PROVINCE OF ALBERTA
Research Council of Alberta Report No. 52
University of Alberta, Edmonton, Alberta

Geology of
Ribbon Creek Area
Alberta

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EDMONTON
PRINTED BY A. SHNITKA, KING'S PRINTER
1949

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Geology of Ribbon Creek Area Alberta

Chapter I

INTRODUCTION

LOCATION AND ACCESS

Ribbon Creek map-area lies within the front ranges of the Rocky Mountains of southwestern Alberta and immediately south of the Bow river. This area adjoins two previously mapped areas, these being Highwood-Elbow on the south (Allan and Carr, 1947) and Canmore on the north (MacKay ,1935). The area included in the map is slightly under 150 square miles; only about one-half of this has been mapped geologically, however, since the principal object of the survey was to map the coal resources of the Mesozoic. General consideration only has been given to the Paleozoic formations. The map-area lies between longitudes 115 degrees and 115 degrees, 20 minutes west, and between latitudes 50 degrees, 40 minutes and 51 degrees, 5 minutes north. On the basis of governmental land surveys, the geological area mapped is located in ranges 8, 9 and 10, townships 21, 22, 23 and 24, all west of the fifth meridian. It straddles the Kananaskis river, which, draining northwards in these parts, divides the map-area into two more or less equal parts. Except for a small portion at the north end, the area is wholly within the Rocky Mountains Forest Reserve. The central part of the area is occupied by the Kananaskis Forest Experiment Station, which is operated by the Federal Government. The north boundary of the map-area is about five miles southeast of the coal mining town of Canmore; the south boundary lies on the height of land separating the Bow and Elbow River systems. The area itself is about fifty miles due west of Calgary.

Trend throughout the length of the map-area is in a northwest-southeast direction, and has been determined by the attitude of the strata and by the direction of the stratal breaks. These breaks are directed about 30 degrees west of north, and are directly responsible for the trend of the Rocky Mountains in these parts as elsewhere in Alberta. The east and west boundaries of the map-area parallel the average strike of the strata.

Although the area is situated on the south side of Bow river only a few miles from the main line of the Canadian Pacific Railway, there is no bridge at this point, and access to the area is obtained by way of Canmore or Seebe. The northern part is best reached by way of a road extending from Canmore to the mouth of Pigeon creek. From thence a pack trail leads to Kananaskis river via Wind, Pigeon, and Lorette creeks. The central part can be reached by a graded, gravelled road, which extends from the railway siding of Seebe southwestwards along Kananaskis river. This road leads to Kananaskis lakes, but a few miles beyond Evans-Thomas creek it becomes unsuited to most motor vehicles. A pack trail extends southwards along Evans-Thomas creek into the region drained by Elbow river. Certain parts of the map-area adjacent to Kananaskis river have been timbered, and are readily reached by lumber trails. One such part lies between Ribbon and Lorette creeks. In most parts travel is difficult owing to the steep slopes, heavy timber, muskeg, deadfall or burned-over areas.

PREVIOUS WORK IN THE REGION

Earliest records of the geology of this region were made by Dr. James Hector (Hector, 1863), who was attached to Captain John Palliser's expedition. Palliser's map of this region is one of the earliest to have been compiled, and many of the current geographical names in the Bow River region were bestowed by members of this expedition. G. M. Dawson investigated the geology of the region in the years 1881-1884; his reports give some attention to the coal deposits of the Cascade coal basin, which includes the area covered in this report (Dawson, 1885; Dawson, 1886). R. G. McConnell, formerly an assistant to Dawson, did further work in the Rocky Mountains (McConnell, 1887), and is largely responsible for the division of the rock succession into lithologic units, which have undergone little revision to this day. McConnell also referred to the coal seams in Bow valley. The first detailed geological surveys of the region were made by D. B. Dowling in 1903 (Dowling, 1904) and 1904 (Dowling, 1906). In subsequent years, Dowling contributed further data regarding structure, stratigraphy, and economic possibilities of the coal seams of the Cascade coal basin (Dowling, 1907, 1909, 1914, 1923). Dowling's geological maps of this region were the first large scale maps (1 inch to 1 mile) to be published, and his Report on the Cascade Coal Basin, Alberta, is the most complete on that area. In 1934 B. R. MacKay mapped in great detail a small area in the vicinity of Canmore (MacKay, 1935), but no report accompanies his maps.

The valley of the Highwood, which is due southeast of the Ribbon Creek area, and which contains important coal seams, has been the subject of investigations by many workers. Dawson's geological explorations there were of a reconnaisance nature (Dawson, 1886). B. Rose studied the coal measures of that area in 1918 (Rose, 1919). Further work in this area was done by J. A. Allan and J. L. Carr in 1945 and 1946, and a report in some detail was published (Allan and Carr, 1947).

PRESENT WORK

Though the Cascade coal basin had been investigated by government geologists on numerous occasions, detailed surveys had been confined to special areas, and some parts had received comparatively little attention. One such area was that lying between Highwood-Elbow area (Allan and Carr, 1947) and Canmore area (MacKay, 1935), and is the subject of the present report. Within this area, along Ribbon and Evans-Thomas creeks, coal had been shown to be present in some quantity by independent prospectors. Since this area was close enough to the railroad to warrant development should occasion arise, it was considered advisable to obtain more information on it by detailed surveys.

Geological data and most of the other information included in this report were gathered during three months of the 1947 field season and during a few weeks of the 1948 season.

Between 1886 and 1919 some survey lines had been run by Dominion Government agencies, and the monuments thus established were used in the present surveys as the basis for a network of horizontal control stations. Topographic control was supplied in part by the following maps: Calgary Sectional Sheet No. 114, and Palliser-Kananaskis area, Publication 1962, both being issuances of the Department of Mines and Resources, Ottawa. Some of the topography within Kananaskis Forest Experiment Station was kindly supplied by officers of that station, who were currently conducting within its boundaries surveys of that nature. These maps have been used in the compilation of the geological map which accompanies this report. In addition to the foregoing, minor corrections with respect to the drainage have been made by reference to aerial photographs, which became available for the first time in the winter of 1947-48, since the area was photographed from the air in the fall of 1947. A few other corrections were made from observations in the field.

Stratigraphic sections were measured by steel tape, step method, plane table, or telemeter surveys. Some sections were trenched to expose bedrock, and it was found necessary to uncover most of the coal seams in order to determine their thickness and the character of the coal. A number of coal samples were taken, and have been analysed by the Fuels Division, Research Council of Alberta. Wherever pertinent, stratal sections measured were plotted to scale for the correlation of various horizons, especially coal seams, and for comparing thicknesses of formations.

Collections of macrofossils were obtained from Paleozoic, Triassic, Jurassic and Cretaceous formations. In general, the formations are not very fossiliferous, and our fossil collections have not added much to the present knowledge of their faunas and floras.

ACKNOWLEDGEMENTS

Able assistance in the field in 1947 was given by Gordon G. Scruggs, student assistant, and John T. Cook, cook. In 1948, W. H. A. Clow, assistant geologist, and J. T. Cook and P. H. S. Byrne, student assistants, performed their duties in a capable manner. W. H. A. Clow studied the thin sections and otherwise assisted in the preparation of this report. Frank Wilson, packer and cook, fulfilled those functions to the satisfaction of all. J. S. Groot, draftsman of the Research Council of Alberta, prepared the accompanying map and figures. Appreciation is extended to the above for the assistance rendered. Members of the staff of the Department of Geology, University of Alberta, have been generous in giving their qualified advice. Dr. J. A. Allan, head of the department, and also member of the Technical Advisory Committee, Research Council of Alberta, offered suggestions which contributed considerably towards the organization and progress of the investigation. Dr. P. S. Warren identified the fossil faunal collections, read parts of the manuscript, and gave valuable guidance in reaching conclusions regarding the stratigraphy of the area. Dr. R. L. Rutherford aided greatly in determinations of rock types. Dr. W. A. Bell, paleobotanist with the Geological Survey of Canada, kindly identified fossil plant collections.

Messrs. H. L. Holman, J. L. McLenahan and O. C. Larrson, officers of the Dominion Forestry Service rendered many courtesies during the survey, and to them the writer expresses his gratitude. Facilities of the Service as well as data from topographic surveys, which were currently being run under the direct supervision of Mr. Larrson, were placed at the disposal of the Research Council. Messrs. T. F. Blefgen and J. Kovach of the Alberta Forest Service are given thanks for services cheerfully rendered.

Officials of the Canmore Mines Ltd., Messrs. R. M. Young, W. Wilson, H. Crawford, and C. S. Dewis gave every assistance possible in the progress of the survey; and appreciation is extended to them for their many courtesies and for the data supplied. Drill hole and other data relative to operations of the Kananaskis Exploration and Development Company were kindly supplied by Messrs. A. D. Sturrock and H. J. Scott, officials of that company, and by G. A. Vissac, consulting engineer.

Chapter II

GENERAL CHARACTER OF THE REGION

PHYSICAL FEATURES

The most prominent topographical feature of the region is the broad valley extending through the centre of the map-area in a northwesterly-southeasterly direction, and formed by the coalescence of the valleys of Pigeon, Lorette, and Evans-Thomas creeks, together with that section of the Kananaskis valley lying between the mouths of the two last-named creeks. This broad valley is structurally and topographically related to that part of the valley of Bow river adjoining the map-area on the north, for it lies between the same two parallel rows of mountain ranges that extend from the south end of the map-area northwestwards beyond Canmore. Within the map-area the valley is delimited on the west by Wind mountain, Mounts Bogart and Kidd, The Wedge and Mounts Evans-Thomas, Packenham and Hood; and on the east it is defined by Pigeon mountain, and Mounts Lorette, McDougall, and Fisher. In the northern part of the map-area Mount Allan is situated within this topographic basin, and hence the floor of the valley is deflected eastwards and upwards to pass around the base of the mountain. Southeast of this mountain mass the floor of the valley drops to meet the Kananaskis River valley, and the trough resumes its regular southeast trend. From thence the valley rises and narrows rapidly as it follows along Evans-Thomas creek, and finally terminates in the vicinity of Mount Evans-Thomas. Northwards from Mount Allan, the floor descends to the valley of Bow river.

The development of this trough can be ascribed to the nature of the bedrock as well as to the geological structure mentioned above; for the trough is floored with Mesozoic sandstones and shales of the Spray River, Fernie, Kootenay, and Blairmore formations, whereas the walls are composed of Paleozoic limestone, dolomite and quartzite, which are relatively much more resistant. Hence more rapid erosion of the Mesozoic sediments has caused Paleozoic rocks to stand out in a relief that is often many thousands of feet in height. Structurally the trough is a syncline; the strata of the mountains on the eastern side, viz., Pigeon, Lorette, and McDougall dip westwards from 15 to 45 degrees, but on closely approaching the western limestone wall, dips decrease to almost zero and then are abruptly reversed, the strata dipping from 75 degrees eastwards to 50 degrees westwards overturned. This syncline is the southern end of a larger structure somewhat synclinal in nature for the greater part, which extends northwestwards from this map-area to include parts of Bow valley, Cascade valley and even valleys of the headwaters of the Panther river, a tributary of the Red Deer river. Hence the probable length of the syncline is about sixty miles. Its width is much less, having a maximum of about 6 miles.

The syncline is widest where it is occupied by the valley of the Bow and for a few miles along the projection of this valley southeastwards. In the vicinity of Kananaskis river it begins to narrow, and southwards tends to lose its identity as a structural unit, since the strata become so greatly contorted and faulted that any definite form is lost.

