CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY

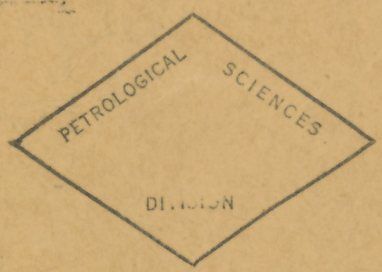
PAPER 44-19

DUNLEVY-PORTAGE MOUNTAIN MAP-AREA, BRITISH COLUMBIA

(Report and Map)

BY

H. H. Beach and J. Spivak



OTTAWA

1944

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(Summary Account)

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H.H. Beach and J. Spivak

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CONTENTS

Illustration

Dunlevy-Portage Mountain Map-Area,

British Columbia

INTRODUCTION

This report is the result of a reconnaissance geological survey, in 1942, of parts of an area in east-central British Columbia lying between latitudes 55°45' and 56°15' and longitudes 122° and 122°30'. The village of Hudson Hope, at the western edge of the Peace River Block, lies just east of the map-area and is reached by a road extending about 120 miles north and west from Dawson Creek, British Columbia. This road continues westwards from Hudson Hope, north of Peace River, across the map-area. The northern and southern limits of the area are reached by pack trails, indicated on the accompanying map.

Field work was carried on by two parties under the general supervision of the senior author, who worked in the western parts of the area and made reconnaissance trips up Peace River and into Graham River Valley 20 miles north of Peace River. Spivak's party traversed the eastern parts of the area from Moberly River northwards to Graham River. The work was accomplished largely with the aid of air photographs, as no accurate topographic maps were then available. Capable assistance in the field was given by Messrs. O.A.Erdman, H.R. Robinson, S.J. Kidd, K. Huff, and D.W. Axford.

STRATIGRAPHY

All strata within the map-area are of sedimentary origin and range in age from Permian to Upper Cretaceous. They have a total thickness exceeding 13,100 feet. Reconnaissance up Peace River into the Rocky Mountains and in the hills immediately west of the area has substantiated the existence there of Devonian and Mississippian limestones, dolomites, and shales lithologically similar to formations of the eastern Rocky Mountains in southwestern Alberta. It is reasonable to assume that these underlie the present map-area.

Table of Formations

Age	Group	Formation and thickness Feet	Character
Pleistocene and Recent			River gravels Lake clays Glacial drift
Erosional Unconformity			
Upper Cretaceous		Dunvegan 1,100+	Buff weathering, grey to greenish sandstones; some conglomerate lenses with interbedded, sandy, green to brown shales; non-marine.

Table of Formations (cont'd)

Age	Group	Formation and thickness Feet	Character
Upper Cretaceous			
Lower Cretaceous	Fort St. John group	Cruiser 900 ±	Black shale, with finely crossbedded sandstone beds; marine (?)
		Goodrich 550	Sandstone, buff to red weathering, fine to medium grain, interbedded shale; conglomerate near base; marine.
		Hasler 1,300 ±	Shale, grey to black, sandy, thin sandstone members near top; Gastropolites horizon about 600 feet above base; marine.
		Gates 250-400	Three or more massive, greenish grey, medium-grained sandstones; some shale; marine.
		Moosebar 1,000-1,200	Shales, friable; thin concretionary bands; thin sandstone; marine.
	Bullhead group	Gething 1,400	Sandstone, fine to medium, grey to brown; shale; clay ironstone; coal beds.
		Dunlevy 3,000-3,200	Coarse, conglomeratic sandstone; finer sandstone; quartzitic sandstone; shale.
Jurassic		Fernie 700-1,100	Black fissile shale; thin ironstone bands; limy sandstone beds; marine.
Triassic		Schooler Creek 2,500 +	Marine limestone; calcareous, fine sandstone; siltstone.
Permian		415 +	Soft, calcareous sand; marl; coquina; limestone; base not exposed; marine.

