58-5

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

PAPER 58-5

BEEHIVE MOUNTAIN,
ALBERTA AND BRITISH COLUMBIA
82 J/2 E½

(Report and Map 14-1958)

By

D. K. Norris

OTTAWA
1958

Price, 50 cents

CONTENTS

BEEHIVE MOUNTAIN, ALBERTA AND BRITISH COLUMBIA

INTRODUCTION

The primary interest in Beehive Mountain map-area lies in the possible extension of the Savanna Creek gas field beyond the southern termination of Highwood Range, in the occurrence of gas-bearing structures to the west of this range, and in stratigraphic data on the westward continuation of Palaeozoic formations exposed in Livingstone and Highwood Ranges.

To date the Geological Survey has completed the following 1-mile maps in the vicinity: Mount Head area (Douglas, 1950)[1] to the north, Pekisko Creek area (Hume and Hage, 1942) to the northeast, Livingstone River area (Norris, 1958) to the east, and Gap area (Douglas, 1951) to the southeast. The remainder of the region is covered only by the 4-mile Upper Highwood and Elk River map (Stewart, Rose, and Marshall, 1924).

LOCATION AND ACCESSIBILITY

Beehive Mountain map-area straddles the continental divide between lat. 50° 00' and 50° 15' and long. 114° 30' and 114° 45'. It includes the southern termination of Highwood Range in the northeast corner and a part of High Rock Range trending slightly west of north through the western third of the map-area.

The eastern part of the map-area may be reached via Kananaskis Trail and the forestry road up Oldman River and the western edge of the area from Natal, B. C., via a road up Elk River valley and a private road running part way up Fording River. Beehive Pass is the only easy means of crossing the continental divide within the map-area and it may be traversed with horses. A horse-trail is maintained by the Alberta Forestry Branch, connecting the road up Oldman River and Cataract Creek via Oyster Creek, as well as a branch trail from Oyster Creek eastward to the Kananaskis Trail via Savanna Creek.

FIELD WORK AND ACKNOWLEDGMENTS

Beehive Mountain map-area was studied by the writer during the summer of 1956, who was assisted by H. R. Greiner, E. W. Mountjoy, L. Romaniuk, W. N. Hamilton, M. J. Ogaranko and W. Gilmar. Their able assistance is gratefully acknowledged.

---

[1] Dates in parentheses are those of references given at the end of this section.

BIBLIOGRAPHY

Allan, J. A., and Carr, J. L.
1947: Geology of Highwood-Elbow Area, Alberta; Research Council, Alberta, Rept. 49.

Anderson, E. M.
1951: "The Dynamics of Faulting"; Oliver and Boyd, Edinburgh.

Bell, W. A.
1956: Lower Cretaceous Floras of Western Canada; Geol. Surv., Canada, Mem. 285.

Crockford, M. B. B.
1949: Geology of Ribbon Creek Area, Alberta; Research Council, Alberta, Rept. 52.

Douglas, R. J. W.
1950: Mount Head, Alberta; Geol. Surv., Canada, Paper 50-8.
1951: Callum Creek, Langford Creek, and Gap Map-Areas, Alberta; Geol. Surv., Canada, Mem. 255.
1956: George Creek, Alberta; Geol. Surv., Canada, Paper 55-39.

Glaister, R. P.
1958: Petrology of the Blairmore Sandstones; J. Alberta Soc. Pet. Geol., vol. 6, pp. 43-49.

Hafner, W.
1951: Stress Distributions and Faulting; Bull. Geol. Soc. Amer., vol. 62, pp. 373-398.

Harker, P., and McLaren, D. J.
1958: The Devonian-Mississippian Boundary in the Alberta Rocky Mountains; Am. Assoc. Pet. Geol., Allan Memorial Vol., Jurassic and Carboniferous of Western Canada (in press).

Hume, G. S., and Hage, C. O.
1942: Pekisko Creek; Geol. Surv., Canada, Map 698A with descriptive notes.

McLearn, F. H.
1929: Mesozoic Palaeontology of Blairmore Region, Alberta; Natl. Museum, Canada, Bull. 58.

Newmarch, C. B.
1953: Geology of the Crowsnest Coal Basin; B. C. Dept. Mines, Bull. 33.

Norris, D. K.
1956: Coal Mountain, British Columbia; Geol. Surv., Canada, Map 4-1956 with descriptive notes.
1957a: Rocky Mountain Succession at Beehive Pass; J. Alberta Soc. Pet. Geol., vol. 5, pp. 248-254.
1957b: Canmore, Alberta; Geol. Surv., Canada, Paper 57-4.
1958: Livingstone River, Alberta; Geol. Surv., Canada, Map 5-1958 with descriptive notes.

Raasch, G. O.
1956: The Permian Rocky Mountain Group in Alberta; Alberta Soc. Pet. Geol., Sixth. Ann. Field Conference and Guide Book, pp. 114-119.

Scott, J. C., Hennessey, W. J., and Lamon, R. S.
1957: Savanna Creek Gas Field, Alberta; Alberta Soc. Pet. Geol., Seventh Ann. Field Conference and Guide Book, pp. 113-130.

Shimer, H. W.
1926: Upper Palaeozoic Faunas of the Lake Minnewanka Section, near Banff, Alberta; Natl. Museum, Canada, Bull. 42.

Stewart, J. S., Rose, B., and Marshall, J. R.
1924: Upper Elk and Highwood Rivers; Geol. Surv., Canada, Map 1980.

