Palaeozoic	Pennsylvanian and (?) Permian	Rocky Mountain formation	Dolomitic or limy sandstone, quartzite; sandy dolomite and limestone; siltstone, chert
	Mississippian	Rundle group	Grey crystalline limestone, crinoidal in part, dark fine-grained limestone, cherty in part, all commonly fetid
		Banff formation	Dark cherty limestone and laminated silty limestone, grey limestone, limy siltstone
		Exshaw formation	Black shale; black limestone
	Upper Devonian	Palliser formation	Lower (main) member: massive mottled grey limestone; nodular grey limestone. Upper member: thin bedded argillaceous limestone, mostly nodular
		Alexo formation	Sandstone and sandy limestone; argillaceous limestone

Palaeozoic (cont'd)	Upper Devonian (cont'd)	Fairholme group	Lower part: fine-grained black and grey limestone, stromatolitic and coralline in part; dolomite. Upper part: shale and limestone
	Middle Devonian	Harrogate formation	Fine-grained, black limestone, shaly limestone; shale
	Middle Devonian or earlier	Burnais formation	Gypsum, dolomite, limestone
	Middle Devonian or earlier and(?) Upper Devonian	"Basal Devonian unit"	Dolomite, sandy dolomite, dolomitic sandstone, shale; quartzite, conglomerate
	Unconformity		
	Upper Ordovician Lower and (?) Middle Silurian	Beaverfoot-Brisco formation	Dolomite, limestone; conglomerate and sandstone locally at base, thin graptolitic shale near top
	Disconformity?		
	Middle or Upper Ordovician	Wonah formation	Quartzite, sandstone
	Unconformity?		
	Lower and(?) Middle Ordovician	Glenogle formation	Shale, siltstone, limestone
	Upper Cambrian and Lower Ordovician	McKay group	Limestone, shale; intraformational limestone-conglomerate
	Middle and/or Upper Cambrian	Jubilee and Elko formations	Dolomite
	Disconformity?		

	Middle Cambrian	Burton formation		Shale, limestone; sandstone, conglomerate
	Lower and(?) Middle Cambrian	Eager formation		Shale, limestone, siltstone, sandstone
	Lower Cambrian	Cranbrook formation		Quartzite, grit, conglomerate; sandstone
Unconformity				
Windermere		Toby formation		Conglomerate, argillite; sandstone
Unconformable on Purcell strata				
Purcell or(?) later	Upper Purcell or(?) later	Moyie intrusions		Meta-diorite, meta-quartz diorite
Intrusive contact				
Purcell	Upper Purcell	Mount Nelson formation		Dolomite, argillite, quartzite
		Dutch Creek formation	Roosville formation	Grey and green siltstone and argillite, grey quartzite, dolomite, and limestone; algaloid structures
			Phillips formation	Purple and red sandstone, siltstone and argillite
			Gateway formation	Grey and green siltstone and argillite, commonly dolomitic, dolomite, and quartzite; purple and red siltstone and argillite; salt casts algaloid structures
		Kitchener-Siyeh formation		Kitchener (main) part: grey and green argillite and dolomitic argillite, grey dolomite and sandy dolomite; quartzite. Siyeh part: laminated green and grey argillite locally purple. Purcell extrusions (at top): andesitic lava and tuff

	Lower Purcell	Creston formation	Grey and green argillite and argillaceous quartzite, grey, white and purple quartzite
		Aldridge formation	Rusty-weathering dark laminated argillite, grey and rusty-weathering grey argillaceous quartzite and quartzite
		Fort Steele formation	White quartzite, grey argillaceous quartzite, dark argillite, grey and black dolomitic and calcareous argillite, dolomite

LOWER PURCELL

Fort Steele and Aldridge Formations

The Fort Steele formation occurs only along the east side of the Rocky Mountain Trench between Lussier and Wild Horse Rivers. The characteristic rock is quartzite, much of which is white, siliceous, and conspicuously cross-bedded. The purer quartzites give way upward to quartzites inter-bedded with argillaceous quartzite and dark argillite and, near the top of the formation, calcareous and dolomitic argillites and minor dolomite that weather brown and grey. The exposed section is 6,000 feet thick (Rice, 1937).

The Fort Steele is succeeded by the Rocky Mountain facies of the Aldridge formation. The contact is gradational and has been drawn at the lowest beds in which rusty argillites predominate. The Aldridge formation as developed in the Rocky Mountains consists dominantly of rusty, dark-weathering, dark, laminated argillites, and secondarily of grey to rusty-weathering, light-coloured argillaceous quartzites and quartzites. The latter occur throughout the section but are most abundant in the middle part. The rusty, dark argillites of the upper part grade upward through rusty, grey weathering, grey and green argillites of a transitional zone into similar but non-rusty argillites of the Creston formation. Limy and dolomitic beds occur in the transition zone.

The thickness of the Aldridge in the Rockies is uncertain, because of structural complexities in the area where both contacts occur, but it is almost certainly less than 10,000 feet and may be about 8,000 feet. It is unlike the Aldridge in the Purcell Mountains, where quartzite and siltstone predominate except near the top. There is a distinct possibility that the Aldridge in the Purcells is equivalent to much or all of the combined Fort Steele and Aldridge in the Rockies.

Creston Formation

The Creston formation in the Rocky Mountains, like that in the Purcell Mountains, consists of grey and green argillites and argillaceous quartzites and grey, white, and here and there, purplish quartzites. It is typically non-rusty, with weathered surfaces showing grey, green, in places purplish tints and brownish shades. Purple-mottled quartzite is diagnostic of the formation. In the Rocky Mountains, a zone up to 500 feet thick in which white siliceous quartzite is conspicuous occurs near the top of the formation. The thickness is probably not more than 5,000 feet in the Rockies, whereas it is 6,000 feet in the Purcells. The main lithological difference between the Creston in the Rockies and that in the eastern Purcells is in the nature of its contact with the Aldridge. In the Rockies the two grade into each other over a thickness of several hundred feet whereas in the eastern Purcells the transition is much more abrupt. Mud-cracked

argillites do occur in the base of the Creston in the Rockies, but there is no distinct basal member composed of grey weathering siltstones and mud-cracked argillites as there is in the eastern Purcells. Furthermore, in the Rockies some of the lower Creston is rusty and consequently more difficult to distinguish from the Aldridge.

UPPER PURCELL

The Upper Purcell strata are conformable upon those of the Lower Purcell without known break in sedimentation. The Lower Purcell, however, consists of quartzites and argillites with almost no carbonate, whereas in the Upper Purcell carbonate, chiefly dolomitic, is plentiful.

Kitchener-Siyeh Formation

The Kitchener-Siyeh formation in the Rocky Mountains is similar to that in the Purcell Mountains. The lower or Kitchener part, which is the main one, consists of grey and green argillite and dolomitic argillite that weathers grey to brown, grey dolomite and sandy dolomite that weathers buff to red-brown, and grey quartzite. The upper or Siyeh part consists chiefly of distinctively laminated green and grey argillites with local purple facies, and at the top, the Purcell andesitic lava, partly with pillow structure, and tuff.

The thickness apparently increases from about 4,700 feet near the north end of the map-area to some 7,000 feet near Bull River. The lower contact with the Creston is gradational in the Rockies but in most places more distinct than it is in the Purcells. The upper contact is, by definition, the top of the highest lava.

The Purcell lavas provide an undisputed marker within this region but all other Precambrian formational boundaries are based solely on changes in lithology, which may transgress stratification. For this reason inferences based on apparent variations in thicknesses of individual formations must be accepted with great caution. Inferences based on total thicknesses of several formations are safer but are limited by the lack of any other surely correlatable zones below the lavas.

Gateway, Phillips, Roosville, and Dutch Creek Formations

The names Gateway, Phillips, and Roosville were used for rocks near the 49th Parallel by Daly (1912) and Schofield (1915). Walker (1926) found that this assemblage was indivisible farther north, and he applied the name Dutch Creek to the exposures near and north of lat. 50°.

The writer uses the name Dutch Creek for rocks at the north end of the map-area west of the Rocky Mountain Trench. Elsewhere the terms Gateway, Phillips and Roosville, as applied

at Elko by Schofield (1915), are used provisionally. This hinges largely on the correctness of Schofield's assignment of certain of purple rocks to the Phillips formation. That formation was set up by Daly to describe rocks he saw in only two small areas at the 49th Parallel, and Schofield applied the name at Elko solely on the basis of lithological similarity. The identification remains unproven, however, as similar rocks occur at more than one stratigraphic level.

The Gateway formation consists chiefly of siltstone and argillite, commonly dolomitic, and dolomite and quartzite. The characteristic colours are grey and green, but reds and purples are present here and there. Weathered surfaces are mostly grey, green, buff, or brown, with increasing buffness and browness generally denoting an increase in dolomite content. Salt casts are locally abundant and are rather characteristic of the formation. Layered algaloid structures occur, especially in the lower part. Some dolomitic beds are markedly oolitic or pisolitic.

The Phillips formation, as designated at Elko by Schofield, consists of 400 feet of purple and red sandstones, siltstones, and argillites.

The Roosville formation at Elko consists chiefly of laminated green and grey siltstone and argillite, grey quartzite, and grey dolomite and limestone. Weathering colours are grey, green, and buff to brown, the last depending largely on carbonate content. Some of the purer carbonate beds, which occur chiefly in the upper part of the section, contain conspicuous algaloid growths. The Roosville formation is 1,740 feet thick at Elko, where it is overlain unconformably by Cambrian strata.

The Roosville and Gateway formations are so similar that distinction is difficult where stratigraphic relationships to older rocks are unknown. In general the algaloid structures seem relatively more abundant in the lower part of the Gateway and in the upper part of the Roosville, and salt casts are common in the Gateway but scarce or lacking in the Roosville.

Mount Nelson Formation

The Mount Nelson formation conformably succeeds the Dutch Creek formation west of Kootenay River at the north edge of the map-area. The part within the area consists of a basal quartzite, partly siliceous and partly dolomitic, succeeded by grey and green dolomitic argillite and dolomite that weather buff to red-brown. These are in turn overlain by laminated green weathering green argillites. It is not yet known whether this formation occurs east of the Rocky Mountain Trench in the area shown on the map as "Upper Purcell undivided".