Permian

Strata of Permian age are exposed in the core of a tightly folded and faulted anticlinal structure at the western margin of the map-area, south of Peace River. The following section was measured in a creek canyon, immediately west of Stott Creek:

Top of Section	Thickness Feet
Sandstone, fine-grained, grey-buff, with carbonate cement; vugs partly filled with quartz and calcite and containing small amounts of pyrobitumen; a few fossils.....	275
Sandstone, soft, very light grey, calcareous; many fossils.....	50
Limestone, dark grey, arenaceous.....	25
Limestone, phosphatic, black, thin-bedded.....	10
Sandstone, fine-grained, calcareous cement.....	55
Total.....	415

Underlain by dark grey limestone beds (Rundle formation ?)

The contact between beds of the above section and overlying Triassic strata is not exposed. The section contains a fauna of poorly preserved brachiopods and pelecypods from which A. E. Wilson of the Geological Survey identified the following genera:

Dielasma, Spirifer, Notothyris, Edmondia, Solemya, Schizodus, Aviculopecten, Pterinidae, Pernidae, Allorisma, Aviculopinna, Myalina. Wilson notes that this fauna is new to Canada and considers it Permian in age.

Upper Triassic

Schooler Creek Formation. The Schooler Creek formation was named and described by McLearn (1920)[1] from Peace River Valley, west of the map-area.

[1] List of references at end of report.

Later detailed studies (McLearn, 1930, 1940, 1941) resulted in the formation being subdivided into a lower (Grey) member, and an upper (Pardonet) member, each containing several faunal zones. The thickness of the formation is given as over 2,500 feet.

The only exposures of Schooler Creek beds within the map-area are in an anticlinal structure just west of Stott Creek. Here the beds are poorly exposed, but excellent sections were observed in cliffs along Peace River just west of the area. There the lower part of the section comprises dark, slaty, calcareous shales, overlain by uniformly but thinly bedded, grey, calcareous sandstone and arenaceous limestone, with interbedded siltstones. The upper 500 feet is composed largely of chocolate-brown to purplish grey, calcareous sandstone, grey to black limestones, and siltstones. Fossil collections reveal the presence of the Nathorstites fauna, described by McLearn in Peace River Valley, west of the map-area.

Jurassic

Fernie Formation. Strata overlying the Schooler Creek formation on the Stott Creek structure are considered correlative with the Fernie formation of the Alberta Foothills. The formation is not well exposed in this locality, but some 20 miles west of the map-area, in the hills about 1 mile east of Ottertail River, a section of Fernie beds, about 1,100 feet thick,

was measured. The contact with overlying Bullhead strata is gradational. The upper 125 feet of beds include black, hackly, fissile shales with many thin ironstone bands, interbedded with about equal amounts of calcareous, reddish brown weathering, fine-grained, dark grey sandstone beds. This is underlain by a 50-foot section of finely interbedded black shale and relatively lesser amounts of hackly, carbonaceous, dark brown, crossbedded sandstones. The lower part of the section is largely concealed, but such outcrops as were seen indicate that the beds are mainly black, fissile shales. Such shales are well exposed on Ottertail River about 2 miles above its confluence with Peace River. There the contact with the underlying Schooler Creek formation is distinct and there is no evidence of angular discordance. No fossils were found in either section and a Jurassic age is assigned solely on the stratigraphic position and lithological similarity to beds of undoubted Jurassic age in regions to the south.

East of Ottertail River, in the vicinity of Brown Hill, McLearn (1940) describes strata of Jurassic age, having an estimated thickness of 700 feet. The beds include dark, carbonaceous shale; rare, greenish, glauconitic shale; and some beds of fine sandstone and impure limestones. The contact with the underlying Schooler Creek formation is disconformable.

The difference in thickness between the two sections is considered to be due to thinning of the formation eastwards.