STRATIGRAPHY

TABLE OF FORMATIONS

Era	Period or epoch	Formation or group		Lithology	Thickness (feet)
MESOZOIC	Upper Cretaceous	Belly River formation		Non-marine shale, mudstone	3,500+
		Alberta group	Wapiabi formation	Marine shale, siltstone	2,200
			Cardium formation	Marine sandstone, shale, conglomerate	510
			Blackstone formation	Marine shale, siltstone	1,015
	Disconformity ?				
	Lower Cretaceous	Crowsnest formation		Tuff, agglomerate	150-
		Blairmore group		Non-marine shale, sandstone, conglomerate	2,030
		Unconformity			
		Kootenay formation		Non-marine shale, sandstone, coal	760-
	Jurassic	Fernie group		Marine shale, sandstone	1,000±
	Unconformity				
	Triassic	Spray River formation		Marine siltstone, sandstone, mudstone	150±-650
	Disconformity				
PALAEOZOIC	Mississippian Pennsylvanian (?) and Permian (?)	Rocky Mountain formation		Marine sandstone, dolomite, siltstone	85-1,200
	Mississippian	Rundle group	Etherington formation	Marine dolomite, limestone, sandstone	210-770
			Mount Head formation	Marine dolomite, limestone	630-1,090
			Livingstone formation	Marine limestone, dolomite	1,100-1,220
		Banff formation		Marine limestone, shale, chert	900
		Exshaw formation		Marine shale, siltstone	21
	Disconformity				
	Devonian	Palliser formation		Marine limestone	250+

DEVONIAN

Palliser Formation

The oldest rocks in the area, the upper part of the Palliser formation, are exposed low on the east flank of High Rock Range. There at most some 250 feet of the formation occur above the Lewis thrust. The strata are largely dark grey, fine-grained, medium- to thick-bedded, crinoidal limestones, becoming thin-bedded towards the top. The upper few feet are variably dolomitized and buff weathering. The contact with the overlying Exshaw formation is seemingly conformable.

From the uppermost 2 feet of the formation on the east flank of Beehive Mountain were collected abundant Schuchertella ? sp., Camarotoechia sp., Cyrtiopsis sp. cf. C. normandvillana Crickmay ?, and Athyris sp. According to D. J. McLaren of the Geological Survey, any of these forms may occur at any horizon within the Palliser formation and they indicate only a late Devonian age. No faunal elements distinctive of the uppermost Costigan member were recovered.

MISSISSIPPIAN

Exshaw Formation

The Exshaw formation, like the underlying Palliser, is exposed in the map-area only in High Rock Range. Accessible sections are generally poorly exposed although on the east flank of Beehive Mountain the section examined is complete.

There the formation is divisible into two units and the lithological succession is very similar to that found elsewhere in the southern Alberta Rocky Mountains. At the base is a 12-foot bed of black, silty, pyritic, thin- to medium-bedded, rusty brown weathering shale. The upper unit is a 9-foot bed of medium grey, thin bedded, finely laminated, slightly calcareous siltstone. The lower contact with the underlying limestones is a pronounced break whereas the upper contact is gradational and arbitrarily drawn to include the siltstone bed within the formation, in agreement with usage in Bow Valley (see Harker and McLaren, 1958). No fossils were found in these rocks.

Banff Formation

The Banff formation is well exposed in High Rock Range, although in most places it is inaccessible. Immediately north of Beehive Pass, however, the formation is easily reached. There it is 900 feet thick and is divisible into two parts. The lower part, 505 feet thick, consists dominantly of black, calcareous, shaly siltstones and mudstones in the lower 150 feet and interbedded grey

and black, fine-grained dolomite and limestone, with black, bedded chert in the remainder. The upper part, 395 feet thick, consists of grey and black, fine-grained limestone in part silty and with scattered chert blebs and stringers.

Both contacts of the Banff formation are arbitrarily defined, the lower one being especially difficult to map precisely because of the recessive nature of the basal beds of the unit. Where exposed, however, it is drawn at the base of the thick, black, shaly mudstone succession in the lower part of the formation. The upper contact is chosen to include the fine-grained, cherty limestones within the Banff, and the overlying, coarse-grained, crinoidal limestones within the Livingstone formation. This contact appears gradational and is difficult to discern in inaccessible places as it is rarely emphasized by differential weathering.

Rundle Group

Livingstone Formation

The Livingstone formation is an excellent cliff-former in both Highwood and High Rock Ranges. One of the few completely exposed and accessible sections in the map-area is on the ridge immediately north of Beehive Pass. Unlike other formations which show a pronounced thickening to the west, the Livingstone formation thickens only slightly westward, being about 1,100 feet thick in Highwood Range and 1,220 feet thick at Beehive Pass. Both upper and lower contacts may well be diachronous as they are defined solely on gross lithological characteristics.

Livingstone strata consist dominantly of grey, coarse-grained, thick-bedded to massive, crinoidal limestone, variably cherty, with interbeds of grey, medium- and thick-bedded, buff weathering dolomite more abundant in the upper half of the formation. The lower contact is drawn at the base of the thick, crinoidal limestone succession. The upper contact is sharp and is drawn where the cliff-forming strata give way to generally recessive interbedded limestone and dolomite. This contact is apparently conformable and is generally marked by a distinct physiographic break, with the overlying beds stripped back along the contact.

Mount Head Formation

Strata of the Mount Head formation are well exposed on the flanks of Plateau Mountain at the southern end of Highwood Range, as well as in High Rock Range. On Plateau Mountain the formation is 630 feet thick and consists of alternating limestone and dolomite units rendering it divisible into six members. Details

of the stratigraphy of the Mount Head formation have been presented in marginal notes accompanying the adjacent Livingstone River map-area (Norris, 1958).