WINDERMERE

Toby Formation

The Toby formation occurs on the east wall of the Trench at the north edge of the map-area, resting unconformably on the Upper Purcell. It wedges out sharply in a southeastward direction, partly perhaps as a result of primary depositional thinning but chiefly because of the erosional unconformity at the base of the overlying Cranbrook formation. It consists of interbedded conglomerate, argillite, and quartzite. In the conglomeratic rocks, which are dominant, the ratio of pebbles to matrix varies greatly so that they range from pebbly argillite to close-packed cobble conglomerate. The pebbles, etc., consist of argillite, quartzite, and dolomite. Argillite fragments are abundant, though quartzite and dolomite are more conspicuous because they form larger pebbles and boulders. Igneous rocks were not noted there but they occur in the conglomerate west of the Trench in the adjoining Canal Flats map-area. Subangular shapes are not uncommon among argillite pebbles but the others are almost all rounded. The matrix is argillaceous and ill-sorted. The Toby strata immediately beneath the Cranbrook formation are redder than in the rest of the formation and this is believed to be due to weathering before the Cranbrook was deposited.

CAMBRIAN

Cranbrook and Eager Formations

The Lower Cambrian Cranbrook formation consists essentially of siliceous quartzite, grit, and conglomerate whose pebbles are mostly quartz and quartzite. Magnesite and dolomite occur locally near the top.

The succeeding Eager formation consists chiefly of shale and limestone, accompanied by siltstone and sandstone near the base. Shale is dominant in the thicker sections. The Eager formation has yielded numerous fossils of later Lower Cambrian age but the upper limit of its age is uncertain. The entire Eager section east of the Rocky Mountain Trench near lat. 50° is late Lower Cambrian but the upper contact there with the Jubilee formation may be erosional. The relationship of the Eager formation to the Middle Cambrian strata between Tanglefoot Creek and Bull River is not yet known.

Burton Formation

The Burton formation rests unconformably on the Roosville formation near Elko. At the best-exposed section, above the old Burton mine 2 3/4 miles north of Elko, the thickness is about 190 feet. Details of this section are given below.

	Thickness in feet
Base of outcrops of Elko formation. Covered interval; soil indicates bedrock is shale	100
Shale and limestone	15
Shale, grey-green with minor intercalations of limestone; lower 15 feet contain Kochaspis sp., Fieldaspis sp., Glossopleura (?) sp., Onchocephalus sp., Micromitra sp.	41
Silty limestone and calcareous siltstone; base contains Plagiura (?) sp., Ptarmigania (?) sp., cf. Micromitra sp.	15
Shale, grey-green	11
Sandstone and silty shale; trilobite fragments and non-diagnostic brachiopods.	6
Sandstone and conglomerate, hematitic	2
Unconformable contact with Roosville formation	
	190

A.W. Norris examined the fossils and reported that all diagnostic ones are of Middle Cambrian age.

Elko Formation

The Elko formation (Schofield, 1915) was erected to describe dolomites that overlie the Burton formation on the slopes north of Elko. The formation is about 200 feet thick above the Burton mine. The dolomite is mostly fine grained, grey to black on fresh surfaces and grey, grey-buff, and brownish grey where weathered. The beds are mostly 1 foot to 5 feet thick but are difficult to distinguish in places. This rock greatly resembles the Jubilee dolomite and is probably correlative with it, in which case its age is Middle and/or Upper Cambrian. It has yielded no fossils. The Elko formation is overlain unconformably by Devonian strata.

Jubilee Formation

The Jubilee formation is a cliff-forming dolomite unit that forms the crest of the Hughes Range in the north part of the map-area. The thickness of the formation is of the order of 3,000 to 3,500 feet, somewhat less than that farther north in the Hughes Range.

In the lower part of the formation the bedding is distinct and the beds themselves commonly are laminated. Bed thicknesses are generally 1 foot to 3 feet and laminations are measurable in fractions of an inch. The laminations are here and there disrupted by small-scale sedimentary breccia. The dolomite texture ranges from fine grained and dense to megascopically crystalline. Fresh surfaces are white to dark grey and weathered surfaces are cream coloured to dark grey, but a combination of various types in mottle pattern occur in much of the rock. Chert, ranging from white to black, forms lenses and laminae, generally parallel to bedding, and also forms irregular lacy networks.

In the upper part of the formation beds are thicker and less distinct than in the lower part. The dolomite there is on the whole more coarsely crystalline and lighter in colour, though there are erratic changes in both features. Another feature more characteristic of the upper part than of the lower is the presence of small vugs, the long axes of most of which are about parallel to bedding planes.

In the north the contact with the underlying Eager formation is abrupt. On Wild Horse River, however, the basal Jubilee dolomite is interbedded with the top of a succession of sandstones that rests on the Precambrian. A couple of miles to the south of this locality the basal dolomite is interbedded with the top of a limestone sequence which is in turn underlain by sandstone and conglomerate that rest on the Precambrian. The Jubilee dolomite suddenly disappears there, just south of lat. 49° 45'. Important but poorly understood faults are known to lie in this region but the possibility exists that a sudden facies change is partly responsible for the disappearance of this thick competent formation.

The age of the Jubilee is Middle and/or Upper Cambrian. It is overlain by medial Upper Cambrian beds of the McKay group.

Rocks between Bull River and Tanglefoot Creek

Rocks in this region are thin-bedded grey shales and grey limestones that are in part Middle Cambrian in age but may also include strata of the McKay group, which they resemble. The chief points of difference between the beds known to be Middle Cambrian and the McKay beds are that the shale and limestone mostly occur as distinct separate beds instead of forming nodular shaly limestones as in the McKay, that intra-formational limestone-conglomerates are less common than in the McKay, and that fewer of the limestone beds are distinctly crystalline.

CAMBRIAN AND ORDOVICIAN

McKay Group

Rocks of the McKay group form a major part of the Rocky Mountains west of Bull River. In the Hughes Range there is a complete stratigraphic section but farther east, where the group is thicker, the base is hidden.

The group consists of thin-bedded shales and limestones. In the Hughes Range at the north end of the map-area it is some 2,800 feet thick and comprises two main lithological divisions, the upper of which contains three distinct units. Shale predominates in the lower division, which is about 1,200 feet thick and which contains also nodular shaly limestones, beds of purer limestone, commonly crystalline, and beds of intraformational limestone-conglomerate and breccia. This recessive division is succeeded by a 400 foot cliff-forming unit consisting of thin-bedded limestone with minor shale, which in turn is succeeded by a recessive unit of shale and shaly limestone about 150 feet thick. The uppermost unit is about 1,100 feet thick and is another cliff-maker, consisting chiefly of limestone of various types with interbeds of shale. The contact with the overlying Beaverfoot-Brisco formation appears to be conformable but its unconformity is proven by regional studies. The age of the group is Upper Cambrian and Lower Ordovician, as shown by fossil collections from the adjoining Canal Flats area (Leech, 1954), where the time boundary falls in the lower cliff-forming units.

To the east and south, in the area drained by Bull River, the McKay group is at least 4,000 feet thick, with the base unexposed. There, as in the Hughes Range, there are two main divisions, with shale predominant in the recessive lower one and limestone in the cliffy upper one, which could be further subdivided. In the most complete section, on Van Creek, at least 1,500 feet of the lower division is exposed and the upper division is about 2,500 feet thick. There the boundary between Upper Cambrian and Lower Ordovician occurs in the upper part of the lower division, where, though still recessive, it contains a considerable proportion of limestone. The McKay is overlain with apparent conformity by the Glenogle formation in the region north of lat. 49° 50' and east of long. 115° 25'. Elsewhere the Beaverfoot-Brisco lies directly upon it.

ORDOVICIAN

Glenogle Formation

The Glenogle formation consists of black graptolitic shale, siltstone, and limestone. It occurs north of lat. 49° 50' and east of long. 115° 25'. The western outcrops are distinctive because of the abundance of black shale and laminated black siltstone, and they may be confused only with

one shale sequence in the Brisco part of the Beaverfoot-Brisco formation. The northeastern part of the mapped occurrences, west of Bull River at the north edge of the map-area, however, contains a succession of limestone beds that resemble part of the McKay group. The formation is more than 500 feet thick near lat. 50°. It contains abundant fossils, mostly graptolites, some of which retain their three-dimensional form. The age of the Glenogle in this area is Lower and, perhaps, Middle Ordovician. The Glenogle is overlain by the Wonah formation, except at its southern limit.

Wonah Formation

The Wonah formation consists of quartzite and, especially in the upper part, calcareous sandstone. It is about 200 feet thick near lat. 50° and its distribution is almost the same as that of the Glenogle formation. Although the contact between the two appears to be concordant, the likelihood of an unconformity is suggested by the fact that it apparently rests on different ages of Glenogle strata in different parts of the western Rockies. The age of the formation is Middle or Upper Ordovician.

ORDOVICIAN AND SILURIAN

Beaverfoot-Brisco Formation

The competent Beaverfoot-Brisco sequence is an important constituent of the Rockies west of Bull River and north of Tanglefoot Creek. It comprises an apparently continuous succession of limestones and dolomites whose lower part is Upper Ordovician and whose upper part is Silurian. These parts are so similar that most of the Silurian (Brisco) section cannot be distinguished from the Ordovician (Beaverfoot) section by lithology alone. Further difficulty arises from the scarcity of fossils in the part of the sequence in which the systemic boundary occurs. As a result the sequence is regarded as a single formation. It is 1,800 feet thick in the Top of the World area on the divide between Lussier River and Galbraith Creek.