Lower Cretaceous

Bullhead Group. The term "Bullhead group" (Wickenden and Shaw, 1943) is applied in Peace River region to that succession of sandstones, conglomerates, shales, and coal seams, largely if not entirely of non-marine origin, that overlies the Jurassic, Fernie formation and underlies the marine shale assemblage known as the Fort St. John group. As thus used it includes all strata placed by McLearn (1917) in the Bullhead Mountain formation. He found it convenient, in field mapping, to subdivide that formation into two parts, the lower comprising massive quartzitic sandstones with much chert pebble conglomerate, and the upper consisting of sandstones, shales, and commercial coal seams. To the upper part he assigned the name "Gething member". These subdivisions are employed in this report, but with slight changes in nomenclature. The name "Dunlevy" formation is proposed, at McLearn's suggestion, for those beds previously included with the lower member, and the name Gething formation for the Gething member. Both formations are now regarded as comprising the Bullhead group for, although their contact is gradational, no difficulty is experienced in distinguishing them in the field.

Dunlevy Formation. Dunlevy strata are well exposed on Butler Ridge, Rainbow Rocks, and Gething Mountain. The most continuous section of Dunlevy beds is exposed in a large amphitheatre on the north side of Gething Mountain. The contact with the underlying Fernie formation was not observed, but from studies in regions to the west it is assumed to be gradational. The exposed beds are largely a succession of well-bedded, very hard, fine-grained, quartzitic sandstones interbedded with carbonaceous shales. Details of this part of the formation are as follows:

Top of Section	Thickness Feet
Sandstone, dark brown, coarse-grained, thin-bedded, crossbedded, grey weathering.....	65
Sandstone, argillaceous, thin-bedded.....	13
Concealed.....	33
Sandstone, brown, thin-bedded, fine-grained.....	20
Sandstone, massive, thin-bedded near base.....	36

Top of Section	Thickness Feet
Concealed	48
Sandstone, carbonaceous, brown, thin-bedded	32
Concealed	32
Sandstone, thin-bedded, carbonaceous, brown	20
Concealed	52
Sandstone, argillaceous, brown, thin-bedded	39
Sandstone, quartzitic, massive, white weathering	143
Concealed by large blocks quartzitic sandstone	299
Sandstone, brown, massive	15
Shale, black, arenaceous, thin-bedded	26
Sandstone, massive, brown	26
Shale, carbonaceous, sandy; thin sandstone beds	52
Sandstone, thin-bedded, iron-stained	13
Concealed	13
Sandstone, quartzitic, massive, white weathering	117
Sandstone, carbonaceous, quartzitic	26
Sandstone, quartzitic, massive, crossbedded	377
Sandstone, argillaceous, thin-bedded, dark grey	104
Shales, sandy, black, brown weathering	143
Sandstone, massive, with interbedded shale	13
Sandstone, quartzitic, fine-grained, weathers black	338
Sandstone, quartzitic, with interbedded shales	13
Sandstone, quartzitic, brown	117
Sandstone, fine-grained, platy, chocolate weathering	143
Conglomerate and grit	1
Shale, black, with thin sandstone; indeterminate pelecypods	13
Shale, black, brown weathering	13
Sandstone, buff; interbedded shale	39
Sandstone, quartzitic, brown; carbonaceous fragments	10
Total	2,442

The uppermost beds of this section form the top of Gething Mountain, but it is probably that about 200 feet of additional, similar strata lie between them and the massive conglomerate beds marking the top of the Dunlevy. The latter comprise 400 feet of largely conglomeratic sandstone that shows marked lateral variation not only in the number and thickness of individual conglomerate beds, but in the total thickness of the zone. On the sides of Butler Ridge, for example, the conglomeratic phase is at least 600 feet thick. It would seem that no one conglomerate bed is sufficiently persistent to constitute a reliable horizon marker, although the conglomerate zone as a whole is most useful in field mapping.