In High Rock Range the formation is 1,090 feet thick. Two distinct units may be recognized. The lower one, 465 feet thick, consists dominantly of grey, coarse-grained, thick-bedded and massive, crinoidal limestone with interbeds of light grey, fine-grained, vuggy, buff weathering dolomite. At the base of the unit is a 35-foot bed of recessive, silty dolomite, the easy weathering of which is largely responsible for the stripping back of Mount Head strata on the top of cliff-forming Livingstone beds. The upper unit, 625 feet thick, is dominantly black, fine-, medium- and coarse-grained limestone with minor grey and black dolomite in the lower half of the unit and black, bedded and nodular chert dispersed throughout. The limestones are thin- to thick-bedded with many shaly intervals resulting in the unit being moderately recessive, especially in the lower half.

The contact with the overlying Etherington formation is seemingly conformable and is drawn at the change upwards from medium and dark grey weathering, moderately recessive limestones to light grey, cliff-forming limestones.

Abundant corals of Meremecian age occur in the upper half of the Mount Head formation. The following fauna was identified by P. Harker of the Geological Survey of Canada: Faberophyllum sp. and Koninckophyllum sp. found in shaly limestones 50 feet below the top, and Faberophyllum sp., Lithostrotian sp. cf. L. banffense Warren?, and Syringopora sp. cf. S. aculeata Girty in similar beds 280 feet below the top. According to Harker, this fauna corresponds with that found in the upper half of the Mount Head formation in the type area.

Etherington Formation

The Etherington formation is exposed at the southern end of Highwood Range and in High Rock Range. On Plateau Mountain the formation is 210 feet thick and consists of interbedded, fine-grained, silty dolomite and limestone with thin, green, calcareous shale partings.

In High Rock Range the formation is 770 feet thick at Beehive Pass. Black, fine- and medium-grained, medium- and thick-bedded limestone, in part crinoidal, with thin partings of green, calcareous, earthy weathering shale predominate in the lower half of the formation. The remainder, however, consists of interbedded black, fine- and medium-grained, medium- and thick-bedded, silty dolomites with stringers and blebs of grey

chert. There are occasional grey, fine-grained, calcareous, quartz sandstone interbeds. Silty dolomites and sandstones predominate in the upper 100 feet of the formation and are similar to the basal beds of the overlying Rocky Mountain formation except that they alternate with noticeably less rapidity. The contact appears therefore to be gradational.

The upper contact as drawn appears to include the highest beds containing the Chesteran braciopods Spirifer leidyi Norwood and Pratten and Spirifer increbescens Hall. The contact may therefore correspond in time with that drawn for the top of the formation in Highwood Range.

MISSISSIPPIAN, PENNSYLVANIAN (?), and PERMIAN (?)

Rocky Mountain Formation

Rocky Mountain strata outcrop both in Highwood and High Rock Ranges. They cap Plateau Mountain in the northeast corner of the map-area and form prominent dip slopes on the west flank of High Rock Range.

The formation consists dominantly of light grey, fine-grained, thick-bedded, quartz sandstones. It is 85 feet thick on Savanna Creek at the southern end of Highwood Range and 1,200 feet thick at Beehive Pass in High Rock Range.

On Savanna Creek, grey, bedded chert makes up 30 per cent of the formation. It occurs as massive interbeds and breccias in medium and dark grey, medium-grained, medium-bedded, locally lustre mottled, quartz sandstones.

The base of the formation on Savanna Creek is marked by a 2-foot bed of medium grey, fine-grained, finely laminated, calcareous, quartz sandstone which is locally replaced by angular fragments of milky, quartz sandstone in a grey, calcareous, quartz sandstone matrix. The occurrence of grey, fine-grained, lustre mottled sandstone typical of the Rocky Mountain formation as interbeds in the top Etherington strata suggests however that the conglomerate may have only local significance.

Abundant Euphemites sp. cf. E. carbonarius arenarius Shimer occur in a 1-foot bed 10 feet below the top of the formation on Savanna Creek. E. carbonarius arenarius Shimer occurs toward the bottom of the Rocky Mountain succession at Storm Creek (Raasch, 1956) and at the top at Lake Minnewanka (Shimer, 1926). Both Raasch and Shimer ascribe it to the Permian.

At Beehive Pass the formation is readily divisible into two units, a thick quartz sandstone succession at the top, termed the upper unit, and a sequence of rapidly alternating sandstones, and dolomites with siltstone at the base, termed the Todhunter member. The stratigraphy of the Rocky Mountain formation in this part of the area has been summarized previously (Norris, 1957a) and only the salient features of the unit are discussed here.

The Todhunter member at the base of the formation is an 88-foot sequence of rapidly alternating grey, fine-grained, calcareous, quartz sandstone and grey, fine-grained, cherty, buff weathering dolomite, and a 12-foot bed of banded maroon and light buff siltstone. The member forms a distinct and readily recognizable unit between the dolomite sequence below and the sandstone succession above. The upper unit is a succession of light grey, medium- and fine-grained, medium-bedded, quartz sandstones about 1,110 feet thick. It is in part dolomitic and in part calcareous. The topmost 80 feet are characterized by interbedded light grey, fine-grained, medium-bedded, light grey-buff weathering, silty dolomites with small blebs of medium grey chert and medium grey, fine-grained, thin-bedded, dolomitic sandstone. They are disconformably overlain by Mesozoic strata.

P. Harker identified silicified Composita sp., Spirifer sp., molds of Archimedes sp. and Orbiculoidea sp. which were collected from the upper half of the Todhunter member. Of these the first three are leading elements in Chesteran faunas of the type region, whereas the last is a wide ranging genus of little value as an index fossil. Faunal evidence obtained to date would therefore indicate a Mississippian Chesteran age for the Todhunter member.