Dolomite is more abundant than limestone in the sequence as a whole but the proportion varies from place to place. This is especially noticeable in the lower 400 feet, which in general consist chiefly of limestone but where vagaries of dolomitization cause rapid changes in appearance along strike. The limestones are mostly dark types that weather to shades of grey, commonly with mottled patterns, and form beds 1 foot to 10 feet thick. The dolomites range in colour from light to dark, weathered surfaces being chiefly shades of grey but also white, buff, and brown, and variously combined in mottles. Bed thicknesses are mostly between 1 foot and 10 feet, with those in the 2- to 5-foot range the most common. Blebs and lenses of chert occur throughout and are abundant in some parts. The section in the Top of the World area is summarized as follows:

Top	Thickness in feet
Dolomite, interbeds of limestone, partly shaly	90
Dolomite	460
Limestone	150
Dolomite	630
Limestone, minor dolomite	450
Sandstone and conglomerate	10
Base	1,790

To the north, along and east of Coyote Creek, the top of the section contains 10 to 15 feet of graptolitic black shale and limestone. Devonian strata overlie the Beaverfoot-Brisco formation unconformably.

Fossils are numerous in most of the lower 250 feet of the sequence, except where it is intensely dolomitized, and this fauna is of Richmond age. In the central part fossils are sparse and poorly preserved, especially in the dolomites. They are more conspicuous in the upper quarter, where they are of Silurian age. Straight cephalopods form a distinctive part of this upper fauna. The graptolitic shale in the top of the sequence can be distinguished from similar shale of the Glenogle formation by the fact that a considerable proportion of its graptolites are preserved in circular coils whereas those in the Glenogle are "straight limbed". This graptolite fauna is of latest Lower or earliest Middle Silurian age.

The Beaverfoot rests on the Wonah formation in the northeast and on the McKay group in the south and west. The contact with the Wonah may be an unconformity, although it seems concordant in individual outcrops and it even appears to be transitional in many places, where the top of the Wonah is calcareous and the base of the Beaverfoot is sandy. In the eastern part of the Top of the World area the typical Wonah is lacking and conglomerate and sandstone that may belong to the Beaverfoot rest directly on the Glenogle, which itself disappears within a short distance, leaving the Beaverfoot resting on the McKay. The Beaverfoot is definitely unconformable upon the McKay, although many exposures of their contact give no hint of this relation. The best local evidence of unconformity is provided by basal conglomerate. The distribution of this conglomerate is erratic and changes of thickness are sudden, indicating the presence of distinct local relief when it was deposited. The conglomerates and associated sandstones are characteristically unsorted, with a muddy matrix. Fresh surfaces are mostly green or grey, and weathered surfaces are mostly brown or green. The included fragments are chiefly limestone, limestone-conglomerate, and

shale, mostly of McKay type, and chert. They range in size up to about 8 inches but in many outcrops they are not larger than 3 inches. Interbeds of sandstone occur in the limestones and dolomites that overlie the basal conglomerates.

DEVONIAN

All identifications of Devonian fossils are by D.J. McLaren and the stratigraphic conclusions resulting are from his interpretations. Certain species in the faunal lists are designated by letters of the alphabet, e.g. Atrypa sp. H. These letters are consistent with the classification employed in the Geological Survey's index collection of Devonian fossils.

Basal Devonian Unit

A major east-trending structure on which the south side stood high and the north side low is believed to have formed in the site of the western Rockies near lat. 49° 35' in post Lower Silurian-pre-late Middle Devonian time. To the north the Devonian lies unconformably on the Silurian, whereas to the south it rests on Cambrian and Precambrian rocks (see page 36 discussion of the Dibble Creek fault). The basal Devonian beds are similar in both regions and are characterized by dolomites, sandy dolomites, and dolomitic shales that weather buff, yellow, brown, or less commonly red or purple. Sandstones occur at or near the base of most sections, but these vary from region to region so that part of the area contains white siliceous quartzites and other parts contain brightly coloured heterogeneous sandstones. Conglomerates occur locally.

In the Lussier and Quinn Creek synclines the basal beds are white quartzite and calcareous sandstone whose thickness ranges up to 100 feet and which is non-conglomeratic. This is succeeded by 90 to 150 feet of grey or buff weathering, fine-grained, white, grey or buff dolomite, silty or sandy in part, that weathers buff to yellow and forms beds that are commonly a foot to 3 feet thick but many of which break down in platy fashion. Red argillaceous and silty beds in the dolomite are distinctive in some localities but form a small proportion of the sequence as a whole. The basal white quartzite thins southward and is lacking on the east side of the mid-part of Quinn Creek, where the lowest Devonian beds are pink dolomites and sandy dolomites that weather buff to red.

Along Bull River near the mouths of Sulphur and Quinn Creeks another type of basal sandstone occurs which grades locally to conglomerate and to siltstone. The sandstone is for the most part a medium-grained feldspathic type that is green, grey, or red on a fresh surface and mostly weathers brown or red. On the north bank of the river 1/2 mile below Sulphur Creek this sandstone, which rests on the Beaverfoot-Brisco, contains a lens or bed of pebble conglomerate 2 feet thick and at least 20 feet in strike length in which a large

proportion of the pebbles are granitic rocks, gneisses, vein quartz, and feldspar. This suggests derivation from a "basement" terrane. The pebbles are all, or nearly all, less than 2 inches across and are well rounded, suggesting a distant source. On the other hand, their abundance there, coupled with their absence to the west and northwest and with the fact that they occur in a region where the sub-Devonian unconformity changes from Devonian/Silurian in the north to Devonian/Precambrian in the south, points to the possible occurrence of a local "basement high" to the east or south.

The basal Devonian beds rest on the Precambrian Kitchener-Siyeh formation along the south side of Dibble Creek fault, which passes eastward from the Rocky Mountain Trench at lat. 49° 35'. There the unconformity cuts gently down the Precambrian section as it is traced west. In detail the surface is irregular and the lithology of the lowermost Devonian beds varies greatly from place to place. For example, there may be 10 feet of conglomerate containing angular to subrounded fragments of the underlying Kitchener up to 6 inches long in a dolomite matrix, yet only a quarter of a mile away there may merely be sandy dolomite. A section of the basal Devonian unit exposed near the head of Dibble Creek is summarized as follows:

	Thickness in feet
Argillaceous limestone, shale, limestone - Middle Devonian age Contact distinct, apparently conformable	
Dolomite, sandy	10
Sandstone	4
Dolomitic sandstone and sandy dolomite	42
Sandstone and grit	40
Dolomitic sandstone and sandy dolomite	40
Sandstone	10
Pebbly, sandy dolomite	3
Unconformable contact	149
Kitchener part of Kitchener-Siyeh formation	

The basal Devonian beds on the slopes northeast of Elko resemble those to the north but may not be of the same age. They are overlain by the Fairholme group in which the lowest collection of useful fossils, made 300 feet above the basal Devonian unit, is tentatively assigned to the Upper Devonian. The section exposed 3 1/4 miles northeast of Elko is summarized below:

	Thickness in feet
Fairholme group Contact distinct, apparently conformable	
Mudstone, dolomitic	26
Dolomite, sandy	23
Dolomite, interbeds of shale	6
Dolomite, silty	16
Sparse outcrops of dolomite, possible structural complexity	63
Sandstone, dolomitic, pebbly in part, with a few interbeds of shale and dolomitic siltstone	85
Unconformable contact	219
Elko formation	

The dolomitic sandstones are mostly medium to coarse grained, weather to shades of buff, orange, reddish, and where low in carbonate, grey, and form beds mostly 1 foot to 3 feet thick. The purer dolomites are fine grained and have a dense appearance. They are grey on fresh surfaces and buff to yellow where weathered, and the beds are mostly a foot or less thick.

Burnais and Harrogate Formations

The name "Harrogate limestone" was introduced by Shepard (1926) but without a description. Evans (1933) used the term "Harrogate formation" for the rocks Shepard had noted, and published the first description and stratigraphic section of the type exposures in Brisco Range near Harrogate. The section as described is 698 feet thick but how much of this is actually Devonian is unknown, as the base was chosen arbitrarily at a position midway between the highest Silurian and lowest Devonian fossil collections. As a result most of the lower half of the formation, as described, is unrepresented by fossil collections, which are restricted to one 84-foot member midway in the section. The age of this member is late Middle Devonian. The top of the formation is not exposed.

The Burnais formation was erected by Henderson (1954) to describe an unfossiliferous succession of gypsum and limestone in the Stanford Range. The sequence occurs above Silurian strata and beneath beds corresponding to the fossiliferous member of Evans' Harrogate section, but it is lithologically unlike the lower part of that section. Neither its top nor its base is exposed in the Stanford Range. The Burnais

formation may thus be the age equivalent of the lower part of the Harrogate formation of Harrogate area.

The Fernie area W 1/2 contains in the Lussier syncline at the heads of Lussier River and Coyote Creek a sequence that includes the basal Devonian unit, rocks of Burnais type and rocks of Harrogate age, and which continues into Upper Devonian strata. The terms Burnais formation and Harrogate formation are used with certain reservations in referring to this sequence. The relation of the type Burnais formation to the basal Devonian unit of this map-area is unknown. The term Harrogate is used in its restricted sense but it is uncertain whether all the rocks of Burnais type are older than all the fossiliferous rocks assigned to the Harrogate. Furthermore, the upper limit of the Harrogate formation has never been defined.

The combined thicknesses of the Burnais formation and the basal Devonian unit in the Lussier syncline is about 1,000 feet. The Burnais provides few outcrops and both contacts are hidden, but the formation is probably 600 to 700 feet thick. It consists of gypsum, dolomite, and limestone. Gypsum outcrops are rare and its presence is mostly inferred from the occurrence of sinkholes. The gypsum seen by the writer on the east side of the Lussier valley 7 miles south lat. 50° is the laminated white and grey type that characterizes the Burnais formation elsewhere. There are apparently two, and possibly more, gypsum-bearing zones.