The conglomerate zone consists of a series of massive, crossbedded, coarse-grained, grey to reddish weathering, conglomeratic sandstones and grits, in beds 5 to 20 feet thick, interbedded with 6-inch to 2-foot beds of buff weathering, fine-grained sandstones, carbonaceous shales, and thin coal seams. Some beds consist entirely of conglomerate with pebbles up to 2 inches in diameter and averaging ½ inch. The pebbles are angular to subrounded and consist of green and black chert, white quartz, and quartzite. Individual conglomerate beds are commonly lenticular and wedge out rapidly along the strike of the beds.

The thickness of the entire Dunlevy formation is estimated to be 3,000 to 3,200 feet.

Gething Formation. The Gething formation is well exposed in Peace River Canyon, where a detailed study was made by McLearn (1922). Elsewhere within the area exposures are poor and individual sections rarely reveal over 200 feet of beds. The formation is about 1,400 feet thick. The strata consist of interbedded, buff-weathering, medium- to fine-grained, dark brown sandstones, carbonaceous and micaceous sandstones, grey to black shales, siltstones, clay ironstone, and coal. Sandstones predominate over shale and siltstone. Beds vary in thickness from 2 inches to 10 feet, and average 2 feet. Over fifty coal seams occur within the Gething formation, but only three are over 4 feet thick in the known localities; of these, two seams occur within 250 feet of the top of the formation and one occurs within 200 feet of the base.

A fossil plant collection in the lower part of the formation contained the following species (identified by W.A.Bell of the Geological Survey):

Coniopteris brevifolia (Fontaine)
Nilssonia johnstrupi Heer
Ptilophyllum speciosum (Heer)
Pterophyllum concinnum Heer
Sagenopteris n.sp.
Phoenicopsis angustifolia Heer
Podozamites lanceolatus (Lindley and Hutton)
Pityophyllum nordenskioldi (Heer)
Elatocladus (Elatides) dicksoniana (Heer)
Elatocladus smittiana (Heer)
Cladophlebis virginiensis forma acuta Fontaine

The flora indicates an Aptian (Lower Cretaceous) age, and is considered correlative with the Lower Blairmore flora of the Alberta Foothills.

Fort St. John Group. The Fort St. John group includes all marine Lower Cretaceous strata that lie between the Gething and Dunvegan formations. The term has recently been defined by Wickenden and Shaw (1943). In this area the Fort St. John group includes, in ascending order, the Moosebar, Gates, Hasler, Goodrich, and Cruiser formations. The Hasler formation refers to beds in the map-area previously called Fort St. John formation.

Moosebar Formation. Outcrops of the Moosebar formation occur on Peace River near Contact Point, on branches of Coalbed and Gething Creeks, and on branches of Farrel Creek. On Coalbed Creek, near its junction with

Johnson Creek, the Moosebar has a conglomerate bed at the base. The bed is 2 feet thick and contains well-rounded black, chert pebbles up to 2 inches in diameter embedded in a black argillaceous cement. The conglomerate fills small channels and depressions in underlying Gething sandstone, indicating an interval of erosion before deposition of the Moosebar.

North of Peace River, on Ruddy Creek, a fine conglomerate composed of multi-coloured chert pebbles averaging $\frac{1}{4}$ inch in diameter, with a grey, siliceous cement, overlies the Gething formation. The conglomerate is 35 feet thick and is fossiliferous, containing the pelecypod Dicranodonta n.sp. in profusion.

On the south fork of Gething (Trail) Creek, the following section of Moosebar strata was measured:

Top of Section	Thickness Feet
Sandstone, thin-bedded, grey, medium-grained.....	54
Sandstone, dark grey, thin-bedded, argillaceous.....	45
Shales, grey, sandy.....	10
Shale, black, hackly.....	20
Sandstone, massive, carbonaceous; wood fragments.....	5
Shale, black, sandy.....	15
Sandstone.....	2
Concealed.....	15
Sandstone, grey weathering, shaly.....	33
Concealed.....	2
Sandstone, grey, rubbly, shaly.....	21
Shale.....	5
Sandstone.....	2
Shale.....	4
Sandstone, massive.....	3
Concealed.....	20
Shale, ironstone nodules.....	10
Shale, black, sandy, thin-bedded, buff-weathering....	26
Sandstone, black, massive.....	4
Shale, sandy.....	12
Sandstone, hard, shaly.....	4
Shale, dark grey, thin-bedded.....	15
Sandstone, hard, argillaceous.....	3
Shale, dark grey, hackly; ironstone bands.....	28