Topographic relief within the map-area amounts to nearly 6,000 feet. The highest peak in the area is Mount Bogart which has an elevation of 10,315 feet. This mountain is wholly composed of Paleozoic rocks, and consequently was not mapped geologically. Lowest elevations in the area are found in the valleys of Wind creek and Kananaskis river, where they are about 4,400 and 4,600 feet respectively. Mesozoic rocks comprise many ridges and peaks, and the highest peak exposing non-Paleozoic rocks is that of Mount Allan, lying east of the south end of Wind mountain, and located in section 17 of township 23, range 9. Mount Allan has an elevation of 9,150 feet, and occupies a commanding position in the topographic trough and structural syncline described above. It probably owes its origin and preservation to a thick capping of massive, weather-resistant conglomerates and to a well developed synclinal structure. This mountain almost blocks the inosculating valleys of Pigeon and Lorette creeks, and topographically almost divides the major valley into two parts. From this peak three long ridges radiate, the most prominent taking a northeastern direction, so that the mountain covers an area of many square miles.

Adjacent on the east to the limestone ranges which comprise the western wall of the syncline there are a number of ridges composed essentially of Mesozoic sandstones and shales. These ridges are disposed with their longer axes at right angles to the trend of the mountain ranges. They vary in length, and Wind ridge, which lies immediately north of West Wind creek, and at the extreme north end of the map, is one of the longest. The ridges have elevations of over 7,000 feet, and are separated by deep gorges. Usually they are connected to the Paleozoic limestone ranges by saddles. Especially prominent are the ridges that are attached to the eastern side of Wind mountain (Figure 1); less prominent ridges are found on the eastern side of the mountain called "The Wedge" and also on Mount Kidd. Mount Evans-Thomas has well-developed ridges extending northeasterly and easterly from it. All ridges are well timbered, almost to their tops in most cases, and are precipitous in the many places where thick sandstone beds outcrop. Both forest cover and precipices are factors in making prospecting for coal difficult.

Topography has been greatly modified by glaciation, the wide valleys of Bow and Kananaskis rivers having the U-shape typical of glaciated valleys. This is also true of the valley of Evans-Thomas creek, which has been enlarged by ice action since it is much wider and deeper than is warranted by the size of the stream. Often streams head in cirque-like amphitheatres or hanging valleys that ostensibly once sheltered glaciers. Mount Allan has two such well-developed cirques (Figure 1), and probably growth of these features is responsible for the development of the peak and the sharp ridges radiating from it. These cirques terminate in steep cliffs, and a few are sufficiently basin-like to hold small lakes. West Wind creek arises in a large cirque at the north end of Wind mountain. Roches moutonnées are present in the valleys of Lorette and Evans-Thomas creeks. Glacial deposits do not form a continuous mantle, and when present consist of small piles of gravel, boulder clay, and glacial erratics. The last are abundant and are found as high as 7,500 feet above sea level, and some of them may be relics of lateral moraines. Some morainal deposits are situated in the lower parts of the valleys of Pigeon and Evans-Thomas creeks, and along Kananaskis river. Boulder clay is present in patches especially in some of the gorges, and indicates a pre-Glacial age for at least some of these deep valleys. One such deposit has been carved into earth columns or hoodoos (Figure 2).

River terraces are present in Kananaskis valley. Some are in an advanced state of dissection and are identified as such by flat tops, and equal elevations with known terraces.

Drainage within the map-area is effected by the Bow and Kananaskis River systems, and in the extreme southwestern corner by the Little Elbow-Elbow system. Pigeon creek and its principal tributaries, South Wind and West Wind creeks, drain the northern part of the area into Bow river. Kananaskis river, which bisects the map-area, through which its course is mainly northward, arises in Kananaskis lakes some twenty miles south of the map-area, and joins Bow river at Seebe. Drainage of the larger part of the map-area is accomplished by this river, since Ribbon, Marmot, Lorette and Evans-Thomas creeks flow into it. Most of the streams within the area have their origin in snowdrifts, hence their waters are highest during the early summer when snow is melting; many are dry in late summer. West Wind creek is fed in part by muskegs which occupy parts of a large basin at the north end of Wind mountain, and therefore it is not subject to the extreme variations in flow as are most of the other streams. Ribbon creek receives its waters principally from a few small lakes, and from the snowdrifts of the ranges on the west. Many of the streams such as Pigeon, Lorette and Evans-Thomas, parallel the mountain ranges and are subsequent streams. In that part of its course across the map-area Kananaskis river cuts through mountain ranges and is therefore antecedent. Rapids and small waterfalls are common in the streams, and in most places the falls arise where the stream course is normal to the strike of the strata. Evans-Thomas is the longest creek within the map-area. Its water does not reach Kananaskis river directly since it sinks into gravels as it approaches within one-half mile of the river. The extreme southern part of the map-area is drained southwards into Little Elbow river by a small creek that arises in springs, muskeg and a small lake. The divide separating this stream from Evans-Thomas creek has little topographic expression, consisting of a small group of grassy, shrubby knolls and rocky knobs in the centre of a wide valley. These elevations are almost completely surrounded by muskeg.

There are few lakes within the area. One of these lies within a land-locked basin near the mouth of Evans-Thomas creek. Another small lake serves as a source of water for the main branch of Ribbon creek, and there are three small lakes at the head of the south fork of Ribbon creek. In addition to these there are several cirque lakes at higher elevations.

CULTURE

There are no permanent settlements within the map-area. At times lumbering operations have been carried on in it, especially during and following World War II when camps, now abandoned, were maintained on Marmot, Ribbon and Evans-Thomas creeks. These camps were largely staffed by prisoners of war, whose energies were directed principally towards the salvaging of timber from burned-over areas for use in coal mines. The operators have left a network of roads, that facilitated travel in the present surveys. Other buildings in the area are several pavilions which have been constructed along Kananaskis river for the convenience of anglers and vacationers, who frequent the region in considerable numbers during the summer season. In addition the Alberta Forest Service has two temporary camps within the area.

A coal mine was opened up on Ribbon creek in the fall of 1947. Plans for a townsite were under consideration at the time of the writer's visit in September, 1948.

FAUNA AND FLORA

Since the map-area lies within a game preserve, wild animals being protected are abundant. Black and brown bears are numerous, and constitute a constant threat to any camp commissary. Grizzly bears are present but seen only occasionally. Elk, deer, mountain sheep, and mountain goats are quite plentiful, and do not manifest much alarm at the presence of humans. Smaller animals include beaver, muskrats, coyotes, marmots, rabbits, porcupines, weasels, squirrels, chipmunks and conies. The region is renowned for its fish-ing, trout and grayling being obtained in the lower parts of the streams. Since waterfalls are a common feature of the terrain, they often prevent fish from invading the upper reaches of the streams. Grouse and partridge are common, and several coveys of ptarmigan were seen on the uppermost slopes of Mount Allan. Smaller birds are quite numerous.

Trees and shrubs are those usual to the Rocky Mountains of these latitudes, with the possible exception of Douglas fir, which is found in groves in a few localities within the area. Willow and black poplar thrive at the lowest elevations, jackpine dominates the burned-over areas, and spruce covers the sides of the ridges and mountains to timber line, which here occurs at elevations of 7,000 to 7,500 feet. Tamarack grows near the timber line, but is nowhere abundant. A profusion of flowers covers some of the slopes during the middle of the summer. The area has a varied and bountiful alpine flora, for many of the flowers were observed only at and above timber line.

There are numerous muskegs within the area. The largest one observed lies at the head of Wind creek and occupies a large part of this basin. Another such area is situated close to Evans-Thomas creek and between it and The Wedge. The waters of Evans-Thomas creek and Little Elbow originate largely in muskegs.

The valleys of Evans-Thomas, Ribbon, Lorette, Pigeon, Wind, and West Wind creeks are heavily timbered for the greater part. The forest growth hampers movement, and so conceals bedrock that examination of the latter is confined principally to water courses and to those parts above timber line. Occasionally, clearings, muskegs and burned-over areas occur. The valley of Kananaskis is fairly open within the area, and this is especially true of that part of the valley adjacent to Mount Kidd. Here the southerly-dipping slopes and river terraces are grass-land, with occasional clumps of trees. Kananaskis valley north of Ribbon creek has been cleared of timber to a large extent, operations that were accomplished by prisoners of war and others during World War II.

Chapter III

STRATIGRAPHY

GENERAL STATEMENT

All rocks which were observed in the map-area are sedimentary and range in age from Devonian to Recent, though there are several large breaks in the succession since Permian (possibly), Middle and Upper Triassic, all Upper Cretaceous and Tertiary are lacking. Paleozoic rocks, Devonian and Carboniferous in age, are prominently exposed on the east and west confines of the area. Pre-Devonian rocks may be present, but were not identified. since the survey did not involve a detailed study of the Paleozoic formations. Of the Mesozoic rocks, only Triassic, Jurassic and Lower Cretaceous formations are represented. Upper Cretaceous and Tertiary rocks were unquestionably present at one time, but were eroded from the area since and during the Rocky Mountain orogeny. Pleistocene deposits are present in the form of boulder clay, silt, glacial erratics, and other glacial deposits. Recent deposits consist of a thin soil mantle, which is not present everywhere, and beds of gravel, sand, silt, and clay which have been deposited by stream action during periods of high water.

The immense stresses of mountain-building movements during the Laramide Revolution, when the Rocky Mountains were formed, have affected the once flat-lying strata, so that now they repose at various angles, are folded, faulted, fractured, and often contorted. The resulting disorder, combined with a general paucity of key beds and sporadic exposures, makes the accurate measurement of formational thicknesses very difficult.

PALEOZOIC FORMATIONS

Paleozoic rocks dominate the horizon since, being more resistant to erosion and weathering, they form the highest mountain ridges and peaks, which almost surround the map-area. Many good sections of Paleozoic rocks are exposed; and, because the strata dip westward, could be conveniently studied along the several antecedent streams, especially along Kananaskis river. Excellent sections are exposed on the faulted eastern faces of some mountains, such as Pigeon, but in many cases these faces are so steep as to be inaccessible, or accessible only with great difficulty. Field acquaintance with the Paleozoic stratigraphic succession was more or less casual, since only sufficient examinations of them were made to permit recognition. Fairholme, Palliser, Exshaw, Banff, Rundle and Rocky Mountain formations were identified in the area.

The **Fairholme formation,** consisting of dark grey, fine-grained dolomites was observed at the base of the eastern faces of some of

TABLE I

TABLE OF FORMATIONS

Group	System	Series	Formation	Character	Thickness feet
Cenozoic	Quaternary	Recent and Pleistocene		Soil, gravel, silt, talus, boulder clay.	
			Unconformity		
Mesozoic	Cretaceous	Lower Cretaceous	Blairmore	Green, grey, black and maroon shales, interbedded with grey and greenish grey sandstones; limestone nodules; massive conglomerate at base.	Only lower part present 1000+
			Contact apparently conformable		
			Kootenay	Dark grey and black shales, interbedded with fine-grained, silty sandstones, dark grey, coarse-grained sandstones; conglomerate beds near top; coal seams; thick sandstone member at base.	3400
	Jurassic	Upper Middle Lower	Fernie	Fine-grained, grey sandstone at top; greenish grey, dark grey and black shale; ironstone nodules and stringers.	1095
			Unconformity		
	Triassic	Lower	Spray River	Dark grey, sandy shale and shaly, fine-grained sandstone, dolomitic shales and argillaceous dolomite; limestone.	600
			Unconformity		
Paleozoic	Carboniferous	Pennsylvanian Mississippian	Rocky Mountain Rundle Banff	Limestone, dolomite, calcareous shale, shale, quartzite, sandstone.	?
	Devonian	Upper	Exshaw Palliser Fairholme		

the mountains. The **Palliser formation** forms most of the precipitous eastern mountain faces. It also is essentially dolomite, and weathers light grey. The typical SPIRIFER WHITNEYI fossil zone at the top is sparsely fossiliferous in the few places where it was examined in the area. The dark brown to black **Exshaw** shale is well developed within the map area, but yielded no fossils. It weathers to a distinctive reddish brown color, which enables it to be traced from mountain to mountain. It erodes quite readily as compared to the underlying Palliser and overlying Banff formations, hence usually occupies a depression. The **Banff formation** contains a number of thick, massive limestone strata in its upper part, and these make the upper boundary of the formation difficult to place. The Banff formation does not form the precipitous faces as is the habit of the Palliser and Rundle formations, and hence can usually be recognized by the less severe slopes between those formations. In places the Banff formation is abundantly fossiliferous. The **Rundle formation** consists of cliff-forming limestones, which weather to present a typical banded appearance when viewed from a distance. It caps many of the mountains, and is also exposed in the valleys of Bow and Kananaskis rivers.