Abundant silicified productids with affinities to Dictyoclostus portlockianus Norwood and Pratten occur 90 feet above the base of the upper unit. According to Harker these may indicate a Pennsylvanian age for these beds. No fauna was found in higher strata of the upper unit and they are considered Permian in age solely on the basis of a lithological correlation with the Permian Storm Creek member at Highwood Pass (Norris, 1957a).

TRIASSIC

Spray River Formation

On the west flank of Plateau Mountain interbedded brown, quartzose siltstone and grey and brown, fine-grained, calcareous sandstone lie disconformably between strata of the Rocky Mountain and Fernie formations. There the measured thickness is 275 feet. This is estimated to be about twice the true stratigraphic thickness because of faulting and folding observed in the section. At the base

is a pebble-conglomerate generally less than 1 foot thick. It consists of black, sub-rounded chert pebbles up to $\frac{1}{2}$ inch diameter in a matrix of fine-grained, porous, limonitic, quartz sandstone. The top of the formation is arbitrarily drawn at the top of a 20-foot, very fine-grained, platy, dark grey weathering sandstone.

About 145 feet above the base of this section occur abundant indeterminate fragments of fish and lingulae. Although these fossils cannot be used in dating, they are known to be common in the Lower Triassic part of the Spray River formation. The presence of these faunal elements and the equivalent stratigraphic position to beds of known Triassic age on Evans Thomas and Pickle Jar Creeks (Allan and Carr, 1947) would suggest this unit is the Spray River formation.

The Spray River formation is prominently displayed on the west flank of High Rock Range. It consists of interbedded light grey, fine-grained, thin- and medium-bedded, finely laminated, pinkish weathering sandstones and dark grey and brown, thin-bedded, dark brown weathering, calcareous siltstones with a recessive black to rusty brown weathering mudstone unit at the base.

On the south side of Beehive Pass the formation is 650 feet thick. The basal recessive mudstone unit is 95 feet thick and is partly covered and the contact with the underlying Rocky Mountain formation is not exposed. Three miles to the southeast, however, dark grey, pinkish brown weathering, unfossiliferous mudstones are disconformably underlain by a medium to dark grey, fine-grained, grey-buff weathering, silty dolomite with vugs lined and filled with light grey chert. There is no evidence of an erosional contact and no basal chert-pebble conglomerate. The topmost beds are resistant sandstones. With the stripping back of overlying recessive Jurassic strata the upper contact is rarely exposed. It was not examined in the map-area.

Approximately 250 feet above the base of the formation at Beehive Pass, well-preserved Claria cf. C. stachei Bittner were collected. According to E. T. Tozer of the Geological Survey of Canada, shells of this type are confined to strata of early Lower Triassic age. Indeterminate fragments of fish and lingulae were collected in a 115-foot siltstone bed beginning 300 feet above the base of the formation.

JURASSIC

Fernie Group

Strata of the Fernie group occur in two north-trending belts, one on the east and one on the west side of the map-area. The latter is poorly exposed and was not studied. The former is

generally highly deformed because of its proximity to the McConnell thrust and an accurate thickness of the group could not be determined there.

Two sections were studied in detail, one on the west flank of Plateau Mountain and the other 7 miles along strike to the south at the headwaters of Savanna Creek. Both sections are faulted. The latter section, however, is complete except for the lowest beds and a fairly accurate estimate (within 10 per cent) of the overall thickness of the group is 1,000 feet.

Three prominent sandstone beds divide the dark grey and black shales of the group into six recognizable units. Ranging from 50 to 150 feet above the base is the Rock Creek member (sensu stricto), characteristically fossiliferous, grey, blocky, calcareous, quartz sandstone. About the middle of the group is a grey, thin-bedded, calcareous siltstone, with thin, fine-grained sandstone interbeds, and containing abundant belemnite fragments. This unit is of variable thickness, being about 110 feet thick on the east flank of Livingstone Range in Livingstone River map-area, 80 feet thick at the headwaters of Savanna Creek, and thinning to 6 feet immediately west of Plateau Mountain. It is apparently absent in the Highwood-Elbow area 12 miles to the northwest (Allan and Carr, 1947) but may be present farther north, as the Pigeon Creek member on Mount Allan in Canmore area (Crockford, 1949) occurs in an equivalent stratigraphic position. At the top of the group, the sandstones of the 'passage beds' are readily divisible into two units, a lower transition zone, generally about 100 feet thick, consisting of alternating dark grey, silty shale and dark grey, fine-grained, colour laminated, calcareous, quartz sandstone. The sandstone interbeds become progressively thicker and more numerous as the top of the unit is approached. Overlying these are dark grey, fine-grained, thick-bedded to massive, brown weathering, locally calcareous, quartz sandstone of the upper 'passage beds'.

The base of the group is characteristically marked by a grey, coarse-grained, conglomeratic, quartz sandstone with black, sub-rounded, phosphatic pebbles generally less than 1 inch maximum dimension. On the west flank of Plateau Mountain, however, the pebbles are absent. Beds immediately overlying this are variably sandy with black, chippy shales in whole or in part being displaced by grey, thin-bedded, calcareous, quartz sandstone (similar to the sandstone unit in the middle of the group). In the southwest corner of the map-area about 100 feet of black to rusty brown mudstones immediately overlie Rocky Mountain strata; there is no pebble-conglomerate at the base.

The upper contact of the group is drawn within massive sandstones at a colour break between grey, brown weathering beds below and black, dark grey weathering beds above. It was mapped

to conform as closely as possible to the formational boundary as defined by McLearn (1929), although Newmarch (1953) has reported an ammonite, Titanites occidentalis Frebold at the top of the dark grey weathering beds proving their marine origin and their age to be late Portlandian. As pointed out by Bell (1956) the top of this sandstone succession (i.e., the top of the basal Kootenay sandstone member) might be a more suitable upper contact for the Fernie group.