Section (Cont'd)	Thickness Feet
Shale, rectangular columnar jointing; ironstone bands	72
Shale, dark grey	90
Shales, a few marcasite concretions	60
Shales, dark grey; seventeen ironstone bands	94
Shales, dark grey; numerous concretionary bands near top	180
Shales, dark grey; clay ironstone nodules	200
Shales, grey, hackly; some concretionary bands; 4-inch bentonite bed near top	120
Shales, dark grey, hackly; eight ironstone bands	60
Shales, thin-bedded; 6-inch limy bands at 6-foot intervals near base	50
Shales, thin-bedded, hackly, dark grey; ironstone bands 6 inches thick about 3 feet apart	50
Conglomerate, chert pebbles	2
Total	1,336

Underlying beds - Gething formation

This section is much thicker than the estimated value given by McLearn (1922) on the north bank of Peace River, near Contact Point. The upper 236 feet, however, contains several sandstone members and probably includes strata of the overlying Gates formation. It is believed that the Moosebar formation is over 800 feet thick and may in this region attain a thickness of between 1,000 and 1,200 feet.

Fossils found in the Moosebar formation include species of the following genera (identified by McLearn of the Geological Survey): Beudanticeras cf. affine Whiteaves, Dicranodonta, Lemuroceras ?, and Pecten (Entelium). The fossils are marine and indicate an Albian (Lower Cretaceous) age.

Gates Formation. The Gates formation was first described by F. H. McLearn in 1917. The type locality is at the Gates, 7 miles east of Hudson Hope, where a sandstone member 50 to 80 feet thick occurs between the Moosebar and the overlying shales. West of Hudson Hope two sandstone members, with interbedded shales, overlie the Moosebar formation and attain a thickness of about 400 feet. The sandstone members are each 75 to 100 feet thick and are separated by 200 feet of shales. On Johnson Creek, strata at the same stratigraphic zone comprise shales and sandstones in a section 430 feet thick. Near Steamboat Island a section includes the following strata:

	Thickness Feet
Sandstone, crossbedded, platy; plant fragments	75
Shale, black	60
Sandstone, massive, quartzitic	30

	Thickness Feet
Shale.....	75
Sandstone.....	5
Total.....	245

Underlying beds - Moosebar formation

This group of strata, varying at different localities within the map-area, is tentatively referred to the Gates formation and has a thickness of between 250 and 400 feet. Marine fossils collected from it were examined by McLearn of the Geological Survey, who identifies the following: Beudanticeras, Yoldia cf. kissoumi, Thracia?, Protocardium, Modiola, Pinna, Tancredia?, and Pecten (Entolium). The fauna is probably of Albian (Lower Cretaceous) age.

Hasler Formation. The Hasler shales have been referred to in early reports as the Fort St. John formation. That name is now used to designate a group of marine Lower Cretaceous formations (Wickenden and Shaw, 1943) including the Hasler, and the latter term applies here to the shales overlying the Gates formation in the western Peace River region. The best exposures are opposite Starfish Creek north on Peace River, and reveal a continuous section, 700 feet thick, of fine, dark grey, thin-bedded, marine shales with thin, interbedded, sandstone members. About 600 feet above the base, some shaly sandstone beds contain the Gastropolites ammonoid fauna. The upper part of the Hasler is not well exposed in the area. On Burnt Trail Creek, a 200-foot section near the top of the formation includes shales, siltstone, and thin-bedded, grey weathering sandstones. The thickness of this formation could not be determined within the area. McLearn estimated the thickness at 1,300 feet, at Cache Creek, 28 miles east of Hudson Hope (1917).