The **Rocky Mountain formation** is composed chiefly of dolomite, quartzitic sandstone and quartzite. Strata of this formation cover the western slopes of many mountains and quartzitic members are readily recognized by the dark, purplish grey colour when seen from a distance. Good sections are exposed in Pigeon and McDougall mountains. Slices were observed under the Paleozoic overthrust on Mounts Kidd and Evans-Thomas. Contact with the Rundle is placed at the change from coarse, grey, fossiliferous limestone to fine-grained, creamy-white weathering, cherty, dolomite. Contact of the Rocky Mountain formation with the overlying Spray River formation was not observed in the map-area, although beds estimated to be only a few feet from it were examined. An almost complete section of Rocky Mountain formation is present on the east slope of Pigeon mountain, but the very uppermost beds are hidden by talus from the cliffs of Spray River shale. The thickness of Rocky Mountain formation measured on the mountain, is about 607 feet. This figure does not include a concealed interval, estimated to be about 20 feet, so that 625 feet seems a reasonable estimate to apply to the formation in this area. Along Evans-Thomas creek the actual Rocky Mountain-Spray River contact is concealed by the gravels of the stream bed. The uppermost observed bed of the Rocky Mountain formation is a breccia composed of angular chert and rounded quartz pebbles and having the uppermost surface deeply pitted. These pits measured as much as 18 inches in diameter and 12 inches deep, and are suggestive of an erosional surface. In one place a few feet of black sandy shale with quartzitic nodules lie above the chert conglomerate, but it is not known whether this bed is persistent.

MESOZOIC

TRIASSIC

Spray River Formation

NAME: Originally this formation was designated the Upper Banff Shales by McConnell, and given a Carboniferous age (McConnell, 1887). Dowling applied the same name to the formation (Dowling, 1907), but suggested a Permo-Triassic age, since the formation lay between strata of known Carboniferous and Jurassic ages. Lambe and Kindle were the first to prove the Triassic age for the formation (Lambe, L.M. and Kindle, E.M., 1916). Later Kindle revised the formational nomenclature of the Banff region, giving this formation the name by which it is now known (Kindle, 1924).

DISTRIBUTION: With few exceptions the Spray River formation occurs as a band extending throughout the northwest-southeast trending valleys of Pigeon, Lorette, Marmot and Evans-Thomas creeks and the headwaters of Little Elbow river in the south of the map-area (Figure 3). Due to the relative weakness of the siltstones, which largely comprise the formation, the streams have cut their channels deeply into these rocks. Remnants of this formation still cling to the sides of some of those mountains which form the eastern boundary of the mapped area, the most prominent occurrences being on the western slopes of Pigeon mountain and Fisher peak. Several Triassic outliers are present on the upper slopes of Pigeon, Lorette, and McDougall. Dips are low in the outliers, an attitude that has contributed to the endurance of these rocks.

Thin slices of Spray River formation have been carried up under Mounts Hood and Evans-Thomas by the Paleozoic overthrust.

THICKNESS: A section of Spray River formation, complete except for about 20 feet at the bottom, is exposed on Evans-Thomas creek, and is considered to be the type section for the map-area (Figure 4). The section measures 583 feet, and consequently 600 feet is suggested for the thickness of the whole formation. Except for a few small, transverse faults, the strata are only slightly disturbed. The figure of 600 feet accords fairly well with that of 240 to 800 feet in the Highwood-Elbow area adjoining on the southeast (Allan and Carr, 1947, p. 15) and that of 900 feet in the Canmore area adjoining on the northwest (MacKay, 1935, Structure Sections). The formation decreases in thickness from west to east, since a probable thickness of over 1,800 feet has been recorded at the south end of Sulphur mountain about 20 miles to the northwest (Warren, 1945, p. 481), and at Moose mountain some 15 miles east of Evans-Thomas creek, no Triassic rocks are present (Beach, 1943, p. 5). The variation in thickness is attributed to the weakness of the rocks, which allows few good outcrops on account of contortion and susceptibility to weathering, and to the long periods of erosion succeeding deposition of the Spray River sediments, in which time, varying thicknesses of rock have been removed.

LITHOLOGY: Rocks which constitute the Spray River formation in the Ribbon Creek area are essentially argillaceous siltstones, though dolomitic, calcareous and arenaceous types are well represented. Some beds of impure dolomite and occasionally limestone are present. The color of the fresh rock is generally grey to dark grey and black or dark blue grey. A fine banding is common to those beds in the lower part of the formation. Thickness of individual beds varies from paper-thin to several feet. Paper-thin beds weather the more readily and form slopes, whereas the thicker beds may form vertical cliffs. This is especially true of the topmost beds which are the most resistant of the formation, and usually cause waterfalls or rapids, and form escarpments, hogbacks, or cliffs. The strata weather to a characteristic reddish brown color. This color and the shaly habit of the rocks upon weathering make for easy identification in the field.

Rocks of the Spray River formation have been variously described as shales of such types as arenaceous, dolomitic, or calcareous; but study of thin sections of various rock types in the Evans-Thomas Creek section show the prevailing rock type there to be a siltstone. The silt particles were determined to be largely angular quartz and feldspar and to vary in size up to 0.1 millimeter. The various types are gradational into each other, and some are not easy to classify.

The greater part of the Spray River formation is thin-bedded, for most beds are not more than a few inches thick, a habit that is attributed to deposition in shallow waters (Figure 3). Upon exposure the rocks break up into thin angular plates, one-quarter to one inch thick, which litter the slopes with a thick covering of debris, and which usually conceal the underlying bedrock.

The fine banding in some of the beds is caused by thin-layers of quartzitic sandstone. Concentrations of pyrite in fine-grained aggregates occur in these sandy bands and to a lesser extent in the enclosing rock. Dolomitic siltstones at the top of the Sulphur Mountain member contain as much as 30 per cent or more carbonates, and the excellent erosion-resistant properties of these strata are probably due to the dolomite content. Only one bed of true dolomite was recognized in this section, and no limestone is present, though beds of this latter rock were seen elsewhere at about the same horizon as the dolomite.

Both upper and lower formational contacts are abrupt. The Spray River-Fernie contact was examined in several places, and in every instance the hard dolomitic siltstones give way to soft, black, fissile shale. There is no appreciable change in the dip of the two formations. No exposure of the Rocky Mountain-Spray River contact was seen within the map-area, but it was studied at the west end of Lake Minnewanka, along strike and some miles to the northwest. There soft, brown Spray River shales rest on the slightly uneven surface of the Rocky Mountain formation. Moreover a few phosphatic, quartzitic nodules occur at this contact, but none was seen on the uppermost Rocky Mountain surface in Ribbon Creek area.

As mentioned above the most complete section is that occurring on Evans-Thomas creek in legal subdivision 4, section 18, township 22, range 8, west of fifth meridian. The section as measured is given below.

EVANS-THOMAS CREEK SECTION OF SPRAY RIVER FORMATION

Overlying beds—shale, black, platy, fissile (Fernie formation).

Erosional Contact	Thickness Feet
Siltstone, dark blue-grey, dolomitic, massive, hard, dense, brittle; few scattered knots of white quartz in upper few feet; beds two to five feet thick; forms cliffs and falls	27
Siltstone, dark grey, argillaceous or arenaceous streaks, thick-bedded, cliff-forming occasional dolomitic, hard, resistant bed	45
Siltstone, thin-bedded, argillaceous, paper-thin in places, sandy, usually forms a slope; FLEMINGITES zone 45 feet below top	130
Siltstone, argillaceous, thin-bedded, having beds up to 1.5 feet thick; scattered LINGULAE present; dolomitic	30
Siltstone, thin-bedded, fissile, sandy, with a few beds of hard, fine-grained sandstone; becomes dolomitic towards top	27
Dolomite, blue-grey, dense, massive, argillaceous; LINGULAE abundant; (limestone may also be present at this horizon)	5
Siltstone, dark grey, hard, dense, argillaceous, with numerous sandstone lenses up to four inches thick; algal impressions abundant on some bedding planes	183
Siltstone, hard, brittle, dark grey, argillaceous, distinctly stratified in beds up to six inches thick; laminae of fine sand abundant; one bed shows minor unconformity; occasional beds of fine-grained, hard, quartzitic sandstone up to eight inches thick; pyrite in minute grains and aggregates	61
Siltstone, dark grey, hard, brittle; platy, in beds up to four inches thick; evenly bedded; laminae of fine quartzitic, sandstone numerous; fossiliferous, containing such ammonties as OPHICERAS (?)	45
Shale, dark grey, fissile, in beds one-quarter to one-half inch thick; poorly indurated, and difficultly friable	30
Concealed, but probably as above	17
Total thickness Spray River beds	600

Probable erosional contact

Underlying beds—conglomerate, composed of pebbles and cobbles of grey quartzite and chert firmly cemented in a siliceous matrix (Rocky Mountain formation).

AGE AND CORRELATION: The Spray River formation of Triassic age outcrops in the central and southern Rocky Mountains in Alberta. It is divided into two parts, a lower, the Sulphur Mountain member of Lower Triassic age, and an upper, the Whitehorse member, Middle Triassic in age. The latter member is not always present, and has not been recognized in the Ribbon Creek area. The Lower Triassic age of the Sulphur Mountain member has been proved by Warren (1945), and McLearn (1945). The ammonite, FLEMINGITES, which occurs 117 feet below the top the Evans-Thomas Creek section is placed by McLearn in the lower part of the Lower Triassic (i.e., lower Eo-Triassic). Therefore, it may be concluded that no rocks younger than Lower Triassic are present in the Spray River formation within the map-area. The occurrence of Middle Triassic beds (Whitehorse member) has been suggested for the areas adjoining on the south (Allan and Carr, 1947) and on the west (Warren, 1945), such identifications being based on lithological resemblances only.

The Spray River formation is sparsely fossiliferous, and furthermore, these fossils are not easy to find since they consist of impressions only. The poor state of preservation is often such as to render generic determination difficult and specific determination impossible. There are three fossil horizons which appear to be consistent, not only for the Ribbon Creek area but also for the adjoining regions. The lowest of these horizons carries the ammonite OPHICERAS (?) in some numbers, and occurs from 45 to 55 feet above the base. The pelecypod, CLARAIA STACHEI, has been found at this horizon in adjacent regions, but was not collected in this area. The next zone is noted for its great abundance of LINGULAE, of which there are at least two species present. This zone extends from 336 feet to 368 feet above the base. The third and uppermost horizon carries a large number of FLEMINGITES, which was collected 483 feet above the base of the formation. About 15 feet above the FLEMINGITES zone the ammonite, MEEKOCERAS (?), was also collected.

Algal impressions are numerous in some beds, but do not appear to be confined to any particular horizon. Fragments of fish bones are not uncommon, especially in the lower part of the formation.

Lower Triassic strata are present elsewhere in western North America, and some have been correlated with the Spray River formation. McLearn considers the following formations to be correlatives of the Spray River; Grayling formation of Liard river, British Columbia; Woodside formation of Idaho and Utah; and the lower part of the Candelaria formation of Nevada (McLearn, 1945).

JURASSIC

Fernie Formation

NAME AND DISTRIBUTION: The name, Fernie formation, was given by Leach in 1911 to a black shale series that underlies the coal-bearing Kootenay strata in Crowsnest Pass area (Leach, 1912). He assigned a Jurassic age to these beds. He had made the separation of Fernie from Kootenay in 1902, but had not formally applied a formational name to the 700 feet of black shales (Leach, 1903, p. 168).

Fernie strata have since been identified throughout the front ranges of the Rocky Mountains in Alberta from Carbondale river in the south to Smoky river in the north. These rocks are exposed most often in the eastern ranges of the Rocky Moutains, but occasional bands do occur farther west as in the Fernie basin of British Columbia.