The Burnais limestones and dolomites are mostly fine grained, grey to black, and weather grey or tan. In some sections they are silty and in some there are shaly interbeds. The beds are mostly 4 inches to 3 feet thick and, although certain ones show laminations on weathered surfaces by colour changes or silty layers, this feature is not nearly as distinct or as common as it is in the Burnais rocks farther north. Breccias with angular fragments of limestone or dolomite in a carbonate matrix are not uncommon. Along Lussier River outcrops occur that weather yellow and in which even freshly broken surfaces are yellowish and have an altered appearance. A distinctive dense black fetid limestone that breaks to angular fragments and a breccia of the same rock occurs in and near some of the sinkholes. This overlies the highest gypsum but may possibly also occur beneath some of the gypsum. In many places it contains indeterminate gastropods. Similar rock occurs in the lower part of the succession assigned to the Harrogate. Small outcrops containing fossils of probable Harrogate age occur near, and structurally beneath, zones of abundant sinkholes and, in one instance, structurally beneath a gypsum outcrop. As a result, and in the absence of a completely exposed section, the position of the Burnais-Harrogate boundary is in doubt.

The parts of the Harrogate formation that outcrop consist of limestone and shaly limestone, with subordinate shale. The limestone is characteristically fine grained, black, commonly fetid, and weathers dark grey or black. Bed thicknesses are mostly 2 inches to a foot. Nodular shaly limestone is probably an important part of the formation but yields few outcrops.

Those observed contain nodules 1 inch to 3 inches long of black limestone in a shaly matrix and are richly fossiliferous. Some outcrops contain interbeds of silty limestone and beds or partings of black shale. Dense-looking black limestones in the lower part contain an abundant but poorly preserved gastropod fauna.

Collections from the black limestone of the lower part of the formation, not far above gypsum of Burnais type, contain: Schizophoria sp. E, Emanuella meristoides (Meek), Emanuella sp. B, Emanuella sp., small gastropods indet.

Collections from outcrops in the Lussier syncline adjacent to gypsum or sinkholes but, as noted above, whose stratigraphic positions cannot be determined contain: Eostrophalosia sp. H, (Productella cf. belanskii Stainbrook of Warren and Stelck), Atrypa cf. A. independensis Webster, Atrypa sp., Emanuella meristoides (Meek), Emanuella sp. A, pelecypods indet., turbinate gastropods. McLaren believes that these beds probably correspond to the Harrogate formation but points out that the small numbers of species in the faunules make regional correlation uncertain.

A collection from beds that structurally are immediately beneath a gypsum outcrop contains: Atrypa sp., Allanaria? sp. indet., Emanuella meristoides (Meek) and small gastropods indet.

The upper part of the sequence provisionally referred to the Harrogate is described in the following section.

From the Middle Devonian rocks provisionally assigned to the Harrogate formation in the Quinn Creek syncline four collections, representing a total of 140 feet of strata in the centre of the syncline 3 miles south of lat. 50°, yielded: Devonoproductus sp. A, Productella sp. indet., Chonetes sp., Atrypa cf. A. independensis Webster, Atrypa sp., Emanuella meristoides (Meek), Emanuella sp. B, Nucleospira cf. N. concinna (Hall), orthocone nautiloid indet., small gastropods indet. McLaren comments: "These four collections are of comparable age and the strata are correlated with those of the Harrogate formation, on the basis of Emanuella meristoides and the Atrypa species. The presence of Devonoproductus is of especial interest. The Waterways formation is the earliest in which this genus has hitherto been recorded, and the fauna represented by these collections is probably older."

Harrogate strata on the bank of Bull River near Quinn Creek yielded: Alveolites sp., Coenites sp. A, "Acantho-phyllum" sp. A, Atelophyllum sp. A, Productella sp. indet., Atrypa sp. H, Spinatrypa cf. S. borealis (Warren), Emanuella meristoides (Meek), Conocardium sp., Dechenella sp. tails.

The southernmost rocks believed to be of Harrogate age that have been recognized to date lie along the south side of the Dibble Creek fault, which runs east from the Rocky Mountain Trench at lat. 49° 35'. The exposed Devonian

section there is 307 feet thick, the lowermost 149 feet of which is assigned to the basal Devonian unit. The latter is succeeded in turn by shale, dolomite, and dolomitic mudstone and muddy limestone, and finally by purer limestone, all dark coloured, in beds 6 inches to 3 feet thick. A small thickness of gypsum may occur locally immediately above the basal Devonian unit and its presence above the limestone at the top of the section is suggested by a zone that lacks outcrops but contains sinkholes. Impure limestones and dolomites between 41 and 108 feet above the basal Devonian unit, i.e., between 190 and 257 feet above the sub-Devonian unconformity, yielded, chiefly between footages 220 and 257, the following fossils: Alveolites ex gr. A. subor-bicularis Lamarck, Chonostegites? sp., Coenites sp., Favosites sp. C, Syringopora sp., solitary coral indet. cf. digonophyllid, solitary corals indet. McLaren comments: "The species of Favosites is widespread in the Harrogate and Rampart (Nahanni) formations, and in the Dease series of northeastern British Columbia. The Alveolites is similar to a form from the Harrogate. The age of the fauna is therefore presumed to be early(?) late Middle Devonian (Givetian stage of the European standard)."

Middle and Upper Devonian Rocks in the Lussier Syncline

The lower part of the Devonian sequence consisting of poorly exposed rocks of the basal Devonian unit and Burnais and Harrogate formations, was described previously. The upper part of the sequence is represented by a relatively well-exposed section extending from within the Harrogate beds into Upper Devonian strata. This section, at the south end of the syncline, is summarized below, with all thickness approximate.

Top of ridge	Thickness in feet
Shale, silty, and siltstone, shaly, dark grey to black, weathering brown, calcareous in part; contains occasional 1" beds of fine sandstone and a few 1" beds of dark silty limestone	200
Limestone, fine-grained, black, weathering dark grey to black; beds 1" to 4" thick which, where less weathered, make up units to 6' thick; lower part yields chunky rubble, upper part more nodular, with shaly partings; beds near the top yielded Schizophoria sp. E, productellid indet. Atrypa sp. I, Atrypa spp., Eleutherokomma cf. E. killeri Crickmay (G.S.C. Cat. No. 32300); the topmost beds yielded Schizophoria sp., Calvinaria cf. C. ambigua (Calvin), Atrypa sp. I, Atrypa sp. (G.S.C. Cat. No. 32301)	200

Shale, and shaly limestone, dark grey, weathering buff; fossils pyritized; terebratuloid brachiopod?, gastropod indet.	50
Limestone, fine-grained, grey to black, weathering grey; beds 1" to 4" thick separated by 1" beds of yellow-weathering shale, platy; productellid indet., Eleutherokomma? sp.	40
Limestone, fine-grained, black, weathering black; beds 4" to 6" thick, chunky; contains near base: Schizophoria sp. E, Eostrophalosia sp. H, (Productella cf. belanskii Stainbrook of Warren and Stelck), Atrypa cf. A. independensis Webster, Eleutherokomma cf. E. killeri Crickmay, Tentaculites sp. (G.S.C. Cat. No. 32296)	40
Limestone, fine-grained, black, weathering dark grey; beds 6" to 1' thick; Hypothyridina ex gr. H. procuboides (Kayser), Atrypa cf. A. clarkei Warren, Atrypa sp., Allanaria cf. A. allani (Warren), Athyris sp., Cyrtina billingsi Meek, Leptodesma sp. A, small gastropods indet. (G.S.C. Cat. No. 32295)	20
Dolomite, grey, weathering yellow to buff	30
Limestones, grey to black, weathering grey; beds generally 1" to 4"; shaly in part, a few beds of dolomite	200
Limestone, fine-grained, black, weathering dark grey to black; beds 2" to 2'; interbeds of fine-grained, black, platy limestone and shaly limestone; Schizophoria sp. E, Emanuella meristoides (Meek), small gastropods indet. (G.S.C. Cat. No. 32297)	20
Harrogate (remainder) Burnais formation and basal Devonian unit, poorly exposed	1,000
	1,800

The limestone at the base of the described section is assigned to the Harrogate formation on the basis of lithology and stratigraphic position. Gypsum apparently occurs not far beneath it. The top of the Middle Devonian strata may be some 250 feet above this limestone, as noted below.

Opinions differ as to the criteria for recognizing the boundary between the Middle and Upper Devonian in Western

Canada. Referring to fossil collections Nos. 32295 and 32296, McLaren states that these faunules may be correlated with reasonable confidence with those from the Waterways formation of northeastern Alberta, collection 32295 suggesting the lower part of that formation and 32296 the upper. He commented further that: "Either the whole Waterways succession is early Upper Devonian (Finger Lakes stage) or the boundary between the Middle and Upper Devonian must be placed somewhere within it--at present a possibility that is difficult to accept".

Referring to collections 32300 and 32301 from the limestone near the top of the section, McLaren states: "These faunas are of Upper Devonian age. The faunule from No. 32300 corresponds either to the Mildred member of the Waterways (the highest member) or to beds immediately above it. It may correlate with the Starbird formation of the Windermere area. Atrypa sp. I occurs in the Hay River shale and is probably the species referred to A. brandonensis Stainbrook by Crickmay. The presence of Calvinaria suggests a further correlation with the Perdrix formation or the lower part of the Mount Hawk formation of the Fairholme group of the Alberta Rockies."

Fairholme Group and Alexo Formation

The main areas of these rocks within the region mapped to date are in the Lizard Range west of Fernie, north of Elko, and in the Rocky Mountain Trench near Wardner. In addition, the Lussier syncline contains Upper Devonian rocks, equivalent to part of the Fairholme group, as noted in the preceding section.

In the Lizard Range and near Elko the Fairholme group lies with apparent conformity on buff weathering dolomites of the basal Devonian unit which in turn rests on Cambrian and Precambrian beds and which on the map is not differentiated from the Fairholme group. The base of the latter is generally dolomite but most of the lower part consists of limestone, locally dolomitized, in many beds of which stromatoporoids and corals are conspicuous. This part contains cliff-forming members. The upper part of the Fairholme group consists of black shale with interbedded black limestone. The Alexo formation which succeeds it, is for the most part lithologically distinct, consisting as it does of sandstone and sandy grey limestone. The two are, however, combined for field mapping at the present scale. The Alexo formation underlies the Palliser formation with apparent conformity. In the Rocky Mountain Trench there are members in the Fairholme consisting of crystalline stromatolitic dolomite, that do not occur at Elko but which may be equivalent to some of the limestones there.