Goodrich Formation. The Goodrich formation is exposed on the south side of Peace River, on Tworidge Mountain, and near Pete Lake in the Moberly River region. Its thickness is estimated to be 550 feet. The formation includes a series of interstratified, buff to light grey, medium- to coarse-grained sandstones, and black, sandy shales. On Burnt Trail Creek the lowermost 50 feet of the Goodrich includes 20 feet of coarse conglomerate containing variegated chert pebbles $\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. Underlying beds are of medium- to coarse-grained, grey, crossbedded sandstone, with some clay ironstone bands.

North of Tworidge Mountain, a creek section near the base of the formation contains the following:

Top of Section	Thickness Feet
Sandstone, fine-grained, greenish grey.....	122
Sandstone, thin-bedded, grey; thin shale beds.....	21
Shale, black, fissile; ironstone concretionary bands.....	42
Sandstone, grey, fine-grained, partly micaceous.....	41
Sandstone, grey-green; some concretionary bands.....	29
Sandstone, quartzitic, grey-green.....	11
Shale, black, sandy; carbonaceous fragments; fossils.....	6
Total.....	272

Base of formation not exposed.

The strata contain a marine pelecypod fauna including Posidonomya nahwisi var. goodrichensis, P. nahwisi var. moberliensis, and Oxytoma sp. This fauna is found in the Goodrich formation of the Commotion Creek region on Pine River. It evidently has a wide distribution as it is now recognized far to the north in the Sikanni Chief and Muskwa River regions.

Cruiser Formation. Black shales overlie the Goodrich formation on Tworidge Mountain and in the Moberly River region. The strata occupy the same stratigraphic position as the Cruiser shales in Commotion Creek area, and despite the lack of fossil evidence are considered correlative.

On the north slope of Tworidge Mountain over 400 feet of the formation is well exposed, but the strata are locally folded and faulted so that a continuous section could not be obtained. On the west side of the mountain the structure is apparently gentle, and there the stratigraphic interval of 800 to 900 feet between the Goodrich and the Dunvegan formations is presumed to include a complete section of the Cruiser. The formation consists of grey-black, fissile shales with interbedded, thin, white, finely crossbedded sandstones and black, micaceous sandstone beds.

On Moberly River, near the eastern boundary of the area, a section of Cruiser shales comprises the following:

Overlying beds - Dunvegan formation	Thickness Feet
Shale, sandy, with 4-inch sandstone beds.....	40
Shale, dark grey.....	120
Shale, dark grey; 1-inch, fine-grained, sandstone beds.....	20
Bentonite.....	0.25
Shales, dark grey.....	40
Shales, sandy; finely crossbedded thin sandstones; concretionary bands.....	90
Total.....	310.25

Upper Cretaceous

Dunvegan Formation. Dunvegan strata are best exposed near the top of Tworidge Mountain and in the Moberly River region. On the basis of faunal evidence the strata are correlative with the Dunvegan formation of Commotion Creek area and the eastern Peace River region. The lower part of the formation contains the characteristic Unio dowlingi, a freshwater form.

The Dunvegan consists of massive, coarse- to fine-grained, buff to reddish weathering sandstones. Narrow lenses and thin beds of conglomerate occur near the base of the formation. Higher strata consist of medium-grained, greenish weathering, micaceous sandstones, and interbedded, greenish brown, sandy shales. Large-scale crossbedding is common, and in places some crossbedded sandstones appear to have been distorted before consolidation.