In the present map-area, the Fernie formation extends as a single, narrow band from northern to southern boundaries. Since it has been easily deformed and eroded, its position is usually at or near the valley bottoms. In this manner Fernie rocks can be followed from Pigeon creek southwards to the headwaters of Lorette creek. No exposures were seen in the Marmot Creek basin, the next southerly exposures being on Ribbon creek. Kananaskis river yielded no outcrops of these rocks. Exposures of the formation are quite plentiful on the west side of Evans-Thomas Creek valley. The formation approaches the western limestone overthrust in the southern extremity of the map-area, and passes under it immediately south of the area mapped.

The best exposures of the Fernie are on Pigeon creek over a distance of about one mile above its confluence with Wind creek, and on a small tributary of Pigeon creek that flows off Mount Allan. The latter section is the best in the map-area and is described below. Another good exposure occurs on an east-flowing stream that joins Evans-Thomas creek in the southwest corner of section 18, township 22, range 8. Rocks in this section are folded and faulted, and partly concealed. A slice of Fernie that has been carried up by the western overthrust limestone block is present in section 19, township 21, range 8.

Width of the Fernie outcrop varies with inclination of the strata, with repetition by faulting, and also with its position on the side or bottom of a valley. The incompetent nature of its rocks has allowed a certain amount of flowage, so that thicknesses in different parts of the structure may vary considerably. The easily eroded rock in the formation makes for few outcrops, and for the formation to express itself at the surface by valleys and gentle slopes.

THICKNESS AND LITHOLOGY: A measured section of Fernie formation exposed along a small creek in section 28, township 23, range 9 is 1,095 feet thick. This section is unbroken except for slight deformation in the lower 250 feet, so that the above figure is considered acceptable. In adjoining areas thicknesses are comparable being about 1,100 feet at Canmore (MacKay, 1935, Cross Sections), and along strike in Highwood-Elbow area as much as 1,000 feet is estimated, though a measured section in the eastern part of the area gave 745 feet (Allan and Carr, 1947, p. 20). The formation thins rapidly eastwards, being 220 feet at Moose mountain (Beach, 1943, p. 33).

The Fernie in this area has in general the same faunal zones and lithological members that are evident in other localities in the front ranges of the Rocky Mountains where the formation has been described or has been examined by the writer. The following section except for the bottom 90 feet was measured on a small creek in section 28, township 23, range 9, and serves as a type section for the area. The bottom 90 feet were obtained on Pigeon creek in section 5, township 24, range 9.

MOUNT ALLAN SECTION OF THE FERNIE FORMATION

Overlying beds—sandstone, dark grey, coarse-grained, composed of black chert and white quartz in approximate equal amounts; usually forms prominent ridge; weathers pale grey with pinkish tinge (Kootenay formation).

Conformable contact

	Thickness Feet
Sandstone, fine-to medium-grained, massive to evenly bedded, occasionally cross-bedded, usually finely banded, light grey; calcareous; carbonized plant fragments abundant on some bedding planes; few partings of grey shale; typical weathering is reddish brown to grey brown	170
Sandstone and shale interbedded; medium-grained, banded, light grey sandstone, some finely cross-bedded; brown weathering; beds vary in thickness from 1 to 6 feet increasing in importance upwards and grading into overlying beds. Shale, dark grey, silty and sandy, with plant fragments	90
Shale, silty and sandy, relatively soft; dark grey; weathers to a greenish shade; few thin bands of hard, finely cross-bedded sandstone	100
Shale, silty, medium grey; few sandstone bands to 2 feet thick; fissile; sandstone is thin-bedded and has carbonaceous films on bedding planes	75
Shale, dark grey, silty, flaky; numerous thin sandstone bands one inch to two inches thick	150
Shale, dark grey, silty, flaky; pseudomorphs at base	75
Shale, black, fissile, numerous flat, yellowish brown weathering concretions averaging 6 feet long and 6 inches thick; occasional stringer of rusty brown weathering ironstone	75
Sandstone, hard, black, very fine-grained, calcareous, dense; in beds 3 to 6 inches thick; resistant and forms falls or rapids; sparsely fossiliferous (Pigeon Creek member)	120
Shale, black, hard, brittle, flaky, splintery in places; outcrops only sporadically, and then shows varying effects of pressure; thickness estimated to be	150
Sandstone, calcareous, resistant, medium grey, fine-grained, richly fossiliferous (Rock Creek member)	2
Shale, silty, dark grey, fossiliferous, spheres of pyrite ½ to 1 inch in diameter	10
Shale, black fissile; weathers yellowish to brownish; fossiliferous near top	14
Shale, black platy, fissile; fish fragments near base; lenses of hard, fine-grained, black, calcareous shale	60
Limestone, dark grey, hard, fine-grained, dense, argillaceous, with lenses of limestone breccia; limestone fragments up to one inch across, fill depressions in Spray River surface	4
Total thickness Fernie beds	1,095

Erosional Unconformity

Underlying beds—siltstone, dense, dark grey, thick beds; hard, resistant; characteristic knots of white quartz present (Spray River formation).

The lowest bed in the section is in part a conglomerate, and consequently suggests an interval of erosion. It is not persistent. In many localities elsewhere in the mountains, a bed of phosphatic limestone and nodules occurs, but it appears to be absent in the Ribbon Creek area.

The calcareous sandstone bed, called the Rock Creek member, though thin, occupies a prominent position in the sequence of Fernie rocks. It is highly fossiliferous, a property that distinguishes it from other strata. Originally named in the Crowsnest Pass area (Warren, 1934), it has been identified as far north as Cadomin. In the Ribbon Creek area the bed occupies a position 88 feet above the base of the Fernie, and being resistant to erosion as well as persistent it makes an excellent marker bed. Another good marker is the 120-foot sandstone member, herein called the Pigeon Creek member since it was first observed on that creek, and since it is useful in field mapping. In some places sandstones of this member, being more resistant than some other parts of the formation alone remain exposed, and serve to identify the formation. It occurs in the interval between 240 to 360 feet above the base. The member has not been recorded elsewhere in Alberta, and is apparently developed only in the Ribbon Creek area.

A concretionary zone overlies the Pigeon Creek member, and has a wide extent. In addition to other exposures it appears in the slice that has been brought up in the thrust fault in section 19, township 21, range 8. A zone of pseudomorphs, having a radial structure, spherical in shape, and one-half to one inch in diameter lies immediately above the concretionary zone and about 435 feet above the base of the formation. The pseudomorphs are siliceous, and appear to be a replacement after marcasite. They occur at about the same horizon in Highwood-Elbow area.

The shales below the pseudomorph zone are black and fissile or flaky, but above this interval they become silty, sandy and lighter in color. The first change observed is an increasing siltiness and change from black to dark grey. Then sand is introduced, either disseminated in the shale or in thin stringers; at the same time the shales take on a greenish cast. Sandstone beds increase in number and thickness upwards in the formation; and culmination is attained in the 170-foot section of sandstone beds at the top. The sandstones are probably marine since they are almost devoid of cross-bedding. They contain comminuted plant fragments. In the upper 450 feet a transition from marine to freshwater conditions is indicated by increase in the quantities of silt and sand, and by the presence of plant fragments. The retreat of the Fernie sea is thus clearly demonstrated. However, freshwater deposition did not obtain until early Kootenay time.

The Fernie-Kootenay transition is similar to changes observed elsewhere in Alberta where marine sediments have been succeeded by brackish and ultimately freshwater deposits. Such instances include the Pakowki-Foremost-Oldman transitions of southeastern Alberta, the Bearpaw-Edmonton contact of southeast central Alberta and the Wapiabi-Belly River contact of southwestern Alberta foothills. In all these instances dark grey marine shale grade upwards into shales that become lighter in color, take on greenish shades, and at the same time include increasing quantities of silt and sand, not only scattered in the shale but in the form of beds from a fraction of an inch to many feet in thickness. No unconformity has been noted in any one of the examples cited. Therefore since the Fernie-Kootenay transition parallels them, there appears to be no good reason for concluding that a break in sedimentation of any importance is present at this horizon (Figure 5).

The uppermost member, the massive sandstones, which vary from 100 to 170 feet in thickness, and the basal Kootenay sandstones usually express themselves topographically by forming shoulders, ridges, or low swells. They are therefore useful to the geologist in field mapping and to the prospector in defining the base of the Kootenay coal measures. Though often prominent, they are not always exposed in their entirety.

The upper contact of the Fernie is placed at a break in the type of sediment in the thick sandstones mentioned above. Fernie sandstones are fine-grained to medium-grained, quartzose and calcareous, whereas basal Kootenay sandstone is coarse-grained, dark grey, cherty, and non-calcareous. The contact is not always easy to identify owing to minor interdigitation of the two kinds of sandstone beds, so that it may be confined to a zone a few feet thick, in which case the selection is arbitrary. There are no indications of erosion at the top of the Fernie in any contacts examined in Ribbon Creek area, so that the gradation from marine to freshwater deposition appears to be unbroken.

The nature of the Fernie-Kootenay contact was further studied by petrographic methods. The contact was determined to have a position 46 feet below the top of a sandstone zone, 155 feet thick, which is exposed in the valley of Evans-Thomas creek. Representative rock samples were selected from this zone at intervals of twelve to fifteen feet, and thin sections were made from them. Ten samples were taken from this outcrop, four from the Kootenay, and the remaining six from the Fernie. Study of the thin sections does not indicate any sudden change in sedimentation, such as might be expected if an unconformity were present. Certain differences do, however, exist. Feldspars are almost absent in Kootenay sandstones, but are fairly abundant in the Fernie. Calcareous material, an important constituent in the lower Fernie sandstones, becomes decreasingly so as the contact is approached, and is absent in the Kootenay. In the Kootenay sandstones, chert may make up approximately 35 per cent of the minerals in the rock; it is present only in minor quantities in the Fernie. Grain size is another index, for the Fernie sandstones are fine-grained to medium-grained, whereas coarse-grained phases are common in Kootenay strata .

The lower contact of the Fernie formation is abrupt and readily recognized wherever exposed. The dense, hard, tough, dolomitic siltstone at the top of Spray River are in marked contrast to the relatively weak, thin-bedded, fissile shales of the Fernie.

AGE AND CORRELATION: Recognizable fossils are rare in the Fernie, except at the horizon of Rock Creek member. The basal shales contain abundant fish remains, which are too fragmentary for identification. The Pigeon Creek member yielded only a few belemnites and an imprint of a jelly-fish. No fossils were collected above this member. Impressions of worms and algae are very common in some of the strata; but, as far as could be ascertained, these markings are not confined to definite horizons. Plant fragments, mostly in the form of carbonized woody material, are common in the upper 400 feet of the formation, but they are not large enough for identification. On the whole, fossils of the Fernie formation in Ribbon Creek area do not furnish any information that is not already known about the age of its various members.

The largest collection of fossils both in number of fossils and species represented was made from the Rock Creek member on Pigeon creek in section 5, township 24, range 9. The following specimens were collected: GRAMMATODON FERNIENSIS Warren, CUCULLAEA ABBREVIATA Warren, CUCULLAEA ROCKYMONTANA Warren, INOCERAMUS BURNSI Warren, INOCERAMUS FERNIENSIS Warren, OXYTOMA MCLEARNI Warren, GRYPHAEA sp., TRIGONIA TRAFALGARENSIS Warren, ENTOLIUM PARVIAURE Warren, MODIOLUS ABBREVIATUS Warren, PLEUROMYA BURNSI Warren, PLEUROMYA OBLONGATA Warren, PLEUROMYA SIMPLIS Warren, THRACIA ? DUBIA Warren, ARCTICA SUBTRIGONALIS Warren, ASTARTE sp., STEMMATOCERAS sp., STEMMATOCERAS cf. MCLEARNI Warren, STEMMATOCERAS MCLEARNI Warren, DEFONTICERAS sp., DEFONTICERAS cf. OBLATUM Whiteaves, ITINSAITES cf. ITINSAE McLearn, KANASTEPHANUS sp., BELEMNITES.