A prolific mid-Bajocian fauna was collected at various points in the Rock Creek member and indeterminate belemnite fragments occur at scattered horizons between this member and the top of the grey sandstone unit at the middle of the group.

LOWER CRETACEOUS

Kootenay Formation

Kootenay strata are extensively exposed in the east half of the map-area and at two localitites in the southwest corner. As is characteristic of the Disturbed belt, the formation is generally highly deformed because of the tendency for thrust faults to glide at this stratigraphic level. At the headwaters of Savanna Creek, however, the formation is about 85 per cent exposed and is believed to be unfaulted. There the formation is 760 feet thick. Seven miles to the north, along strike, also in what is believed to be an unfaulted section on the west flank of Plateau Mountain, the formation is about 50 per cent exposed. There the formation is 585 feet thick.

The formation is readily divisible into three members, herein termed the basal sandstone member, the shale member, and the upper sandstone and conglomerate member in keeping with terminology in use at Canmore, Alberta (Norris, 1957b). At the headwaters of Savanna Creek they are, respectively, 110, 500, and 150 feet thick.

The basal sandstone member is a dark grey and black, coarse-grained, thick-bedded, quartz sandstone, locally fine grained and calcareous. As indicated above, it lies with gradational contact on Fernie strata but it is overlain abruptly by the recessive shale member. The latter consists of interbedded black, shaly, carbonaceous siltstone, black, carbonaceous shale, and black and dark grey, coarse-grained, thick-bedded, chert and quartz sandstone. No coal seams were observed in this unit in the northeast corner of the area although coaly fragments in the rubble suggest the presence of one or more thin seams. Interbedded black, fine-grained, thin-bedded, quartz sandstone and siltstone form a gradational contact with the overlying member. The sandstone and conglomerate member in this area is made up largely of black, coarse-grained, very thick-bedded, chert and quartz sandstone

with minor interbeds of black, carbonaceous shale. Pebble-conglomerates are absent, but become an increasingly significant component of the member to the north and west.

The three-fold subdivision of the Kootenay formation is widespread in the southeastern Cordillera. It is recognized in Canmore area on the northeast flank of Mount Allan (Norris, 1957b) and on the west flank of Highwood Range in a section described by Allan and Carr (1947). In Mount Head area Douglas (1950) divided the Kootenay formation into a lower part corresponding to the basal sandstone member and the shale member and an upper part corresponding to the upper sandstone and conglomerate member. The three parts are also recognized on the east and west flanks of Livingstone Range in Livingstone River area, on York Creek, 3 miles south of Coleman, Alberta and possibly also in Fernie area. In Carbondale River area (Adanac strip mine) the upper member appears to be absent, possibly because of pre-Blairmore erosion.

On Coal Mountain in Corbin area (Norris, 1956) and at Coal Creek 2 miles from Fernie, B. C., the basal sandstone member and the shale member are certainly present. Moreover, the similarity of the Elk formation (Newmarch, 1953) to the upper sandstone and conglomerate member of Canmore area is striking. Both are made up of grey and black sandstones with interspersed pebble-conglomerates and minor black, silty shales and coal. In addition, both lie above and in gradational contact with the shale member, the principal coal-bearing component of the formation, and are overlain by a lower Blairmore conglomerate. It is significant, moreover, that Newmarch's plant collections from the lower part of the Elk formation "included no forms diagnostic of the Blairmore, but such characteristically Kootenay species as Czekanowskia cf. rigida and Ctenis borealis" (Bell, 1956).

The upper sandstone and conglomerate member is correlated on the basis of lithology with reasonable certainty in the Alberta part of the southeastern Cordillera. Lithological characters and floral content would suggest that the equivalent of this member in southeastern British Columbia is the Elk formation.

Blairmore Group

Exposures of Blairmore strata are confined largely to the east half of the map-area. There the group is generally folded and faulted and the only complete section was on Slacker Creek, a tributary of Oldman River, where the group is 2,030 feet thick.

On Slacker Creek a basal chert and quartzite pebble-conglomerate unconformably overlies Kootenay strata and grades upward into light grey, fine-grained, thick-bedded, quartz sand-

stone. The assemblage is 40 feet thick. This is overlain by 160 feet of strata, mainly interbedded grey, medium- and coarse-grained chert and quartz sandstone and greenish grey shale and mudstone. These in turn are overlain by the "Calcareous" member (Glaister, 1958), a 15-foot bed of grey, exceedingly fine-grained, thick-bedded limestone with calcareous siltstone and shale interbeds. The remainder of the group is for the most part a monotonous succession of greenish grey mudstones and silty shales with resistant interbeds of light grey and greenish grey, coarse-grained chert and quartz sandstone.

Twelve feet below the top of the group on Slacker Creek is a 7-foot bed of interbedded green, very coarse-grained, feldspathic, calcareous, chert and quartz sandstone, and conglomerate with well-rounded pebbles (generally less than 3 inches maximum diameter) dominantly of black chert and pink and white quartzite. A few volcanic and granitic pebbles were observed. The upper conglomerate is loosely consolidated.

Overlying this and forming the top bed of the group is a greenish grey, medium-grained, thin- to thick-bedded, feldspathic, calcareous, chert and quartz sandstone. It is a resistant marker whose top forms a mappable upper contact for the group.

Crowsnest Formation

Strata of the Crowsnest formation outcrop at a single locality in the map-area at the junction of Slacker Creek and Oldman River, although blocks of agglomerate were observed in a covered interval immediately beneath Blackstone strata along the south boundary of the area, 2.1 miles west of the southeast corner.