On Moberly River, near the eastern boundary of the area, a section of lower beds of the Dunvegan is comprised as follows:

Top of Section	Thickness Feet
Sandstone, green, shaly, fine-grained, rubbly.....	20
Sandstone, grey, medium-grained.....	10

Top of Section (Cont'd)	Thickness Feet
Sandstone, green, shaly, with interbedded sandy shale	200
Shale, green, sandy.....	30
Concealed.....	100
Sandstone, massive, medium-grained.....	1
Sandstone, crossbedded, fine-grained.....	70
Conglomerate, fossiliferous.....	0.5
Sandstone, crossbedded, grey, micaceous.....	30
Total.....	461.5

Underlying beds - Cruiser formation

The top of the Dunvegan formation has been removed by erosion within this area. Its total thickness may exceed 1,100 feet.

STRUCTURAL GEOLOGY

The map-area lies at the eastern edge of the Foothills Belt. The extreme western border is about 22 miles east of the most easterly range of the Rocky Mountains where the latter are intersected by Peace River just west of Ne Parlez Pas Rapids. The general structural trend within the map-area is 25 degrees west of north. This trend is known to be maintained beyond Graham River, paralleling Peace River 20 miles to the north. South of the map-area, however, there is an appreciable swing in the structural trend to 45 degrees west of north.

The major structural features of the Peace River Foothills are narrow zones of anticlinal folds, commonly broken by high-angle thrust faults, separated by broad synclinal basins of gently folded strata. Locally, smaller, symmetrical, "flat-topped" or "box" anticlines are developed with steeply dipping limbs and broad flat crests, but these either plunge out in short distances or enter fault zones along strike. Anticlinal zones occur in the vicinity of Bullhead and Portage Mountains, and on Stott Creek at the western limit of the map-area.

The Portage Mountain-Butler Ridge structural zone, 2 to 3 miles wide, consists of an anticlinorium trending northwesterly. The conglomerate and quartzitic sandstone zones of the Dunlevy formation are exposed in the cores of the anticlines. Near Johnson Mountain these folds plunge steeply to the southeast, as shown by the progressively younger formations along the crestal area southeast of Coalbed Creek. To the northwest of Bullhead Mountain the anticlines run into high-angle faults. North and west of Chinaman Lake, the Butler Ridge structure is a westerly dipping thrust block of Dunlevy strata, overlying progressively younger formations northwestwards towards Graham River.

Portage Mountain is a broad anticlinal structure, with steeply dipping east and west limbs, adjacent to an asymmetrical syncline and anticline along the eastern slope of the hill. The east limb of the main anticline is broken by a high-angle fault. The west limb of the easterly anticline is in fault contact with the Gething formation; the surface trace of the contact indicates that the fault plane dips westwards.

The structures on Portage Mountain continue northwestwards on Bullhead Mountain and Butler Ridge. On the former, the easterly anticline is more strongly developed as a nearly symmetrical structure, with dips of 50 to 60 degrees on the limbs. Locally the east limb dips 75 degrees east to vertical and may be faulted. The Bullhead Mountain structure continues northwestwards for 9 miles, and from available information has a closure of about 500 feet

at the top of the Dunlevy formation. The syncline between the Bullhead Mountain and Butler Ridge anticlines is faulted locally and has steep flanks. The Butler Ridge anticline has a steeply dipping west limb (60 to 75 degrees west), a gentle easterly dipping crest, and a steep east limb. To the northwest, near the headwaters of Brenot Creek, the crest is gently synclinal (See map), and farther along strike the fold enters a fault zone. West of the Butler Ridge structure a third symmetrical anticline apparently plunges rapidly to the southeast and enters a fault zone to the northwest. This anticline could not be traced southwestwards to Portage Mountain. West of Chinaman Lake the Butler Ridge structure and the westerly anticline enter a complex fault zone. Northwest of this region the continuation of Butler Ridge is a faulted series of westerly dipping Dunlevy strata of the quartzite zone overlain by beds of the conglomerate zone and the Gething formation (See map). East of the ridge there are anticlinal structures in the Gething formation, but exposures are scarce and structural details could not be determined.

West of the Portage Mountain-Butler Ridge structural zone there is a broad, gentle syncline 10 miles wide. Strata of the Dunlevy and Gething formations are exposed in the trough of the structure.