On a small tributory of Evans-Thomas creek, in section 7, township 22, range 8, the Rock Creek member furnished these additional species: RHYNCHONELLA ALBERTENSIS Warren, RHYNCHONELLA MOOREI Warren, CUCULLAEA ELONGATA Warren, EXOGYRA sp., TRIGONIA sp., CAMPTONECTES ALBERTENSIS Warren, MODIOLUS sp., PLEUROMYA NUDA Warren, THRACIA CONVEXA Warren, ARCTICA DUBIA Warren, CYPRINA cf. IDDINGSI Stanton, PRAECONIA BURNSI Warren, PROTOCARDIA ERECTA Warren, PLEUROTOMARIA BOREALIS Warren, ITINSAITES sp.

The fauna of the Rock Creek member is Bajocian (Early Middle Jurassic) in age. The above fossil lists show no unusual features, except for the abundance of the ammonite, STEMMATOCERAS MCLEARNI. This fossil is exceedingly rare elsewhere in the Fernie.

Since no diagnostic fossils were found above or below the Rock Creek member in the Ribbon Creek area, the age of the upper and lower limits of the formation cannot be stated definitely at this time. However, thickness of the formation in this area is probably slightly more than the greatest thickness for the adjoining Highwood-Elbow area, and therefore time ranges of the formation in these adjacent areas should compare favorably. In Highwood-Elbow area, fossils of Lower Jurassic age were found in the black shales at the base, and these strata are certainly present in Ribbon Creek area. McLearn has identified an ammonite, collected along Ribbon creek in 1908 by James McEvoy (McLearn, 1928), as YAKOUNITES (SEYMOURITES) MCEVOYI. This fossil occurs in the upper Yakoun fauna of Queen Charlotte Islands, and is Callovian (early Upper Jurassic) in age. McEvoy did not state the horizon at which the fossil was found in the formation, so that its stratigraphical position is not known. To sum up, it appears that the Fernie formation in Ribbon Creek area includes strata varying in age from Lower Jurassic to Callovian. No unconformity has been recognized between the Fernie and the Lower Cretaceous Kootenay formation.

The Fernie formation is not the same age everywhere in Alberta and British Columbia. This is not unexpected since the thickness is so variable and consequently some horizons may be lacking in places. Stratigraphic relations and lithology are usually sufficient for identification of the formation in Alberta and eastern British Columbia. Other Jurassic rocks are found in western British Columbia. At Harrison lake, Middle and Upper Jurassic rocks were identified (Crickmay, 1930). Rocks of an age identical with the Rock Creek member are present in the Hazelton group of the north central part of the province (McLearn, 1926). In the Sweetgrass Hills of Montana the Jurassic formations, Sawtooth, Rierdon and Swift, outcrop, and have a time range from upper Bathonian or Middle Jurassic to Argovian, which is late Upper Jurassic (Cobban, 1945, p. 1290). These three formations, formerly known as the Ellis formation, are encountered in deep drill holes in southern Alberta. They more or less correlate with the Fernie formation. The Twin Creek limestone of Idaho has a fauna that has affinities with the Rock Creek member, and therefore correlates with the lower part of the Fernie formation (Imlay, 1945, p. 1021).

CRETACEOUS

Kootenay Formation

NAME AND DISTRIBUTION: The term Kootenay was introduced in 1885 by G. M. Dawson for a series of shales, sandstones, coal seams and conglomerates in the Crowsnest Pass area (Dawson, 1886). Fossil plants collected from the formation were given a Lower Cretaceous age by Sir J. W. Dawson (Dawson, 1885). The formation was subsequently delimited by geologists who worked in the area. The black shales at the base of the formation were shown by Leach to belong to the Jurassic, and were given the formational name, Fernie (Leach, 1912, p. 193). Leach also placed the top of the Kootenay coal measures at a conglomerate bed that is quite persistent in that area and northwards. Later Rose observed an unconformity at the base of the conglomerate and included the bed in the overlying Blairmore formation (Rose, 1917, p. 110). The upper and lower boundaries as defined by Leach and Rose are still accepted.

The distribution of Kootenay rocks has been known for many years, since they are important for their coal seams, and have long been prospected. They outcrop in southwestern Alberta foothills and mountains and in south-eastern British Columbia. Strata of Kootenay age are found northwards in the foothills of west central Alberta and in northeastern British Columbia, but are not everywhere coal-bearing. In southwestern Alberta they outcrop almost without interruption from Carbondale River area in township 5 to Panther River area in township 30. In all these places they have been brought to the surface by faulting and folding. Kootenay rocks do not appear to be present beneath the Alberta plains, and the eastern limit of these strata occurs approximately at the eastern edge of the foothills.

Within Ribbon Creek area Kootenay strata outcrop in one continuous band from northern to southern boundaries (Map 21). The width of this band is variable, but is greatest in the vicinity of Mount Allan. The structure in which Kootenay rocks outcrop is a broad syncline, of which the width depends on the extent to which it has undergone erosion. The band is somewhat narrow in Kananaskis valley, where erosion has been more active in removing the eastern margin of the east limb of the syncline. The band is wedge-shaped in the southern part of the area, and pinches out by passing under the western overthrust immediately east of Mount Hood.

Best exposures of Kootenay strata in the map-area are found above timber line, and on the ridges that extend eastwards from Wind mountain, Mounts Bogart, Kidd, The Wedge, and Evans-Thomas. Several excellent stratal sections are exposed on Mount Allan. Many of the slopes above timber line are grassed over, thereby concealing bedrock. Good sections are also to be found in some of the gorges and gullies below timber line, but as a rule the rocks at this level are usually obscured by forest cover or muskeg. Kootenay outcrops below timber line are infrequent due to the forest cover, and to the preponderance in the lower part of the formation of shale. Outcrops are scarce on Wind and Ribbon creeks, and on Kananaskis river.

THICKNESS: In Ribbon Creek area the Kootenay formation is 3,400 feet thick as measured on the eastern slope of Mount Allan in sections 21 and 28, township 23, range 9. In the Canmore area the thickness apparently is from 3,100 to 3,300 feet (MacKay, 1935, Cross Sections), and southwards in Highwood-Elbow area, Allan and Carr report thicknesses from 709 to 2,400 feet. The formation thickens notably from east to west, being only 220 to 350 feet in Moose Mountain area (Beach, 1943, p. 37). In the Elk River valley of British Columbia, which lies about 50 miles south of Ribbon Creek area, Marshall measured 3,500 feet of coal measures, a figure that does not include the top of the formation (Marshall, 1921, p. 9). In Crowsnest Pass area, the thickness of the Kootenay formation varies from 280 feet in the Carbondale River area to 4,000 feet in the Fernie area (MacKay, 1932, p. 21). The thickness as measured in the Ribbon Creek area is not considered excessive, though there is the possibility that some beds are repeated by unobserved faults. Such faulting if present, is minor in character, since repetition of great thicknesses of beds is not evident.

LITHOLOGY: The formation consists essentially of shale, siltstone, sandstone and conglomerate. Coal seams are present, and form a minor part of the rock succession. The various rock types are gradational from one to the other. The shales are generally dark grey to black, crumbly to blocky, rarely fissile, and usually silty and sandy. Thin beds of black, carbonaceous shales are common. Maroon and greenish shales are rare, and when present are found only close to the top of the formation. Coal seams, many of commercial thickness, occur at irregular intervals in the shales. Fossil leaves were collected from some shale beds, and appear to be most abundant in the shales associated with coal seams. The siltstones are generally dark grey to black, and grade into shale or sandstone. They are often tough, and break into angular fragments. Frequently both shales and siltstones weather to a dark rusty brown color. The sandstones are varied, ranging from fine-grained to very coarse-grained types. They are usually dark in color due to a high content of black chert grains. The very coarse-grained types are often quartzose. They weather to various shades of rusty brown and shades of grey. Many sandstone beds are thin-bedded and platy. Cross-bedding is common, especially in the coarser types. The sandstones often contain impressions of branches.

A few hundred feet from the top of the formation lenses of conglomerate are present in the sandstone or form individual beds. The pebbles comprising the conglomerate are black, brown, green and grey chert, and white, grey and yellowish brown quartzite. The pebbles vary from one-quarter of an inch to two inches or more in diameter, and are fairly well assorted as to size. As a general rule the stratigraphically lowest conglomerate bed contains the smallest pebbles; and, as the beds rise in section, the pebbles become larger. They reach a maximum size of 6 to 8 inches across in a massive conglomerate, at least 50 feet thick, which is considered to be the base of the Blairmore (Figure 7). It was also observed that the proportion of white quartzite pebbles to the other constituent pebbles is greatest in the beds close to the contact, and decreases gradually as beds become older. The older conglomerates are usually dark, due to a preponderance of dark chert. The conglomerates are well indurated, and the pebbles so firmly cemented together that fractures pass through pebbles and matrix alike.

Except for the basal sandstone beds, the formation is a freshwater deposit. A marine origin is ascribed to the basal sandstone since it is continuous with the sandstones at the top of the Fernie formation, in which marine fossils have been found in the Highwood-Elbow area.

The Kootenay formation is roughly divisible into four members on the basis of the dominant rock types. At the base there is a sandstone member, above it a shale or coal-bearing member, then an upper sandstone member, and at the top a conglomerate member. The basal Kootenay sandstone extends throughout the area, and has a thickness which varies from 40 to 70 feet (Figure 5). The shale member has few thick sandstone beds. In Ribbon Creek area it appears to contain most, if not all, the coal seams of economic importance. It weathers to form slopes of moderate inclination. The top of this member occurs at about 1,215 feet above the base of the Kootenay at the top of a 31-foot, black shale bed, which is partially concealed. The upper sandstone member extends from the 1,215-foot level to the base of the 45-foot sandstone and conglomerate bed, which occurs 3,054 feet above the base of the formation, and therefore is 1,839 feet thick. In the sandstone member occur the thick, precipice-forming sandstone beds that are so common near the top of and above timber line. The remaining and uppermost 346 feet belong to the conglomerate member. Although conglomerate beds comprise less than one-half the total thickness of the member, it is a recognizable and distinct unit. The thickness of this member varies somewhat widely within short distances. In section 10, township 23, range 9, on the south slope of Mount Allan it is 203 feet thick; on east the slope below the peak of Mount Allan, and on the west and vertical limb of the syncline its thickness is 440 feet; also on Mount Allan on the west side of a cirque in section 20, township 23, range 9, it is 410 feet thick. On the south slope of Wind ridge it measured 618 feet, an excessive thickness probably produced by repetition through thrust faulting. The variation in thickness is probably owing to the lenticularity of the beds and to the lateral variation in size of the pebbles, both of which contribute to confusion in selecting key beds. A thickness of about 425 feet is considered to be an average thickness for this member. It is absent in that part of the area south of Kananaskis river. In the Highwood-Elbow area the conglomerate member has been named the Pocaterra Creek member, and is included in the Blairmore formation (Allan and Carr, 1947, p. 28).

The upper beds of the Kootenay fault blocks have been eroded in most of the map-area, so that opportunities for obtaining a complete sequence are limited. The most complete and best exposed section measured is located on the eastern slope of Mount Allan, and is continuous with the Fernie formation described on page 24. The base of the Kootenay stratal section is in section 28, township 23, range 9. The section is as follows:

MOUNT ALLAN SECTION OF THE KOOTENAY FORMATION

Overlying beds—conglomerate and sandstone interbedded; pebbles of chert and white quartzite up to 2 inches across in coarse, grey sandstone (basal Blairmore conglomerate).