The combined thickness of the Fairholme and the Alexo, in a section measured 3 1/2 miles northeast of Elko, is 1,335 feet. This section consists of three main divisions, the lowermost one being 576 feet of limestone (dolomite at the base) containing stromatoporoids and corals, the middle one being 225 feet of interbedded shale and limestone, and the uppermost one being 534 feet of sandstone and sandy argillaceous limestone, and, at the top, purer limestone. A summary follows:

	Thickness in feet
Contact with Palliser formation, apparently conformable	
Limestone, fine-grained, light to dark grey, weathering grey to buff; beds 6" to 3' thick; silty laminae	63 1/2
Sandstone, fine-grained, grey, weathering buff; beds 1' to 4' thick	78
Limestone, fine-grained, black, weathering grey; beds 4' thick; small nodules; contains productellid indet., Camarotoechia sp. E, Cyrtospirifer indet., "Bellerophon" sp. (G.S.C. Cat. No. 32276)	14
Sandstone, fine-grained, grey, weathering buff; beds 1' to 4' thick	71
Limestone, sandy, fine-grained, grey, weathering buff with grey nodules	4
Sandstone, fine-grained, grey, weathering buff	14
Limestone, sandy, argillaceous, dark grey to black, weathering grey and buff; beds to 10' thick; laminated; layers with small grey-weathering nodules of purer limestone in buff-weathering argillaceous matrix; contains Camarotoechia n. sp. D, Nudirostra sp. ex gr. N. walcotti (Merriam), Pugnoides? sp., Cyrtospirifer portae Merriam, Cyrtospirifer cf. C. portae Merriam, Cyrtospirifer sp., Athyris sp. B (G.S.C. Cat. Nos. 32266, 32270, 32271, 32277)	108 1/2
Sandstone, limy, fine-grained, grey, weathering buff	5
Limestone, sandy, argillaceous; as above	20 1/2
Sandstone and limestone interbedded	23
Covered	16
Shale, limy, black	4
Sandstone, limy	24
Limestone, sandy, fine-grained, black or dark grey, weathering buff; layers, lenses, and nodules of grey-weathering purer limestone; interbeds of silty, limy, black shale at base	88

Limestone and shale, interbedded silty or sandy, fine-grained, black limestone, and silty, limy, black shale; alternating in thicknesses of 6" to 6 1/2'	39
Shale and mudstone, limy, black, weathering brown to black	55 1/2
Shale and limestone, shale is limy, limestone is silty	38
Covered	25
Limestone, very fine-grained, black, weathering grey; beds 4" to 1'; contains Schizophoria sp. F. cf. S. amanaensis Stainbrook, small spiriferoid cf. Eleutherokomma (G.S.C. Cat. No. 32321)	12 1/2
Limestone and shale, interbedded (poorly exposed)	55
Limestone, fine-grained, black, weathering light grey; beds commonly 5' or more thick; nodular at top of sequence; contains Amphipora, stromatoporoids, tabulate corals	143 1/2
Limestone, fine- to very fine-grained, black or dark grey, weathering light grey; beds mostly 3' to 6' thick; upper 38' contains "Clathrodictyon" sp., Alveolites sp. C, Thamnopora sp. (G.S.C. Cat. No. 32320)	88
Limestone, fine-grained, black, weathering grey and buff; beds mostly less than 1' thick; contains Amphipora, stromatoporoids, corals incl. Spongophyllum sp. D (G.S.C. Cat. No. 32319)	11 1/2
Limestone (poorly exposed), very fine-grained, black, weathering grey with buff mottling; beds irregular, nodular, 2" to 2' thick; contains stromatoporoids, Schizophoria sp., Stropheodonta spp., Productella spp., Atrypa spp., Allanaria sp. (G.S.C. Cat. No. 32265)	66
Limestone, fine- to very fine-grained, black, weathering light grey; beds mostly 2' to 10' thick; contains "algal biscuits", stromatoporoids	97 1/2
Limestone, fine-grained, grey, weathering grey and buff; beds less than 2' thick, laminated; contains Amphipora and Cladopora	80 1/2

Dolomite, minor limestone; dolomite fine-grained, black, weathering grey-brown, limestone black and grey, weathering light grey; beds mostly less than 3' thick, laminated in part; contains Amphipora	89 1/2
Contact with basal Devonian unit apparently conformable	1, 335

The faunas collected from the lower or "limestone" division of this Fairholme-Alexo section are neither abundant nor well preserved. McLaren is tentatively of the opinion that they are all early Upper Devonian in age and represent the interval equivalent to the Flume and Perdrix formations of the Alberta Rockies.

The faunas from the upper or "sandstone and limestone" division of this section correspond to those in the Alexo formation in Alberta. McLaren states that those in collections 32266, 32270, 32271, and 32277 occur in the lowermost part of the Alexo formation at Deception Creek and Medicine Lake, Alberta, in the Trout River formation of the Northwest Territories, and in the highest part of the upper Devil's Gate formation of Nevada, and that the age is early late Upper Devonian (Famennian stage). Referring to collection 32276, the upper one from the "sandstone and limestone" division, he states "The Camarotoechia sp. E is a very distinctive form that occurs in mid-upper Alexo (member B) at Medicine Lake, Alberta. Its age is early late Upper Devonian".

Palliser Formation

The cliff-making Palliser limestone forms the crest of the Lizard Range west of Fernie and a chain of bluffs above Elko; it also occurs in the Rocky Mountain Trench between Plumbob Creek and Bull River.

The Palliser formation is about 800 feet thick. It comprises two divisions, the lower one of cliff-forming limestone about 600 feet thick and the upper one of recessive limestone about 200 feet thick. This is comparable to the two fold division of the Palliser in the Alberta Rockies, where the members are named Morro and Costigan, respectively. The major division of the Palliser formation consists of fine- to medium-grained, dark grey limestone that weathers light grey, generally with a mottled pattern. Bed thickness is hard to define in much of the lower division, because the apparent thickness is largely a function of the degree of weathering, but thicknesses of 2 to 5 feet are probably the most common, though there are massive beds 15 to 20 feet thick. Nodular limestone similar to parts of the Fairholme group forms beds or successions of beds here and there in the section. Brachiopods and crinoid fragments are fairly abundant in some beds. The upper division consists of thin-bedded, fine-grained, dark grey argillaceous limestone that

weathers buff, tan, and grey. The rock is mostly nodular, with nodules of grey-weathering purer limestone in a buff-weathering argillaceous matrix. It breaks down to rough-surfaced slabs 2 inches or so thick and on further weathering yields buff or tan coloured soil with limestone nodules. Fossils are numerous and many of them weather free from their matrix.

Rocks typical of the Palliser formation are lacking in the Lussier syncline.

DEVONIAN OR LATER

Sedimentary and Volcanic Rocks east of Wild Horse River

A distinctive group of sedimentary and volcanic rocks of unknown age occurs at the northeastern headwaters of Wild Horse River, just northeast of lat. 49° 45', long. 115° 30'. The outcrop area is about 5 miles long and up to 3/4 of a mile wide and occupies the core of a tight syncline. The stratigraphic section is of the order of 1,000 to 1,500 feet thick. It consists of conglomerate, sandstone, dolomite, shale, limestone, and lava and pyroclastic rocks. The outcrops and rubble have a tan, brown, orange or red appearance in distant views, in distinct contrast to the greys of the adjacent Beaverfoot-Brisco strata.

Conglomerate which occurs at or near the base weathers orange to brick-red and fresh surfaces show grey fragments in a dark matrix. Bedding is generally lacking, though lenses of sand-sized material occur here and there, and the rock is a jumble of fragments ranging from silt to 3-foot boulders. The matrix is limy. The fragments consist of dolomite, limestone, quartzite, and chert, with dolomite and limestone being the most numerous and largest. Fragments with angular corners are abundant. On weathered surfaces many of the carbonate fragments develop an apparently siliceous rim which stands in relief. Some of the conglomerates, though not as far as is known the lower ones, contain volcanic fragments, as mentioned later. The conglomerate bodies are markedly lenticular and are probably discontinuous. The greatest observed thickness is in the part of the east edge of the outcrop area that lies on the Galbraith Creek side of the range. There a 300-foot section is almost all conglomerate but 1/2 mile to the north the body is only a few feet thick. This predominantly conglomeratic section contains at least 3 beds, each about 4 feet thick, of grey, fine- to medium-grained, silty dolomite. It also contains lenses of "greenstone", 10 to 15 feet thick. This dark green rock is fractured and partly dolomitized adjacent to some of the fractures. Some of the "greenstone" may be volcanic, as the least altered mass observed is amygdaloidal and the conglomerate with which it occurs contains volcanic fragments with trachytic texture.

A shale and limestone sequence some 500 feet thick overlies the conglomerate section. The shale, which

predominates, is grey and olive-grey and weathers silvery grey to red. Practically all of it is limy grading into shaly limestone, and much of it contains nodules of grey limestone an inch or so long. Most of the interbeds of grey-weathering, grey limestone are 4 to 8 inches thick. Many are flat-pebble limestone-conglomerates with matrices of crystalline limestone and the rest consist of finely crystalline massive limestone. The limestones are dolomitized locally and then weather orange. In the localities investigated the limy shale in the upper part of the sequence has a silvery lustre in sunlight, because of micaceous minerals associated with intense cleavage. This part contains also argillaceous limestone in beds up to 4 feet thick that weathers brown to red.

Four lenses of altered igneous rock were noted in the shale and limestone sequence. They are 20 to 30 feet thick and up to 200 feet long. Weathered surfaces are brown, fresh surfaces are grey and the rock consists chiefly of fine-grained carbonate "talc", and chlorite.

A mixture of sedimentary and pyroclastic materials overlies the shale-limestone sequence. The rocks weather rusty but the rubble is partly grey and green because outcrops and fragments spall repeatedly along cleavages. Much of the rock contains visibly fragmental material, some fragments being up to 2 inches long. This rock has for the most part a blotchy appearance; the fragments are flattened and stretched, and they, like the matrix, consist now largely of fine-grained micaceous and chloritic minerals and carbonate. Some beds consist of "greenstone" fragments in a tuffaceous matrix, whereas others contain argillaceous fragments in a muddy matrix, but in much of the rock the fragments are so altered that origins are undecipherable. The sequence is at least 200 feet thick.