The Gething Mountain-Stott Creek structural zone extends across the southwestern part of the map-area. On Gething Mountain the anticline reveals strata of the Dunlevy quartzitic zone dipping steeply to the west (45 to 60 degrees), then a flat or gently arched crest 1 mile wide, and a steeply dipping to overturned east limb. East of the structure is a major thrust fault, in which beds of the quartzitic zone are thrust over the conglomerate zone of the Dunlevy formation. Towards the northwest, at lower elevations, the core of the anticline exposes Fernie, Schooler Creek, and Permian strata. The anticlinal structure apparently narrows to the northwest and the displacement along the fault increases. Several subsidiary folds occur to the east of the fault. The fault zone at the southwest corner of the southern part of the map-area may be the southeasterly continuation of the Gething Mountain fault.

The "flat-topped" or "box" anticlines differ markedly in cross-section from the folds that characterize the Foothills Belt south of Athabaska River. They appear to represent the concentric types of folding as they become narrower at depth. An excellent vertical section more than 2,000 feet high exposes the core of the structure forming Gething Mountain. The fold at the top of the mountain has a broadly arched crest with the limbs dipping at high angles, but in the valley below, where the Permian is exposed in the core, the strata are tightly compacted in a narrow zone of intense deformation. The impression was gained that such folds are more superficial than folds of similar size in the southern Foothills.

ECONOMIC GEOLOGY

Oil Possibilities

Drilling for oil in the map-area should be confined to tests of the Schooler Creek or older formations, as all overlying strata are fully exposed. The Triassic and exposed Permian beds are of marine origin. The former appear to have very little porosity or permeability, whereas the Permian strata are appreciably less consolidated and contain numerous vugs. Some of the vugs contain pyrobitumen, which may indicate the past presence of petroleum. As only the uppermost beds of the Rundle formation are exposed in the Stott Creek anticline no information regarding the value of these strata as source beds or reservoir rocks was obtained.

Of the structures studied, the most easterly or Bullhead Mountain structure appears to be the most favourable for a test. It apparently has about 500 feet of closure on the top of the Dunlevy formation and lies east of the complex fault zone of Butler Ridge. However, the structure has

steep easterly dips on the east limb, and may be faulted. The Dunlevy formation contains at least 2,600 feet of dense, very hard sandstones and conglomerate beds, which may present considerable difficulty in drilling. However, the preglacial river channel between Portage and Bullhead Mountains may have been cut so deeply as to have removed the Dunlevy formation in this valley (Beach and Spivak, 1943), making it possible to reach pre-Cretaceous horizons without encountering Bullhead strata.

The British Columbia Government drilled six diamond drill holes in the vicinity of Farrel Creek in 1922. The holes penetrated the Hasler, Gates, and Moosebar formations and about 800 feet of Gething strata. Hole No. 6 on Brenot Creek penetrated a 2-foot bed of tar clay the analysis of which indicated an oil concentration of 80 gallons of oil per ton (Dresser, 1922). The oil had a paraffin base. The bed occurred at a depth of 2,273 feet below the surface and was apparently in the upper part of the Gething formation. No such beds have been observed in surface exposures. One other hole, 12 miles to the northwest, penetrated this horizon, but drill samples did not show the tar clay bed.

Coal Deposits

The coal deposits of the Peace River Canyon region have been studied and described in detail by McLearn (1922) and by McLearn and Irish (1944). On creeks east of Butler Ridge, only a few narrow seams were observed; one such seam, 1½ to 2 feet thick and dipping 18 degrees east, could be traced for 1,200 feet along the middle branch of Ruddy Creek. In general, exposures are too scarce to permit estimates of the coal resources without undertaking detailed studies. It is possible that the coal seams thin out northwards and eastwards, for drilling on Farrel Creek encountered only a few seams, 2 inches or less in thickness, at stratigraphic horizons where thicker seams are known to occur in Peace River Canyon.

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