On Slacker Creek, interbedded grey tuffs and greenish grey, agglomeratic tuffs occur immediately below the top Blairmore conglomerate strongly suggesting that Crowsnest vulcanism began prior to the close of Blairmore time and the advance of the Blackstone sea. A 143-foot covered interval occurs between the top Blairmore sandstone and a small outcrop of green, massive, slightly calcareous, volcanic agglomerate 5.5 feet thick. Above this the bedrock is masked for about 700 feet to mid-Blackstone strata outcropping on the west bank of Oldman River.

UPPER CRETACEOUS

Alberta Group

Blackstone Formation

The only band of undeformed Blackstone strata is centrally located in the map-area. On a small tributary of Profanity Creek, a fairly accurate measurement of 1,015 feet for the thickness of the formation was obtained. A few discontinuous slices occur in the west half of the area beneath the Lewis thrust.

In general, the formation is poorly exposed, although resistant beds in the conformably underlying and overlying units permit easy mapping of the formational boundaries. On Oldman River, in the central band of Blackstone strata the lowest exposed beds are a 3-foot interval of interbedded dark grey, rusty weathering, pyritic, silty shales and dark grey, fine-grained, thin-bedded sandstones, 30 feet above the base of the formation. Overlying this are 100 feet of dark grey, rusty weathering, silty shales in the top 6 feet of which are six bentonite beds, one 18 inches thick and the remainder less than 2 inches thick.

On the small tributary of Profanity Creek where the lower and upper contacts are exposed, scattered outcrops of the remainder of the formation reveal a gradual increase in the silt content of the shales beginning about 500 feet above the base, and the introduction of thin interbeds of dark grey, fine-grained, finely cross-bedded, calcareous sandstone about 750 feet above the base. The upper 150 feet of Blackstone strata are completely covered. The contact with the Cardium formation is gradational and is arbitrarily drawn at the base of the first thick, resistant siltstone.

Cardium Formation

Cardium strata, like the Blackstone, are limited in the map-area to a central band, and fault slices along the east flank of High Rock Range. Continuous with the Blackstone section on a tributary of Profanity Creek, the Cardium formation is well exposed. There it is 515 feet thick.

There are four, dark grey, fine-grained sandstone members, measuring 14, 28, 33, and 14 feet thick, beginning with the lowest. On a tributary to Wilkinson Creek at the north boundary of the area, four sandstone members are also present and are estimated to be 50, 50, 10, and 25 feet thick, beginning with the lowest. The sandstones occur as interbeds in black, silty shale and black, rusty brown weathering siltstone with scattered lenticular, orange weathering ironstone concretions.

The upper contact of the formation is mapped for convenience at the top of the highest sandstone above which is a covered interval of a few tens of feet to basal Wapiabi strata.

Abundant pelecypods were found in the uppermost sandstone on Profanity Creek. According to J. A. Jeletzky of the Geological Survey of Canada, the fauna contains Pteria (Oxytoma) cf. pectinata (Sow), Pteria (Oxytoma) cf. tenuicostata (Roemer), and Cardium cf. pauperculum Meek. He states that the association of Pteria (O.) tenuicostata (Roemer) with Cardium pauperculum Meek suggests that this sandstone is more probably of basal Wapiabi than of Cardium age.

Wapiabi Formation

The Wapiabi formation occurs in a north-trending strip in the central part of the map-area, as well as in fault slices east of High Rock Range. Exposures are poor and descriptions were limited to isolated outcrops. The resistant sandstones of the formations below and above, however, facilitated mapping of the contacts. An estimated thickness of the formation, obtained graphically at the junction of Oldman River and Profanity Creek, is 2,200 feet.

The formation consists predominantly of dark grey, concretionary, marine shales with thin interbeds of dark grey, fine-grained, thinly laminated sandstone. The sandstones increase in proportion to the shales towards the top of the formation and are in gradational contact with overlying nonmarine Belly River strata.

Belly River Formation

The Belly River formation occurs in the west-central part of the map-area. It is very poorly exposed. Except for the ridge-forming basal sandstone, outcrops are confined largely to the main stream courses. Graphically the formation is estimated to be in excess of 3,500 feet thick barring excessive thickening by undetermined faults.

The basal bed is a medium grey, medium- and coarse-grained, coarsely crossbedded, massive, chert and quartz sandstone. Overlying this is a considerable thickness of recessive, interbedded dark grey, very fine-grained, calcareous sandstone and greenish grey, silty shales.

About 2,000 feet above the base of the formation, on the divide between Oyster and Lost Creeks, an abundant Upper Cretaceous, brackish-water, shelly fauna occurs in greenish grey shales

with sparse greenish grey, rusty weathering sandstones. According to E. T. Tozer, the fauna contains Ostrea glabra Meek and Hayden, Corbicula occidentalis Meek and Hayden and Unionid indet. Tozer states that the most widespread faunule of this type occurs in the basal member of the St. Mary River formation and both species occur in the Foremost formation of the Alberta Plains. At roughly the same stratigraphic interval above the base immediately east of the Lewis thrust along the south boundary of the area abundant Viviparus conradi Meek and Hayden and Campeloma vetula Meek and Hayden occur. According to Tozer, they are forms typical of the Judith River formation of Montana. They occur also in the Foremost formation and the Belly River formation of the southeastern part of the Disturbed belt.

STRUCTURAL GEOLOGY

The Beehive Mountain map-area includes segments of the Disturbed belt and the High Rock Range of the Rocky Mountains. Five structural units make up the area, the four easterly ones within the Disturbed belt and the westernmost forming the High Rock Range. The units are underlain from east to west by the Livingstone thrust, the McConnell thrust, the Coleman fault, the Etherington Creek fault and the Lewis thrust.