Contact apparently conformable	Thickness Feet
Shale, black	2
Limestone, dark grey, argillaceous, whitish weathering, rudely bedded	3
Sandstone and conglomerate interbedded, coarse-grained, cross-bedded, sandstone, with lenses of small chert pebbles of grey and green shades; occasional bed of grey shale	80
Shale, dark grey, sandy	8
Sandstone, coarse-grained, dark grey, cross-bedded	22
Sandstone, fine-grained, grading laterally into dark grey, sandy shale	25
Shale, dark grey, greenish cast, weathers yellowish brown	26
Shale, black, sandy; zone of limestone nodules 6 inches across at top	8
Coal	2
Shale, black	4
Shale, dark grey, poorly bedded, weathers whitish	1
Sandstone, medium-grained, grey with interbeds of light grey shale	40
Shale, blocky, black, greenish cast, weathering brown	27
Sandstone, dark grey, with black shale partings	18
Conglomerate, chert pebbles ¼ to ½ inch in diameter; matrix of coarse-grained sandstone	11
Shale, black, sandy	2
Sandstone, very silty in bottom beds	22
Sandstone and conglomerate, lenses up to 2 feet thick of pebbles having maximum diameter of 1 inch but mostly smaller; pebbles of white quartzite and green chert rare (base of conglomerate member)	45
Sandstone, with occasional interbeds of dark grey to black shale	115
Sandstone, coarse-grained, cross-bedded	22
Sandstone and shale, interbedded: medium-grained to coarse-grained sandstone; grey sandy shale	50
Sandstone, medium-grained, and fine-grained, dark grey	20
Sandstone, fine-grained, silty, weathers rusty brown; interbeds of black shale	225
Sandstone, finely cross-bedded, coarse-grained	40
Sandstone, fine-grained, silty, beds of 3 feet or more thick, weathering yellowish brown; interbeds of dark grey and black shale	36
Shale, grey and black	8
Sandstone, fine-grained, shaly, weathering rusty brown	19
Sandstone and shale, fine-grained, more or less regularly bedded sandstone; few partings of dark grey, sandy shale	42
Sandstone and shale, fine-grained to medium-grained sandstone in beds of 2 to 4 feet separated by shale partings of 6 to 12 inches	100
Shale, black with few lenses of fine-grained, silty sandstone	18
Shale, black	4
Coal	0.5
Shale, black	2.5
Sandstone, fine-grained, finely cross-bedded	9

	Thickness Feet
Shale, black, silty; yellow brown weathering	10
Sandstone, fine-grained with few partings of grey and black shale	45
Shale, black	2
Coal	0.5
Shale, black	1.5
Sandstone, fine-grained, finely cross-bedded; shale partings	6
Shale, black	4
Sandstone	3
Shale, black	0.9
Coal	0.4
Shale, black	0.7
Sandstone, fine-grained to medium-grained	5
Coal	1
Sandstone, medium-grained, cross-bedded and rudely bedded, numerous branch impressions; shale partings two inches thick	35
Shale, black with 2 inches of coal, thin sandstone lenses	7
Sandstone, medium-grained, dark grey, branch impressions, cross-bedded to rudely bedded	29
Shale, black	4
Coal	0.5
Sandstone and shale, fine-grained, to medium-grained; partings of black, sandy shale; occasional very thin coal seam	54
Coal	1
Sandstone, fine-grained, in beds of one foot or more alternating with black shale	41
Coal	0.3
Shale, black	3.7
Coal	0.5
Sandstone and shale interbedded; sandstone beds up to 10 feet thick, with shale beds of corresponding thickness	125
Sandstone and shale interbedded; branch impressions in sandstone; thin beds of black shale	60
Shale and fine-grained sandstone interbedded	58
Coal, powdery	1
Sandstone, coarse-grained, rudely bedded, numerous branch impressions	63
Sandstone and shale, fine-grained to medium-grained, sandstone in thick beds alternating with grey shale	50
Sandstone, fine-grained, weathers brown	50
Sandstone and shale, fine-grained, to medium-grained; beds 4 feet to 5 feet thick, with shale interbeds	60
Shale, black, partly concealed	19
Sandstone, coarse-grained, rudely bedded, dark grey	70
Shale and sandstone interbedded; fine-grained, finely cross-bedded sandstone in beds of two feet or more, alternating with grey and black shale	72
Concealed, few sandstone ledges outcrop	58
Sandstone, cross-bedded, fine-grained, with shaly lenses	28
Sandstone and shale interbedded; beds of brown weathering sandstone in beds of 3 to 4 feet thick separated by thicker bands of dark grey shale	130
Sandstone and shale interbedded; fine-grained, hard, finely cross-bedded sandstone and dark grey shale (base of upper sandstone member)	28
Concealed, in part black shale	31
Sandstone, fine-grained, finely cross-bedded, grey, brown weathering	12
Concealed	35
Shale, with coal intermingled	9
Sandstone, thin-bedded, shaly habit	11
Concealed	175
Shale, dark grey, with sandy shale beds; partly concealed	25.7
Sandstone, medium-grained, cross-bedded	17
Shale, dark grey, with rusty colored beds of silty sandstone, partly concealed	56
Coal, partly dug out, crushed and weathered; 1.6-foot shale parting 2 feet above base	24
Shale, dark grey, with rusty brown, silty sandstone beds; partly concealed; few large concretions 6 feet across	100

	Thickness Feet
Sandstone, fine-grained, interbedded with black shale; few small yellowish weathering concretions	14
Coal	1.2
Shale and sandstone interbedded	65
Coal	1.2
Shale	5.9
Sandstone, dark grey, medium-grained to fine-grained	8.5
Shale and sandstone interbedded	120
Coal, partly lumpy, with 3 inches of shale near top	4.3
Shale and sandstone interbedded	6
Coal, crushed, with 2 inches of shale	1.2
Shale and sandstone interbedded	30.5
Coal, blocky, with two one-inch shale partings	3.7
Shale and sandstone	6
Coal, 3-inch nodular, shaly band in centre	3.5
Shale, black	5.5
Coal	0.5
Shale, black	4.5
Coal	0.9
Shale and sandstone	11.9
Sandstone, fine-grained, argillaceous	5
Shale and dark grey sandstone	15
Shale, black, sandy streaks	12
Coal, weathered, broken into small angular fragments; 2 one-inch shale breaks	9.8
Shale, black, silty and sandy interbeds	38.2
Sandstone, fine-grained, hard, weathers yellow brown	5
Shale, black, silty, partly concealed	110
Sandstone, cross-bedded, coarse-grained	36
Shale, black, sandy	33
Coal, hard, bright	1
Shale, dark grey, blocky	27
Coal, crushed, powdery	3.8
Shale, dark grey	8
Coal, hard, bright, blocky, with 2 inch shale break	3.2
Shale, black, sandy	4.0
Coal	0.2
Shale, partly concealed	23.8
Sandstone, dark grey, coarse-grained	9
Shale, dark grey, silty, blocky (base of shale member)	13
Sandstone, bedded more or less regularly, dark grey, coarse-grained for greater part; weathers light grey; marine (?); basal Kootenay sandstone	68
Total thickness Kootenay beds	3,400

Conformable contact

Underlying beds—sandstone, fine-grained to medium-grained; light grey; brown weathering (Fernie formation).

The lower and upper contacts of the Kootenay formation in Ribbon Creek area are considered to be gradational into the Fernie and Blairmore formations. In the adjacent Highwood-Elbow and Moose Mountain areas, an unconformity has been observed at the base of the formation, but in Ribbon Creek area continuous deposition of sediments apparently prevailed during this time. The Fernie formation is therefore considered to be transitional into the Kootenay. This subject was discussed in detail on page 26. The contact with the overlying Blairmore formation has also been made on a lithological basis. It was placed at the base of the oldest, prominent, massive conglomerate bed, which is 50 feet or more thick (Figure

7). Conglomerate beds in the uppermost few hundred feet of the Kootenay do not approach this bed in thickness or in size of constituent pebbles.

CONDITIONS OF DEPOSITION OF KOOTENAY FORMATION: Kootenay sediments were probably deposited in freshwater lakes and swamps which were not far from the sea, and which had elevations not much above sea level. A high land to the west probably provided gravel, sand and muds which were carried eastward towards the sea by rivers and streams. The sediments were deposited in a narrow belt that did not extend far east of the present foothills belt in Alberta. The climate was humid and warm, conditions favorable for the growth of a lush vegetation in the swamps and lake margins; and in these bodies of water large quantities of vegetable matter accumulated. Unstable conditions of sedimentation are shown by alternating beds of shale, sandstone and coal. Occasionally uplift of the land was sufficient for the removal of some layers of sediment, thereby producing local unconformities. In early Kootenay time a nice balance prevailed between growth of vegetation and subsidence of the land to bring about the accumulation of large masses of plant remains, which were later consolidated to form coal. The period of coal formation was brought to a close by disturbances in the western land mass which elevated it almost continuously. As a consequence coarser clastics were deposited in the Ribbon Creek area, and in the upper part of the Kootenay only insignificant coal seams are present, the principal rocks being sandstone and conglomerate. In the uppermost few hundred feet, conglomerate beds are present and point to pronounced uplifts.

AGE AND CORRELATION: The Lower Cretaceous age of the Kootenay flora was first established by J. W. Dawson (1885). Since that time further collections of fossil plants, obtained between Crowsnest Pass and Bow River areas have largely substantiated his determinations. E. W. Berry (1929) gives the flora a Barremian age, which is middle Lower Cretaceous in European geological chronology; hence it would seem that the Neocomian (earliest Lower Cretaceous) rocks are either absent or had not been recognized in the Kootenay formation. Bell's studies of the Kootenay flora led him to a similar conclusion (Bell, 1944, p. 11). On the contrary Brown (1946) has intimated that all or part of the Kootenay could be Jurassic. Bell later reaffirmed his former findings, and further added that some Neocomian elements might be present with the Barremian flora (Bell, 1946). If no Neocomian rocks are present in the Kootenay, then an unconformity should be present at the base of the formation. No evidence of an erosional interval at this horizon was observed in the Ribbon Creek area. Warren (1949) has suggested that an unconformity at the top of the sandstone member at the base of the formation would solve the problem of the absence of the oldest Lower Cretaceous beds.

In the Ribbon Creek area several small collections of fossil plants were made from the Kootenay. Specimens are types common to the formation. One collection was obtained in the interval from 100 to 200 feet above to the base of the formation, at the mine of the Kananaskis Exploration and Development Company. The following species were identified by W. A. Bell of the Geological Survey of Canada: EQUISETITES BUCHARDTI Dunker, CLADOPHLEBIS VIRGINIENSIS forma ACUTA Fontaine, CONIOPTERIS BREVIFOLIA Fontaine, PODOZAMITES LANCEOLATUS Lindley and Hutton, PHOENICOPSIS sp.

Another small collection was obtained in a gorge in section 36, township 23, range 10. These fossils are probably from a horizon occurring about the middle of the formation. Species are as follows: CONIOPTERIS BREVIFOLIA Fontaine, GINGKOITES LEPIDUS Heer, CTENIS BOREALIS Dawson, NILSSONIA NIGRACOLLENSIS Wieland, PHOENICOPSIS sp.

In section 28, township 23, range 9, the following collection was made 200 feet above the Fernie-Kootenay contact: NILSSONIA sp., PTILOPHYLLUM ARCTICUM Heer, PITYOPHYLLUM NORDENSKIOLDI Heer.

At the same locality, but 820 feet above the base of the formation, another collection was made, which had in addition to the above, specimens of CLADOPHLEBIS VIRGINIENSIS Fontaine. This last species has a wide time range, having been also identified in the Lower Blairmore, but the other three are typical Kootenay flora. PITYOPHYLLUM NORDENSKIOLDI Heer was collected 210 feet below the top of the formation, or only two feet below the base of the conglomerate member of the Kootenay.

On the evidence of fossil flora and stratigraphic position, the Kootenay formation is correlated with the Nikanassin formation, which outcrops in the eastern ranges of central Alberta, and which is not coal-bearing. It also has been shown to be equivalent in age to the lower part of the Bullhead group and to most of the Dunlevy formation of northeastern British Columbia (McLearn, 1945). In Montana, the upper part of the Morrison and the Lower part of the Kootenai may correspond to the Kootenay (Brown, 1946, p. 247). On the other hand Blixt (1941, p. 338) believes that the Kootenay as developed in Canada is absent in the Cut Bank oil field in Montana.