The sedimentary-volcanic group lies unconformably upon the Silurian part of the Beaverfoot-Brisco formation, which provided fossiliferous boulders, and may possibly also overlie beds similar to those of the basal Devonian unit of the Lussier syncline. Aside from fossils in boulders it yielded only crinoid fragments and a linguloid brachiopod. The upper limit of age is unknown and although the shale-limestone sequence has a "Palaeozoic aspect" the group may be as young as Cretaceous.

MISSISSIPPIAN

Exshaw Formation

The Exshaw formation overlies the Palliser formation and underlies the Banff formation. It consists essentially of black shale, partly limy, and contains a minor amount of black limestone and, perhaps locally, siltstone. A section measured in the Lizard Range is 57 feet thick. Both contacts are distinct. It yielded plant remains and the mould of an ammonite, both unidentifiable.

Banff and Rundle Formations

The combined thickness of the Banff and the overlying Rundle formations is 3,800 feet in the Lizard Range, with individual thicknesses of about 1,300 feet and 2,500 feet, respectively. The formations as a whole are distinguishable but their contact is gradational, as rocks characteristic of each occur repetitively and, as a result, it is difficult in reconnaissance mapping to place the contact in a consistent stratigraphic position.

The Banff formation consists chiefly of fine-grained, dark limestone, generally "cherty" and commonly silty, that weathers in shades of grey and tan. The "chert" occurs as nodules and as lenses and laminae in the plane of the bedding. In certain instances the "chert" is derived from silty laminae. The formation is only sparsely fossiliferous.

In the Lussier syncline the Banff formation has a much greater silt content than elsewhere and a concomitantly greater proportion of "chert". The sequence assigned to this formation is about 1,200 feet thick. It overlies black shale and siltstone, partly limy, and is overlain just north of the map-area by crystalline crinoidal grey limestone containing fossils comparable to those in the uppermost Banff and lower Rundle strata of the eastern Rockies. A section measured east of Lussier River at lat. 50° is summarized below:

	Thickness in feet
Top of ridge - believed to be less than 200' stratigraphically below fossiliferous Rundle-type rock occurring to north	
Limestone, silty, fine-grained, dark grey, weathering buff to light grey, fetid in part; beds mostly 4" to 2' thick, commonly with silty laminae, some showing cross-bedding; lenses and layers of grey-weathering dark "chert", much of which is chertified silt	242
No outcrops - scattered blocks of siltstone in debris	104
Siltstone, limy, dark grey, weathering buff to tan; laminated on 1-4 mm. scale, minor cross-bedding; black wormlike markings on some parting planes	30
Limestone, silty, medium- to fine-grained, light grey; weathering grey, fetid, beds mostly 4" to 2' thick; silty layers, some chertified	92

Siltstone, dolomitic, and dolomite, dark grey to black; weathering grey to brown; beds 1/2" to 3' thick, laminated in part, some crossbedded; top grades into overlying unit	176
Siltstone, limy, dark grey; weathering mottled grey and brown; beds mostly 4" to 1' thick, laminated on 1-2 mm. scale with crossbedding and slump structures; dark "chert"; upper part contains a few beds of fine-grained black limestone	210
Shale and shaly siltstone, black; weathering brown; black wormlike markings on some beds; scattered beds of black shaly limestone; interbeds of black "chert" in upper part	38
Limestone, silty, "cherty", fine- to medium-grained, dark grey to black; weathering grey to brown; beds 6" to 5'; much of unit consists of interbedded limestone, silty limestone and "chert" (much of which is apparently derived from siliceous detritus); laminated in part; fetid in part; mid-part of unit is concretionary	140
Limestone, medium-grained, "crystalline", grey; weathering light grey; fetid; beds massive and thick; lenses and layers of dark "chert", weathering grey, in relief	58
	1,090

Black shale and siltstone, exposures sparse

This section yielded no identifiable fossils

The Rundle formation is characterized by crystalline grey limestone that weathers white or grey and which is commonly crinoidal and coralline, and mostly fetid. The beds generally lack internal layering. Light-coloured "chert" is conspicuous in parts of the sequence. Thin-bedded dark "cherty" limestone of Banff type occurs here and there, particularly in the lower part of the formation. In the top 250 feet of the formation in the Lizard Range there are at least two beds of sandstone a foot thick in crystalline limestone that contains Lithostrotion sp. cf. L. banffense Warren. The top of the formation is taken as the top of this limestone which is overlain by quartzite of the Rocky Mountain formation.

INTRUSIVE ROCKS IN THE ROCKY MOUNTAINS

Contrary to oft-repeated generalizations about the paucity of intrusions in the Rocky Mountains, this area

besides containing the Moyie intrusions into Precambrian strata, is by no means free of granitic intrusions in Palaeozoic rocks. Stocks and numerous dykes and irregular small bodies occur well within the Rockies and a stock lies at their western margin.

The largest stock, about 3 miles southeast and east of lat. 49° 45', long. 115° 30', straddles the divides between Wild Horse River, Tanglefoot Creek and Summer Lake. It is unroofed over an area of 1 1/2 square miles in an L-shaped pattern in a series of cirques and inter-cirque divides. It occupies the core of an anticline. The rock in the main or southern part of the stock is pink porphyritic monzonite and quartz monzonite. It consists of medium to coarse subhedral grains of perthitic orthoclase and a little hornblende between which are smaller grains of plagioclase and orthoclase and very fine-grained quartz. The feldspars have a complex history of overgrowth and replacement by both potassic and albitic materials and these apparently deuteric changes were accompanied by destruction of hornblende and increase of quartz. The rocks in the north end of the stock and in its apophyses and satellites are varied, with compositions ranging from granodioritic to syenitic and with textures ranging from almost equigranular to markedly porphyritic with feldspar phenocrysts aligned in flow structure. Some varieties are rich in hornblende and some contain important amounts of garnet, sphene, and epidote. Numerous dykes and small irregular bodies related to the stock occur on the ridge a mile northwest of Summer Lake. The stock has produced a hornfelsic aureole in shaly and limy McKay strata that ranges in width from a few feet to half a mile and which is locally pyritiferous. A little molybdenite is present in grab samples from the oxidized dump of one of a group of old adits on a tributary of Tanglefoot Creek 1/4 mile south of the southeast corner of the stock.

A complex of intrusive and sedimentary rocks on the divide between Wild Horse and Lussier Rivers 5 miles north of lat. 49° 45', long. 115° 30' contains two parts that are chiefly igneous. The eastern of these, in and west of the pass used by the Wild Horse-Lussier trail, is perhaps 1 1/2 miles long and a third of a mile wide. It is cut by an important north-striking fault. The second igneous zone, 1/2 mile west of the first and lying on the east flank of the western pass, which is erroneously shown on some maps as containing the trail, is of the order of a third of a mile in diameter. The igneous rocks are mostly monzonitic, but their appearance and, to a lesser extent, their composition are varied. They range from granular medium-grained types to types that are markedly porphyritic and have an almost aphanitic groundmass. The granular rocks are grey to pink with a peppering of dark minerals and all of them are more or less porphyritic, with feldspar phenocrysts. Their present compositions are mostly near monzonite and quartz monzonite but these have resulted from extensive rearrangements of the components of the feldspars. Hornblende was the principal dark mineral but much of it has been destroyed during pervasive alterations of the feldspars, and the sites of some crystals are marked in part by magnetite granules. Hornblende is well preserved in the markedly porphyritic rocks, of which there are many related varieties with phenocrysts of

potash feldspar, plagioclase, and hornblende in an aphanitic or almost aphanitic groundmass. Glassy or glassy-centred potash feldspar phenocrysts are a distinctive feature of these porphyries. These igneous rocks intrude Upper Purcell, Jubilee, and McKay strata. The Jubilee dolomite is recrystallized and partly converted to lime silicates. The McKay shales are hornfelsic and rusty and locally pyritized. Especially pyritic hornfelsic rocks on the west border of the eastern igneous area were noted in outcrops on the ridge running west from the pass on the Wild Horse-Lussier trail and in talus from the southwest wall of the cirque south of that ridge.

A stock of altered monzonitic or granodioritic porphyry makes a series of small outcrops at the east edge of the Rocky Mountain Trench near the mouth of Bull River. The rock, which has a bleached appearance, consists of medium and coarse, more or less equant, phenocrysts of pink feldspar, some of which have centres of glassy potash feldspar, accompanied by medium and fine phenocrysts of white, grey, and greenish plagioclase whose twinning is visible to the naked eye, all set in a light grey aphanitic groundmass. The paucity of dark minerals is notable, there being only sparse areas of green minerals marking the sites of small hornblende phenocrysts and a few flakes and rare rosettes of specular hematite visible with the hand lens. The plagioclase phenocrysts are albitized and sericitized. The area in which the outcrops occur is 3/4 of a mile long and 1/4 mile wide. No contacts are exposed but the outcrop-area is surrounded closely on three sides by Devonian and Mississippian strata and on the fourth by drift that covers the projected position of a fault that brings the Palaeozoic against the Precambrian.

The drainage area of Wild Horse River and the wall of the Rocky Mountain Trench immediately to the northwest of it contain many dykes and irregular small intrusions related to those already described. One of the larger of these lies just east of the Estella mine at the head of Tracy Creek. It consists of porphyritic granodiorite and quartz monzonite in which medium-grained phenocrysts of white, much-altered plagioclase lie in a grey groundmass containing quartz, potash feldspar, albite, chlorite, epidote, carbonate, sphene, pyrite, and magnetite or hematite.

On a mountain between Van Creek and Quinn Creek, 10 miles northeast of the first of the stocks described, dykes and sills up to about 50 feet thick composed of grey and green altered porphyritic rocks that appear related to those already described intrude McKay strata. The margins of some of the dykes and sills contain calcite and have an amygdaloidal appearance.