LIVINGSTONE THRUST SHEET

The structures within the Livingstone thrust sheet as well as beneath it are particularly significant, in that they involve proven gas reserves in Palaeozoic strata of the Savanna Creek field. The reservoir structure, herein defined as the Savanna Creek anticline, underlies the Livingstone thrust. Its crestal plane is about coincident with that of the Plateau Mountain anticline above the thrust.

The surface anticline culminates in the extreme northeast corner of the area at the crest of Plateau Mountain and plunges south at 5 to 10 degrees within strata that form the southern termination of Highwood Range. The anticline is interpreted to continue beneath highly faulted and folded, incompetent Jurassic and Cretaceous formations through the southwest corner of the adjacent Livingstone River map-area (Norris, 1958) and to form the Fly Hill anticline in the Gap area to the southeast. Three and one-half miles to the north of the culmination the anticline is cut off by the Sentinel Peak fault, and Palaeozoic strata forming the west flank of the anticline continue north as a west-dipping sequence in Mount Head map-area.

Surface and well data suggest that the form of the Plateau Mountain anticline is a fair expression of the form of the subjacent

Savanna Creek anticline. Both fold structures appear to culminate at about the same point although well data indicate little or no southward plunge of the Savanna Creek anticline between the crest of Plateau Mountain and Dry Creek.

The discovery well Husky-Northern-Target Savanna Creek No. 1 was spudded in river gravels on Dry Creek (see cross-section AB). It encountered the Livingstone thrust at a drilling depth of about 100 feet, and drilled what appears to be a normal succession from lower Wapiabi strata through to the middle of the Mount Head formation before encountering a second major thrust at a depth of 5,230 feet (the H-N fault of Scott, 1957). It then passed into Kootenay strata and continued through the underlying formations into the basal part of the Banff formation at a total depth of 9,035 feet. The Phillips-Husky-Northern-Target Savanna Creek No. 2A well was spudded approximately a mile east of the discovery well and after penetrating 420 feet of the Livingstone formation drilled some 1,000 feet of beds thought to be Mount Head formation before cutting the Livingstone thrust at 1,450 feet. This occurrence of possible Mount Head strata is interpreted as due to the presence of a large lens-shaped, imbricated mass involved in a structure not unlike that mapped by Douglas (1956) in the extreme southwest corner of George Creek area. The possibility of this slice consisting largely of unfaulted Mount Head strata with top Livingstone beds in normal succession below it (as necessitated by the thickness of the unit) seems unlikely because of the presence of Carnarvon (top Mount Head) lithology within 200 feet of the Livingstone thrust. Below the Livingstone thrust the drill encountered a normal succession from low Wapiabi to mid-Blairmore strata before penetrating the H-N fault at a drilling depth of 4,400 feet (see structure-section AB). There the fault is entirely within the Blairmore formation and has a stratigraphic throw of about 1,100 feet. Below the H-N fault the drill penetrated a normal succession from high Blairmore to low Livingstone strata at a total depth of 8,481 feet.

On Plateau Mountain 11,000 feet north of the discovery well, P.H.N.T. Savanna Creek No. 3A well was commenced close to the culmination of the surface anticline. Essentially the same stratigraphic and fault succession was drilled and porous Livingstone strata were reached at about the same elevation as in the discovery well. P.H.N.T. Savanna Creek No. 3A was completed in Devonian rocks at a total depth of 13,798 feet.

The surface and drilling data suggest that the Plateau Mountain anticline and the subjacent Savanna Creek anticline were produced during thrusting. They appear to be the result of gliding of the Livingstone thrust and folding of a thick succession of Palaeozoic strata above and Palaeozoic and Mesozoic strata below the fault. Competent Blairmore strata with a veneer of Alberta group immediately underlie a Livingstone thrust glide plane in this

area. Livingstone strata overlie it. As the thrust is believed to cut more rapidly down-section to the west in the Blairmore group there would be a steepening of the thrust plane. The consequent increased resistance to forward movement folded the foot-wall beds anticlinally and bulged up the thrust sheet to form the Plateau Mountain anticline. The reservoir at depth was, moreover, accentuated in a similar manner on the H-N fault.

McCONNELL THRUST SHEET

The surface trace of the McConnell thrust is on the west flank of the Plateau Mountain anticline. In the vicinity of Plateau Mountain and Forest Divide the immediate hanging-wall is intensely imbricated with slices of Etherington, Rocky Mountain, Spray River and Fernie strata. For at least 12,000 feet down dip the foot-wall is believed to consist of Etherington formation. The mapping of this complex and the continuation or petering out of particular splays from the main thrust may be open to alternative views, but the overall picture must remain essentially the same.

To the southeast the McConnell thrust is transferred from an Etherington-Rocky Mountain to a Fernie-Kootenay zone of bedding-plane slippage. The fault complex is additionally complicated by folding of the structure over the Plateau Mountain anticline in the adjacent Livingstone River map-area (Norris, 1958).

West of the McConnell thrust are generally steep-dipping, folded Fernie to Cardium strata inclusive, with minor faulting. The presence of steep dips and extensive bedding-plane slippage of the McConnell thrust sheet towards the top of the Palaeozoic succession indicates that the McConnell (and possibly also the Livingstone) thrust continues to great depths as essentially a bedding-plane feature.

COLEMAN FAULT SHEET

Strata within this sheet form a relatively undeformed north-trending succession in the central part of the map-area. The surface trace of the Coleman fault crosses Oldman River about a mile below the Falls and passes just east of the crest of Cyclamen Ridge and Pasque Mountain. On the ridge west of Wilkinson Creek the fault splays and is tightly folded along with Blackstone and Cardium strata in the immediate foot-wall and the slice of Kootenay and Blairmore beds above it.