Blairmore Formation

NAME AND DISTRIBUTION: Leach, in his studies in Crowsnest Pass area in 1902, was the first to recognize the Blairmore as a lithologic unit, but it was not until 1911 that he assigned this name to the

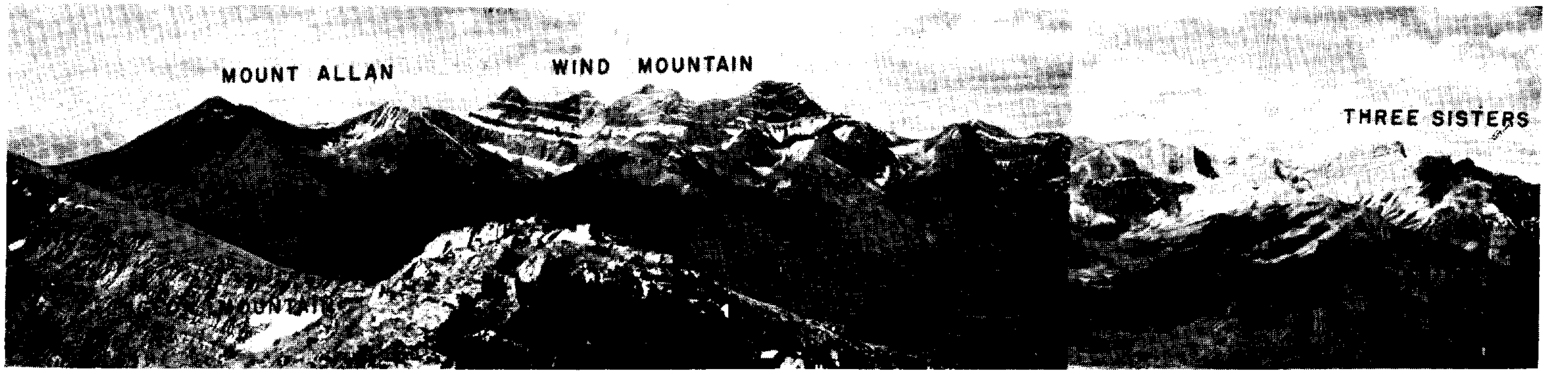

Figure 1—Panoramic view looking west; in centre, ridges and Mount Allan composed of Mesozoic rocks; Wind mountain in background and Pigeon mountain in foreground are fault blocks of Paleozoic strata. Photograph by G. G. Scruggs.

Figure 2—Hoodoos, located in a small valley below Wind mountain and carved from boulder clay by rain and wind; note protecting cap rock on one form. Photograph by G. G. Scruggs.

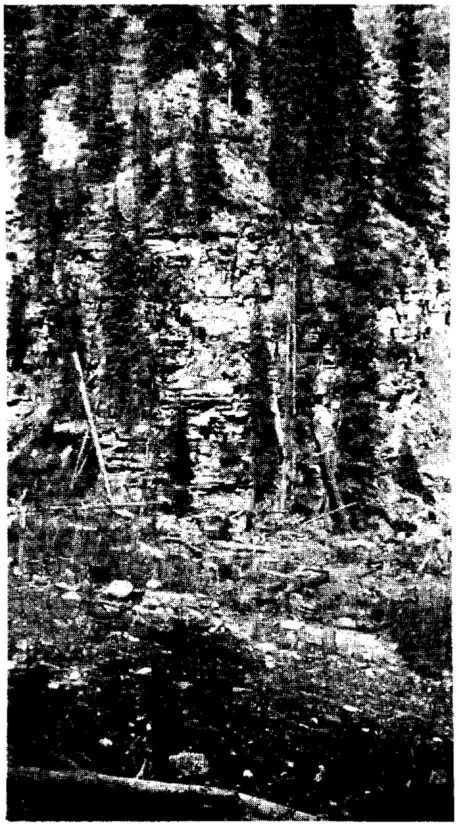

Figure 3—Thin-bedded Spray River siltstones outcropping along Marmot creek.

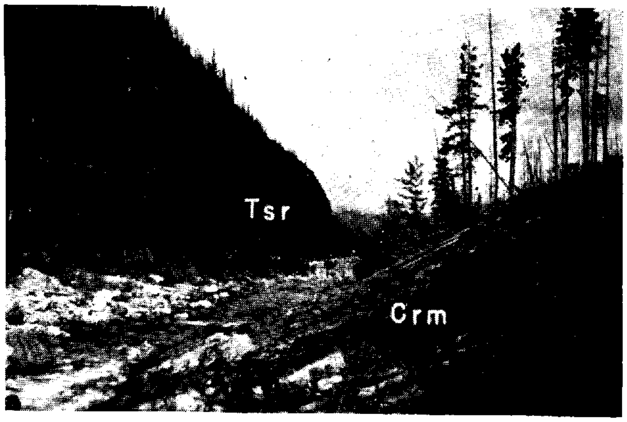

Figure 4—Looking north (downstream) on Evans-Thomas creek; precipitous left bank composed of an almost complete section of Spray River formation (Tsr); right bank, a dip slope, exposes quartzite beds of uppermost Rocky Mountain formation (Crm).

Figure 5—Contact of Fernie sandstone beds (Jf) and Kootenay sandstones (Kk); exposed on Mount Allan at head of a branch of Pigeon creek; note conformity of all beds.

Figure 6—A boulder of basal Blairmore conglomerate on Marmot creek; white quartzite pebbles and cobbles prominent.

Figure 7—Massive basal Blairmore conglomerate bed (Kb 1), approximately sixty feet thick, exposed on the second ridge north of Mount Allan; compare thickness of bed with height of man below contact; Kootenay beds (Kk) below contact.

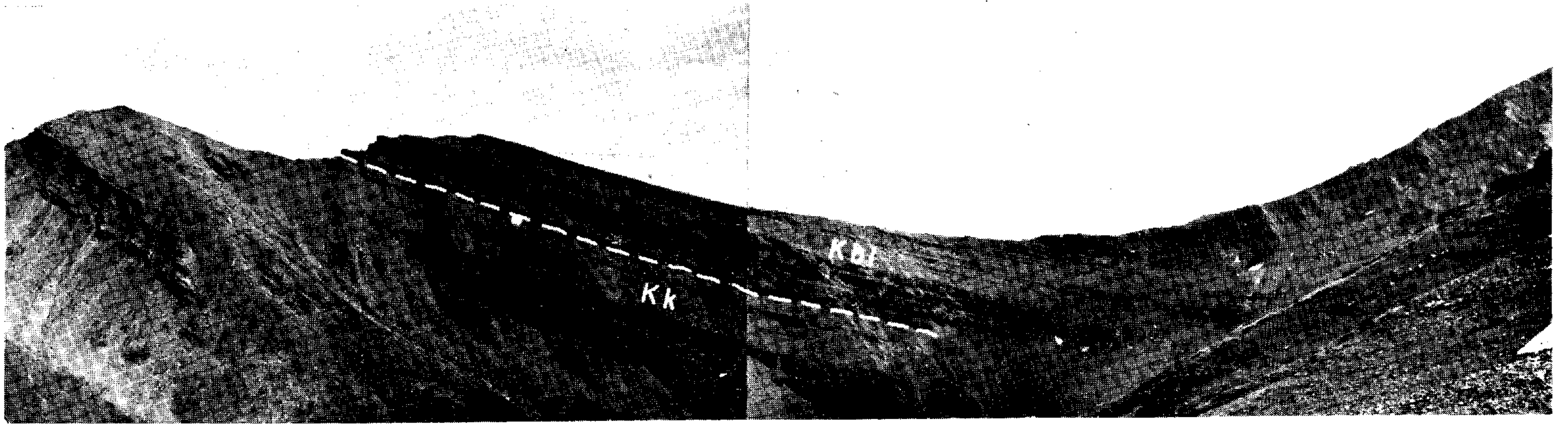

Figure 8—Panoramic view taken looking east and south towards the northeast trending ridge of Mount Allan; synclinal structure of Mesozoic strata well revealed; west limb slightly overturned, east limb moderately dipping; massive basal Blairmore conglomerate beds prominent; Kootenay rocks marked Kk, and Blairmore Kbl; peak of Mount Allan on extreme right.

Figure 9—View looking southeast from near peak of Mount Allan; vertical basal Blairmore conglomerate beds of west limb of syncline in left central foreground. Note synclinal structure in left centre; Mount Kidd in right centre; valley of Evans-Thomas creek in upper centre.

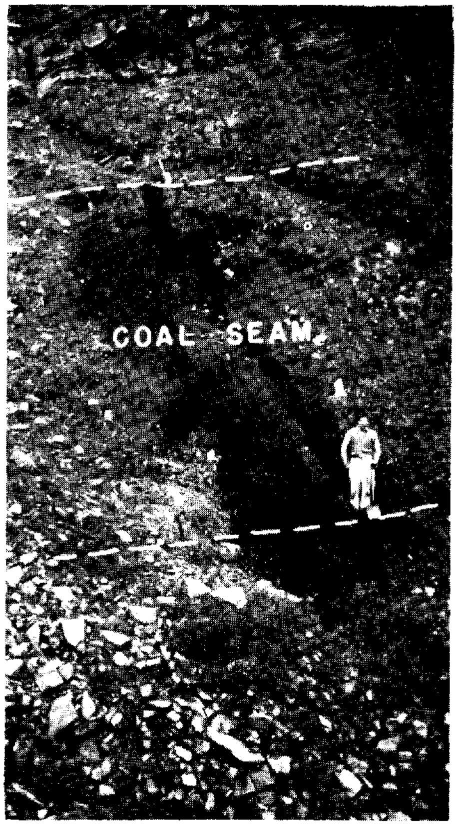

Figure 10—Coal seam, thirty-four feet thick, exposed on east slope of Mount Allan at headwaters of Lorette creek; observer stands on base of seam and point of upper shovel marks top of seam.

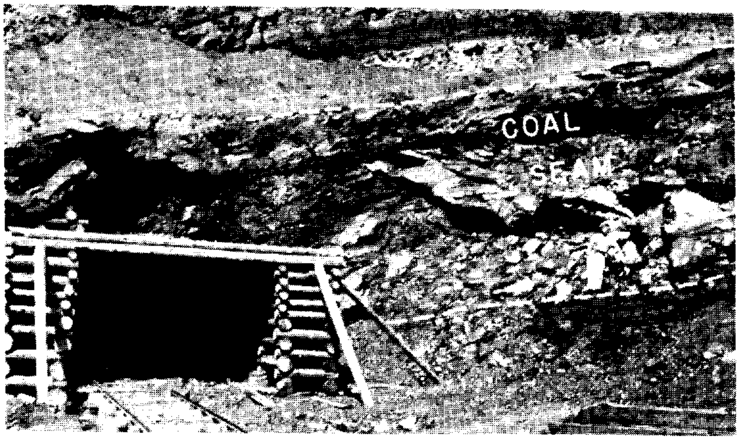

Figure 11—Coal seam, 19 feet thick, being mined by stripping and underground methods; Kananaskis Exploration and Development Co., Ribbon Creek.

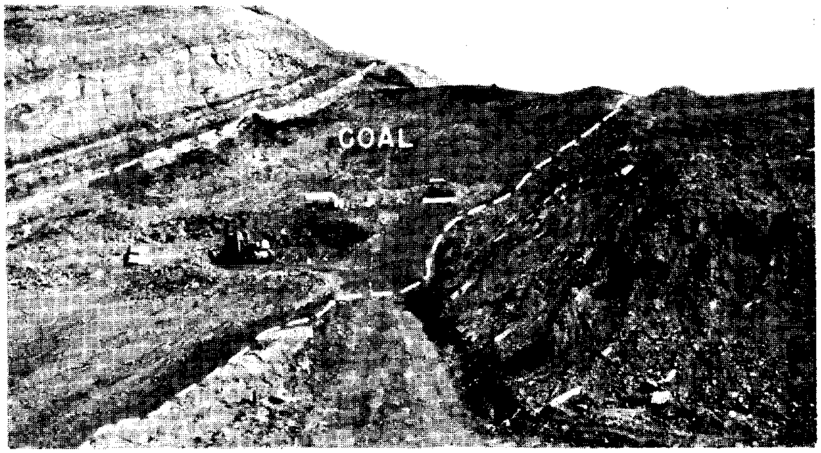

Figure 12—Strip mine, Kananaskis Exploration and Development Co., Ribbon Creek.