The age of the intrusions is probably late Lower Cretaceous or possibly younger.

STRUCTURAL GEOLOGY

The Rocky Mountain Trench is due to erosion along a combination of different fault zones. The part near and north of Fort Steele is a simple erosion feature but near the 49th Parallel the erosion was probably imposed on a form due fundamentally to block faulting. The faults in the Trench are parts of various systems some of which, particularly near and north of Fort Steele, pass obliquely into it northward from the Purcell Mountains and southward from the Rockies. In Fernie map-area the Rockies side of the Trench stands structurally above the Purcell side, which is the reverse of the condition farther north.

The structures on both flanks of the Trench in the northern part of the area are similar. The main structure on the west flank is an anticline that plunges northward at about 25 degrees and whose east limb becomes increasingly steep as it goes south. The Hughes Range, which forms the east flank of the Trench, also consists here of the faulted east limb of a major north-plunging anticline. This limb also steepens southward until near lat. 49° 50' it becomes partly overturned and finally, along Wild Horse River, becomes complexly sliced by faults. The similarity of structures on either flank of this part of the Trench extends to certain minor features. On both sides of the Trench the steeper parts of the structures contain numerous flexures whose shape is the reverse of that to be expected of drag-folds genetically related to the major structure.

The Trench there, as elsewhere, contains important faults, the harmony of the types of structure within its flanks notwithstanding. This is made clear by the discordance of the patterns of rock formations on either side, and is supported by evidence from the adjoining Canal Flats area. A major fault zone enters the Trench obliquely from the lower Lussier valley; its presence is indicated by the way in which Lower Purcell and Jubilee strata lie on strike of one another, and by evidence from more closely spaced outcrops north of the map-area. Longitudinal faults that exist at the north edge of the map-area near long. 115° 45' are known from their occurrence farther north. The net result of the fault movements was to raise the Rockies side relative to the Purcells, perhaps to shift the Rockies flank north relative to the Purcells, and to effect foreshortening across the Trench.

The general order of description in the succeeding pages is first eastward from the Trench at the north end of the map-area and then south along the Rockies near the Trench.

The north part of the east-facing succession in the Hughes Range flanking the Trench is bordered on the east by a longitudinal fault, east of which is the Lussier syncline which underlies the valleys of Lussier River and Coyote Creek. This open syncline plunges gently northward. It is succeeded eastward by the broad easterly overturned Coyote-Quinn anticline that composes the range between Coyote Creek and the through-valley of Quinn and Blackfoot Creeks and which extends well north of the map-area. The axis is horizontal from Inlet Creek, just southeast

of Whiteswan Lake, southward for 20 miles to the head of Van Creek at lat. 49° 50', where the plunge becomes northward and there is a coincident increase in the amount of eastward overturn. The dip of the axial plane is about 65° W at lat. 50° and about 45° W on Van Creek. Erosion has exposed a core of incompetent lower McKay shale on Inlet and Van Creeks and in a few cirques in the intervening segment. Intense west-dipping cleavage obscures bedding in the deepest exposures, where the shale lacks the protection of the more competent younger beds.

The unbreached Coyote-Quinn anticline lies on strike of the zone of intensely cleaved and sheared McKay strata on White River, immediately to the north, which Henderson (1954) termed the White River break and which he considered to represent a major west-dipping thrust fault (1954, pp. 49-50). Evidence from the present investigation indicates that at least the southernmost part of the deformed zone referred to as the White River break is stratigraphically controlled and is not a fault whose west dip is persistent and which continuously cuts across the stratigraphic section. The deformed zone may, however, be part of a thrust fault which was localized in relatively flat-lying McKay shale for a great distance and which became folded with it.

The Coyote-Quinn anticline is succeeded on the east by the Quinn Creek syncline, which is disproportionately narrower than the anticlines on either side. The through valley of Quinn and Blackfoot Creeks is eroded in the Devonian strata of its core. The syncline is isoclinal, with axial plane dipping, within the area, westward at 45° to 65°. It contains west-dipping faults, particularly on its eastern limb, but its form is believed to be relatively unbroken. The axis is horizontal in the north but to the south at 49° 50' there emerges a north-plunging anticline which bifurcates the syncline, producing a western prong that plunges north and an eastern one that plunges south. The strike of this anticline curves from southeasterly, where it arises, to southwesterly, south of lat. 49° 45', and concurrently the degree of eastward and southeastward overturn increases.

East of the Quinn Creek syncline is a broad eastward-overturned anticline that forms the range between the valley of Quinn and Blackfoot Creeks and that of upper Bull River. It is more complex than the Coyote-Quinn anticline and contains numerous subsidiary folds. The axis is horizontal in the northern part of the segment within the map-area but it plunges south opposite the place where the Quinn Creek syncline is split by the emergent anticline.

To return to the east-facing succession that flanks the Rocky Mountain Trench in the north part of the map-area, this adjoins the Lussier syncline only where it is upright. Farther south, in the southwestern headwaters of Lussier River and on Wild Horse Creek, where the east-facing succession is partly overturned, a series of faults, an isoclinal syncline and an anticline with an anomalous westward overturn intervene between it and the south end of the Lussier syncline. The

anticline, which is 10 miles long, extends from the headwaters of Tanglefoot Creek northward to the forks of upper Lussier River. In the south, opposite Summer Lake, it is upright or overturned slightly to the west but from there north it becomes progressively more overturned to the west until its axial plane dips 55° E. The increase in westward overturning is accompanied by a westward shift in the axial line, as if the northern part of the anticline were shoved westward. The southern part of the anticline is the eastern limb of an isoclinal syncline. In the north, however, along the strongly overturned part of the anticline, the axial zone of this syncline is ruptured and the faulted limbs lie face to face, dipping east. The east boundary of the westward-overturned anticline is a fault that brings Beaverfoot-Brisco strata of the anticline against the older McKay group on the west limb of the Lussier syncline. This fault is closely defined for 7 miles south of "Fish" Lake, which is just north of lat. 49° 50'. Its dip is probably steep but the direction of dip is unknown. A mile south of "Fish" Lake the beds east of the fault roll from an easterly dip to a westerly one as they approach it, corresponding to a pattern that could be due to either a west-dipping normal fault or an east-dipping thrust fault, depending on which way the beds face.

Important faults, on which the evidence of the dislocation of formations is puzzlingly conflicting, occur near Wild Horse River. The Purcell lava, an excellent horizon marker, extends with only minor lateral dislocations from lower Lussier River at lat. 50° to the headwaters of the west fork of upper Lussier, where drift conceals it. The lava reappears on strike on the Lussier-Wild Horse divide, passes south beneath drift in the Wild Horse valley, and reappears, still on strike, on the east wall of the valley. At lat. 49° 45', 1 1/2 miles farther south, it is faulted, so that Creston strata lie against Gateway, but the lava reappears about 2 1/2 miles farther south, almost in line with the previous occurrences. From there it is traceable in a series of small fault blocks for 3 miles southerly to the Boulder Creek fault. In summary, the lava provides no evidence of important transcurrent dislocation on Wild Horse River north of the Boulder Creek fault. In direct contrast is the evidence of the Jubilee formation. This competent dolomite extends with only minor offsets for 27 miles southward to the headwaters of Lussier River, and thereafter appears intermittently on strike, parallel to the lava, south to lat. 49° 45', where it presents an outcrop width of 3,000 feet of vertical beds on the north wall of the "East Fork" of Wild Horse River. There it disappears. The disappearance must be due chiefly to faults, though part may be due to facies changes, but as its companion formation, the lava, is traceable much farther south the fault or faults are probably either nearly longitudinal or folded. The fault, or one of the faults, responsible for the abrupt disappearance of the Jubilee is believed to be related to the longitudinal fault along upper Lussier River which separates the previously described east-facing succession, of which the lava and the Jubilee dolomite are part, from the Lussier syncline.

The Boulder Creek transverse fault crosses the Hughes Range from the Rocky Mountain Trench to Tanglefoot Creek near lat. 49° 40'. This fault, whose dip is nearly vertical or steep northward, displaces longitudinal faults. The trace of the lava has an apparent offset along it of 4 miles, south side east, but the fault is by no means a simple left-hand transcurrent one. The lava in the north block is overturned to the east, whereas that in the south block dips and faces east and represents a different structural level.

The region between the Boulder Creek fault and the Dibble Creek fault, 6 miles to the south, contains a Purcell and basal Cambrian sequence that strikes north and northwesterly, faces east, is partly overturned eastward, and is sliced by transcurrent faults. This is the same succession that flanks the Trench north of Wild Horse River but it is depressed relative to that block. Folds within it plunge northward, as they do in the northern block. The transcurrent faults within it dip north or northwesterly and their traces are convex to the south or southeast. Although the general occurrence of younger rocks on their north sides abutting older ones on the south and the relative westward offsets of the northern segments of vertical or east-dipping contacts both suggest gravity faults, these faults are thought more probably to have had complex movements involving oblique net displacements with relative uplift of the north blocks.

The approximate eastern limit of the north-trending succession between the Boulder Creek and Dibble Creek faults is marked by a Cambrian quartzite that extends from Tanglefoot Creek to Dibble Creek. Farther east betwen Tanglefoot Creek and Bull River, the younger Cambrian strata trend northeasterly and contain complex folds overturned in part to the southeast. The structural relationship of the two groups is not yet clear but the presence of a longitudinal fault along the east side of the north-trending succession is suggested by the lack of Jubilee strata.

The Dibble Creek fault, which crosses the east flank of the Rocky Mountain Trench at lat. 49° 35', is an important one that brings together blocks with contrasting histories. Present evidence suggests that the later history of the fault involved relative movement of the north block upward and eastward and that lubrication was provided by Devonian gypsum of the foot-wall block.