To the west of the Coleman fault is a west-dipping succession from Kootenay to Belly River strata with only minor deformation.

ETHERINGTON CREEK FAULT COMPLEX

Between the Etherington Creek fault and the Lewis thrust is a complex of imbricated slices of Kootenay to Belly River strata. Because of extensive forest cover in this area outcrops are few and widely scattered and the continuity of successive slices is conjectural. The southward simplification of the complex to where it is overridden by the Lewis thrust sheet is, however, considered to be real.

The faults are believed to have developed in response to overriding of the Lewis thrust sheet. Their behaviour as they approach the Lewis thrust is indicated in the vicinity of Beehive Mountain. There they are overridden by and folded together with the thrust. Although exposures are few, it is evident that the faults are not truncated abruptly, but rather approach the major sole fault above them asymptotically. This behaviour is to be expected because of the pronounced changes in both direction and intensity of stress in the immediate neighbourhood of a fault surface (Anderson, 1951). The rapid diminution of stress at the fault is believed to create a 'protective zone' (Hafner, 1951) and the development of faults in the foot-wall (as well as in the hanging-wall) leading directly into this zone is considered unlikely.

One-half mile east of Beehive Mountain is a double klippe with Rocky Mountain strata thrust onto Kootenay and these in turn onto low Belly River beds. It provides additional evidence of the tight folding of some of the slices caught in the Etherington Creek fault complex.

LEWIS THRUST SHEET

The Lewis thrust underlies High Rock Range. Its sinuous trace low on the east flank of the range is indicative of a rather gentle westward dip and of some folding. Throughout the area the thrust lies about 250 feet below the top of massive Palliser limestone.

High Rock Range is for the most part a homoclinal, west-dipping succession from top Palliser formation to the upper Kootenay. From Beehive Mountain south to Gould Dome, a distance of about 11 miles, Palaeozoic rocks forming the front of the range are folded together with the Lewis thrust and the complex of fault slices below it. A fenster in the anticlinally folded part of the Lewis thrust has been developed in a large cirque at the headwaters of Ewin Creek. On the east and north sides of the cirque interbedded green, medium-grained, chert and quartz sandstone and green, rubbly, silty shales were observed in fault contact with upper Palliser limestone. The occurrence of Blairmore strata in

the same structural position along strike to the north would suggest that these green beds belong to the Blairmore formation. Similarly Cardium and possibly Blackstone strata may be present in an underlying fault slice concealed in the swampy and low-lying terrain within the amphitheatre (see structure-section CD). The presence of Cardium strata is also inferred in a fenster at Beehive Pass.

The occurrence of about the same thickness of Palliser strata rimming the fenster at the head of Ewin Creek and outlining the re-entrant in the mountain front at Beehive Pass indicates that the Lewis thrust must essentially parallel the bedding for at least 3 miles across the strike where the thrust is folded.

ECONOMIC GEOLOGY

BASE METALS

In High Rock Range on the northeast flank of Mount Gass lead-zinc minerals are present. They occur in two zones along minor splays from the Lewis thrust about 50 feet below the top of the Palliser formation. The lower zone is at most 30 feet thick and the upper one 10 feet thick. Both are well exposed for about 500 feet along the face of the mountain, the lower one having been extensively prospected by West Canadian Collieries, Blairmore, Alberta. No similar occurrences were found anywhere else in the map-area.

PETROLEUM AND NATURAL GAS

The Savanna Creek gas field is in the northeast corner of the map-area. There considerable reserves have been proven in Mississippian rocks of the Savanna Creek anticline. To date three wells have been completed and two are being drilled. Four of these are within the area. The completed wells are H.N.T. Savanna Creek No. 1 and P.H.N.T. Savanna Creek No. 2A in Dry Creek valley, and P.H.N.T. Savanna Creek No. 3A on the crest of Plateau Mountain. The two wells being drilled are P.H.N.T. Savanna Creek No. 11-30 on the west flank of Plateau Mountain and P.H.N.T. Salter No. 1A on the north flank of the mountain in the adjacent Mount Head map-area.

Information to date would indicate that the limits of the Savanna Creek gas field lie within Beehive Mountain and Mount Head map-areas. The northern extension of the Savanna Creek anticline beyond the termination of the surface fold is difficult to assess. Southeastward however it is entirely possible that the reservoir structure continues beneath the Fly Hill anticline with a second major culmination beneath the Turtle Mountain anticline in Blairmore map-area.

The prospects of discovering structures favourable to the accumulation of petroleum and natural gas within the map-area west of the surface trace of the McConnell thrust are not encouraging because of the great depths to possible closures in Palaeozoic rocks. Structural data suggest that the Palaeozoic rocks forming the core of the Plateau Mountain anticline plunge steeply westward with only minor disturbances, to drilling depths much in excess of 10,000 feet. As the front of High Rock Range is approached, moreover, favourable reservoir rocks are at even greater depths because of wholesale thickening of Cretaceous formations within the Etherington Creek fault complex.

COAL

Coal deposits in the Kootenay formation in the east half of the map-area are not considered to be of immediate economic value. The few indications examined suggest thin seams of no great lateral continuity. Experience gained elsewhere suggests, however, that the most favourable horizon for prospecting is at the top of the shale member and hence beneath the resistant sandstones forming the top member of the formation. In the extreme southwest corner of the area the Kootenay formation is about 2,000 feet thick and contains many thin coal seams. The area has been prospected since the turn of this century and the mineral rights are held by the Crowsnest Pass Coal Company, Fernie, B.C.