The stratigraphy and structure on either side of the Dibble Creek fault are very different. To the north and northeast the Devonian lies upon a thick sequence of Silurian, Ordovician, and Cambrian strata, which in turn lie upon the Precambrian Gateway and Kitchener-Siyeh formations; whereas south of the fault the Devonian rests directly on the Kitchener-Siyeh formation. In further contrast, the hanging-wall of the fault consists successively of Aldridge, Creston, Kitchener-Siyeh, Gateway, and Cambrian strata, whereas the foot-wall lies on the same few feet of Devonian beds throughout the distance of 6 miles from the Trench at the mouth of Horseshoe Creek to Dibble Creek. The apparent structural simplicity of

the foot-wall is in marked contrast to the complexity of the hanging-wall. The foot-wall strata, concordant with the fault, dip north, mostly at angles of 45° to 55°. Small folds in them plunge eastward but are not surely related to the fault because similar ones occur elsewhere in the foot-wall block. Foot-wall beds near the fault are fractured but not sheared, in contrast to those of the hanging-wall, where secondary foliation obscures bedding. Along Sunken Creek the cleavage in the hanging-wall strikes with the fault and dips about 55°N, that is, nearly parallel to the fault. The bedding immediately adjacent to the fault likewise seems to be parallel to it, though the fault cross-cuts the formations as a whole. The change in attitude of the beds near the fault may be due as much to subsidiary faults as to folds. Evidence of drag on the hanging-wall at Dibble Creek is provided by an isolated outcrop of the Cambrian-Gateway contact that is overturned and which lies 2,000 feet west of the projected position of the rest of the contact.

The stratigraphic contrasts on either side of the Dibble Creek fault are believed to be due largely to its being near the site of a Palaeozoic structure, rather than to its having juxtaposed two different geological provinces. An easterly trending structure on which the north block stood low and the south block stood high probably existed in this region during some or all of the interval between Middle Silurian and Middle Devonian. As a result, the sub-Devonian unconformity north and northeast of this locality extends only as deep as latest Lower or early Middle Silurian strata, whereas to the south and southeast the Devonian rests on mere remnants of Cambrian strata or, more generally, on the Precambrian, although a considerable Lower Palaeozoic section was originally present in part of that area.

The mountains between Rocky Mountain Trench and Elk River south of lat. 49° 30' contain three physiographic and geological divisions. The first is in the northwest, where, flanking the Trench from Bull River southward for 10 miles to Sand Creek, a range with generally rounded slopes consists of Precambrian strata, chiefly Lower Purcell. Structurally it is part of the crest and east limb of an anticline that plunges gently northwestward. The west side is in fault contact, along and near the margin of the Trench, with Palaeozoic rocks that floor the Trench and which will be referred to later.

To the east of this range, and separated from it by the valley of upper Sand Creek which contains a thrust fault, is the second division, the precipitous Lizard Range, whose topography is closely related to the lithology and structure of its components. Structurally the Lizard Range consists of a prism of sediments overturned to the northeast. It comprises, from west to east, Upper Purcell beds overlain unconformably by Devonian and Carboniferous formations, resistant parts of which form its backbone, and is succeeded on the eastern slope by softer Mesozoic strata. These rocks strike northwesterly and dip at about 65° SW, overturned. The Lizard Range prism and the segment of the anticline that composes the first division may both be parts of the same fold, the part in the first division having been thrust against the Lizard part on the longitudinal fault in upper Sand Creek.

At the north end of the Lizard Range, just north of lat. 49° 30', the strata bend sharply northeast and enter a zone of complex faults and nappe-like folds, which are overturned to the southeast and south, and which underlie the drainage-area of Iron Creek. The same formations continue past Iron Creek to make the mountains north of Fernie and those between upper Elk and upper Bull Rivers, everywhere with structures dominated by folds overturned eastward.

To return to the mountains along lower Elk River and the Rocky Mountain Trench, the third division lies south of Sand Creek and its southeastern tributary McDermid Creek, and geologically it also included Mount Broadwood, south of the west-flowing part of Elk River. The components of this division are Upper Purcell and a few feet of Cambrian strata, overlain by Devonian and Upper Palaeozoic rocks, which form the bolder topography, and Triassic beds that are quantitatively minor but structurally important because of their incompetence. Structurally the division consists of folds whose axial planes strike northwesterly and dip steeply to the southwest and whose axes plunge 10° to 15° NW. The largest fold is the Broadwood anticline through which Elk River crosses as it swings westerly towards the Trench. The west-dipping Broadwood thrust fault cuts the west flank of this anticline almost longitudinally. Its trace is distinct on the walls of Elk River valley 2 1/2 miles east of Elko, where the Upper Purcell Gateway formation abuts the Mississippian Rundle formation. Subsidiary faults splay from it in the higher slopes north of Elk River.

At the Sand Creek thrust fault (not to be confused with the previously mentioned thrust fault in the valley of upper Sand Creek) the first and second divisions are thrust upon the third. The Sand Creek thrust is a folded fault whose folds plunge northwesterly and whose trace runs easterly across the traces of the rocks in the hanging-wall. From a locality in the east part of the Trench about 2 miles southeast of Galloway post office the trace goes northeast to where Sand Creek enters the Trench, then it rises along the north wall of Sand Creek, climbing about 1,500 feet in 2 1/2 miles to an anticlinal culmination. The trace of the folded fault then turns directly down the slope along the nearly vertical east limb of the fold, and recrosses Sand Creek. Farther southeast it truncates the formations of Lizard Range, resulting in the latter's abrupt termination structurally on top of the Broadwood anticline. The fault rises progressively through the stratigraphic section in its foot-wall in the first part of the course described. In the west, near Galloway, it rests on Upper Purcell strata, along Sand Creek it rises across competent Mississippian beds and finally, on the east limb of its fold, it enters and follows the shaly Spray River formation of Triassic age. The relation of the Sand Creek fault to the longitudinal faults on either side, that in upper Sand Creek on the north and the Broadwood thrust on the south, must remain a matter for conjecture, because their intersections are drift-covered. The fault in upper Sand Creek is probably a splay off the Sand Creek thrust but alternatively it is possible that the longitudinal faults are related to each other, and that they interrupt the Sand Creek thrust.

The floor of the Rocky Mountain Trench near Bull River and Wardner consists of Devonian and Mississippian strata whose western margin in Purcell Mountains is, according to Schofield, an unconformity on Upper Purcell rocks. The Palaeozoic strata are thus "rooted" west of the Trench and presumably also across its floor, but their eastern boundary is a fault. The trace of this fault is distinct where it crosses a spur 3 miles south of Bull River and indicates there that the fault dips west into the Trench. This boundary fault is offset just south of this locality and its faulted southern continuation lies somewhere within the physiographic Trench, as is shown by the fact that the isolated outcrops in the eastern Trench floor from there south to Elko are lithological and structural continuations of the rocks that form the eastern Trench wall. In summary, the Palaeozoic rocks in the Trench floor are in contact along a west-dipping fault with Precambrian rocks that stand above them on the east wall of the Trench, and the writer believes them to have been relatively downdropped. It must however be borne in mind that the Precambrian rocks on the Trench wall are themselves a thrust plate and are, at least in part, underlain by Palaeozoic rocks.

ECONOMIC GEOLOGY

Sulphide-bearing deposits occur along the west front of the Rocky Mountains, gypsum in the Rocky Mountain Trench and Rockies, and placer gold in Wild Horse River. The geological work recorded here involves preliminary areal mapping and individual mineral deposits have not yet been investigated. Most deposits near Wild Horse River were reported on by Rice (1937). Occurrences of pyrite and a minor occurrence of molybdenite north and east of the area described by Rice are noted in the section, "Intrusive Rocks in the Rocky Mountains".

The sulphide deposits occur almost entirely in Precambrian rocks, the chief exceptions being those in Palaeozoic rocks adjacent to the intrusions on Wild Horse-Tanglefoot and Wild Horse-Lussier divides. Most of them were discovered before or soon after the turn of the century, some have yielded a few tons of shipping ore over the years, and two, the Estella and the Kootenay King, were recent producers.

Although these two deposits lie relatively near each other in the same belt of Aldridge strata, which at both localities is intruded by Cretaceous or younger granodioritic and monzonitic porphyries, their structural controls and their compositions are different. The Estella deposit, near the head of Tracy Creek, consists of replacement veins and fissure-fillings guided by fractures and sheared zones in a region of complex folds, and it bears no obvious relation to particular beds. The Kootenay King deposit, 3 miles south of the Estella, is on the other hand a replacement of dolomitic (dolomitized?) Aldridge strata, and the ore is localized in one of the anomalous folds that characterize this part of the Hughes Range. The ratio of zinc to lead recovered from Estella mill was about 2 to 1 and that from Kootenay King mill was about 1.2 to 1. The Estella has a significant cobalt content which the Kootenay King does not have, the silver recovered per

ton of Estella ore was about 25 per cent less than at Kootenay King, and the cadmium content is apparently smaller.

Gypsum of Devonian age is plentiful in parts of the Rockies and the Rocky Mountain Trench. The deposits in the Trench, which are near Mayook, at Chipka Creek near Wardner, and on Bull River 3 miles from its mouth, are well known, the Mayook deposit having been an intermittent producer for the cement industry. There are three main gypsum-bearing areas in the Rockies within the present map-area that were previously unreported. The largest is in the Lussier syncline where much of the upper Lussier valley is underlain by the gypsum-bearing Burnais formation. Outcrops are however few and the presence of gypsum is indicated chiefly by sinkholes. Gypsum does however outcrop at an altitude of 6,300 feet on the east side of the valley opposite the junction of the streams that drain "Fish Lake" and the pass to Wild Horse River. The gypsum is the laminated white and grey type that is characteristic of the gypsum along Kootenay River above Canal Flats. Sulphur efflorescences occur on weathered surfaces. The sizes of gypsum deposits in this area cannot be determined by surface mapping but an outcrop of gypsum rock on the east bank of the river 1/2 mile north of lat. 50°, which is 1/3 mile long, illustrates what can occur. The presence of gypsum around Lime Creek, an eastern tributary of Bull River 10 miles above its mouth, and along Bull River above Sulphur Creek is inferred from sinkholes and from occurrences there of strata equivalent to those that are gypsum-bearing elsewhere. The gypsum may outcrop in the drainage basin of Lime Creek but it probably does not do so on upper Bull River.