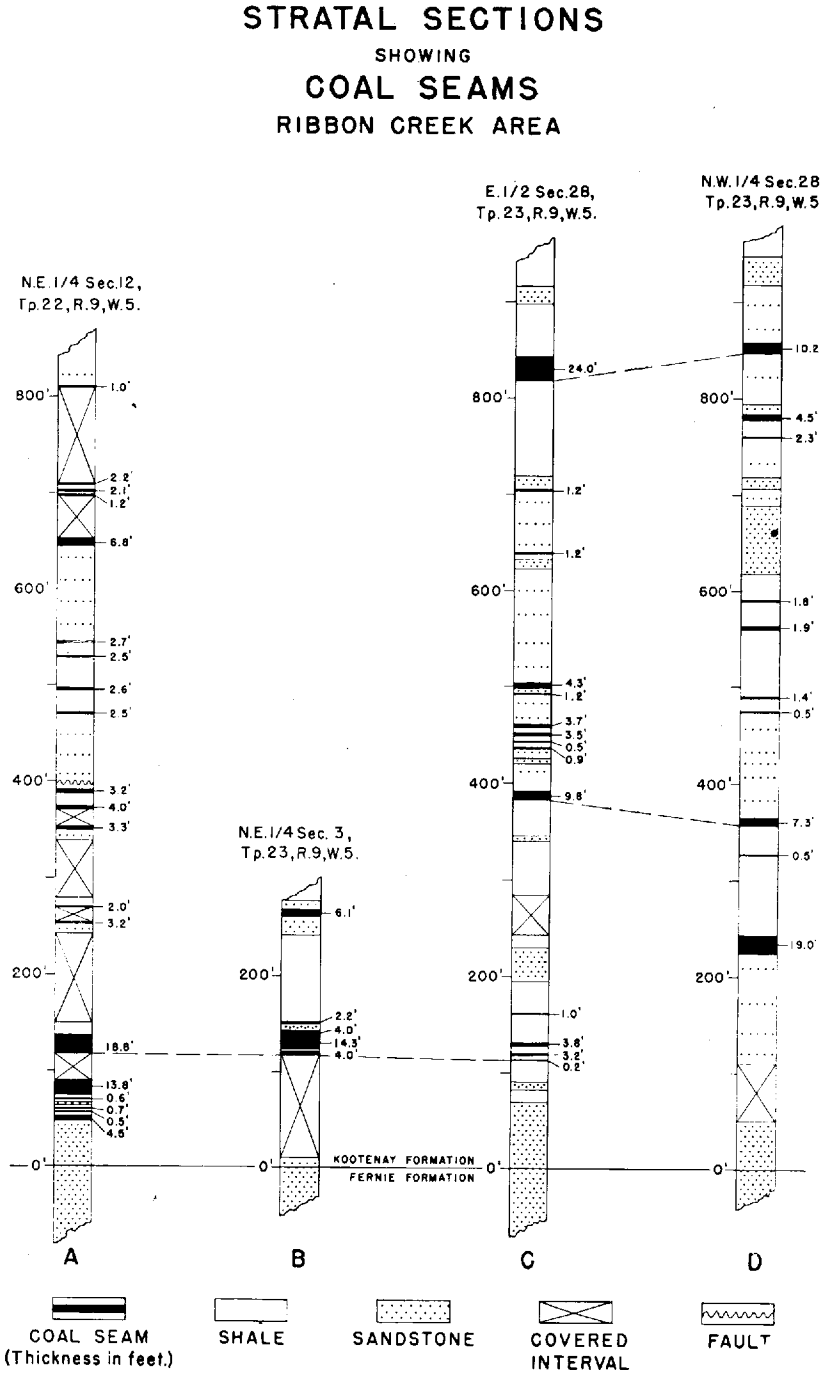

Figure 13—Diagram of stratal sections, Ribbon Creek Area, illustrating number, thickness and some suggested correlations of coal seams; sections given in order from south to north. Section A measured along Evans-Thomas creek, Section B along Ribbon creek, Sections C and D on east slope of Mount Allan.

rock succession (Leach, 1912, p. 234). The basal Blairmore conglomerate originally was included in the Kootenay, but later it was transferred to the Blairmore by Rose (1917, p. 110) on the basis of an unconformity at the base of the conglomerate.

The Blairmore formation outcrops extensively in southwestern Alberta foothills. It is also present in many of the valleys between the eastern ranges of the Rocky Mountains, and in the mountains of southeastern British Columbia. The Blairmore sandstones and conglomerates are well indurated, and many prominent ridges in the area extending from Crowsnest pass to Bow river are composed of these rocks. South of the Ribbon Creek area, Blairmore rocks are prominent in the Highwood-Elbow area; but in the Canmore area adjoining on the north they are exposed only along the top of Wind ridge, which lies partly within the Ribbon Creek map-area.

In the Ribbon Creek area, Blairmore rocks have very limited areas of outcrop, being found only in patches on a few of the higher elevations north of Kananaskis river. The greatest development is on Mount Allan at the tops of the ridges which extend eastward from its peak. Two other outliers cap the tops of the two ridges immediately north of Mount Allan. In all outcrops the lower part of the formation alone has survived erosion, and the thickest remnant occurs on Mount Allan (Figure 8).

THICKNESS AND LITHOLOGY: As only the lower part of the Blairmore formation is present in Ribbon Creek area, its former thickness in this area may be estimated by reference to thicknesses in adjacent areas. In the Moose Mountain area on the east it is 2,000 to 2,200 feet thick (Beach, 1943, p. 38), and in the Highwood-Elbow area a thickness of 3,300 has been measured (Allan and Carr, 1947, p. 27). Since the lower Blairmore strata of Ribbon Creek area contain coarser sediments than in the Highwood-Elbow area, the formational thickness in the former area should exceed 3,300 feet. In Elk River and Flathead areas, about sixty miles south of Ribbon Creek area, Rose reports 6,500 feet of beds in the Elk and Flathead formations, which are the approximate equivalent of the Blairmore. It is reasonable to assume that the complete section of Blairmore in the Ribbon Creek area would have measured between 3,300 and 6,500 feet. The thickest section now remaining is 997 feet.

Blairmore rocks in Ribbon Creek map-area comprise conglomerate and sandstone with minor amounts of shale. Occasional beds of limestone nodules are present. The most prominent feature of the sequence is the number and thickness of conglomerate beds. The following section is the most complete, and was measured on the northeast-southwest trending ridge of Mount Allan. It is continuous with the Kootenay section detailed above (p. 32). It begins on the northeastern end of the ridge, works up the section along the ridge, and ends in the axis of the syncline immediately east of the peak of Mount Allan (Figure 8).

MOUNT ALLAN SECTION OF THE BLAIRMORE FORMATION

Erosion surface	Thickness Feet
Conglomerate, pebbles of white and grey quartzite, grey and black chert in sandy matrix; maximum size of pebbles is ½ inch	7
Sandstone and shale interbedded, coarse grey sandstone and grey green and green shale	100
Sandstone, cross-bedded, coarse-grained, to very coarse-grained; conglomerate lenses composed of chert and quartzite pebbles of ¼ inch to ½ inch diameter	40
Sandstone and shale interbedded; fine-grained, grey sandstone, and greyish green to dark grey and black shale	66
Sandstone, cross-bedded, coarse-grained; conglomeratic lenses of small chert and quartz pebbles having a maximum size of ¼ inch	7
Sandstone and shale, interbedded; fine-grained sandstone; greenish grey shale, some weathering reddish	65
Sandstone and shale interbedded, thick beds of coarse-grained, cross-bedded, sandstone up to 10 feet thick; and grey and grey green shale	82
Sandstone, very coarse-grained, with thin conglomerate lenses	18
Sandstone and shale interbedded; greenish sandstone and greenish grey shale	95
Sandstone, coarse-grained, conglomerate lenses	23
Conglomerate, pebbles of grey chert and grey and white quartz, averaging ¼ to ½ inch in diameter	12
Shale, greenish grey and maroon	15
Conglomerate, pebbles of quartz, very numerous and increasing in size to 6 inches at top	56
Shale, greenish grey, sandy	6
Sandstone, conglomerate lenses having pebbles of chert and quartz up to 1 inch in diameter	32
Sandstone and shale, greenish grey and maroon shale and greenish grey, fine-grained sandstone interbedded; limestone nodules near base	36
Conglomerate and sandstone interlensing; chert and quartz pebbles up to ½ inch across	45
Sandstone and shale interbedded; fine-grained, greenish grey sandstone and greenish grey and maroon shale; limestone nodules about 2 inches in diameter fifteen feet from the top	75
Shale, dark grey with thin lenses of greenish grey, silty, fine-grained sandstone; some green and maroon shale present	92
Shale and sandstone interbedded, grey, black shale, interbedded with fine-grained, grey sandstone	70
Conglomerate and sandstone interbedded; pebbles of chert and white quartz up to 2 inches across in coarse grey sandstone. Basal Blairmore conglomerate	55
Total Blairmore beds	997

Contact apparently conformable

Underlying beds—shale, black (Kootenay formation).

The conglomerate beds are generally interlensing with coarse, pebbly sandstone. The pebbles in the conglomerate range in size from a fraction of an inch to six inches across, and they are assorted as to size in the various beds. The largest pebbles are usually in the conglomerates at the base, and their size decreases upwards. The pebbles are composed of black, green and various shades of grey chert, and white, yellow-brown, and grey quartzite. White quartzite pebbles are very abundant, comprising approximately one half of the pebbles in some beds (Figure 6). The pebbles are embedded in a matrix of quartz sand, and the rock is so well indurated that fractures cut through pebbles and matrix alike. Warren (1938, p. 18) has suggested that the source of these pebbles was the Selkirk Mountains, which were upthrust prior to the Rockies disturbance, and further evidence for this deduction is furnished within Ribbon Creek area. There the conglomerate section is much thicker than in Moose Mountain area, which is some distance to the east, a fact which indicates a westward thickening, and also a westward source of the sediments. This source could be the Selkirk Mountains, some miles southwest of Ribbon Creek area.

In the lower part of the formation there are two or three massive conglomerate beds, each 50 or more feet thick, and the Kootenay-Blairmore contact is placed at the base of the lower one (Figure 7). Though direct evidence is lacking it is thought that the basal conglomerate changes laterally into conglomeratic sandstones and sandstones, and hence may not be recognizable. In several measured stratigraphic sections which included the Kootenay and Blairmore conglomerates, definite correlations between beds could not be established. Therefore it is possible that the basal conglomerate bed described above may not everywhere in the area be the same age.

The sandstones in the Blairmore are usually coarse-grained, quartzose, cross-bedded, and grade into conglomerate, or are conglomeratic. Their color varies from grey to greenish grey, rocks of the latter color being thin-bedded and having a platy habit. Shales vary in color, being greenish grey and green for the greater part, but a few beds of black shale occur, and in the lower part of the formation, there are some maroon shales. Limestone nodules, weathering yellowish, and as large as one foot in diameter, are found approximately three hundred feet above the base of the formation. The presence of the maroon and green shales, together with greenish grey sandstones generally serves to identify any strata as Blairmore.

AGE AND CORRELATION: Leach ascribed a Dakota (lowermost Upper Cretaceous) age to the Blairmore when he originally studied the succession. McLearn (1916) determined the lower part of the formation to be Lower Cretaceous. Later Berry (1929, p. 33) studied the fossil flora of the Crowsnest Pass area, and to the lower Blairmore member he gave a late Aptian and Albian (uppermost Lower Cretaceous) age (Berry, 1929, p. 57). The upper member of the Blairmore he assigned to the Cenomanian (earliest Upper Cretaceous), but it has since been placed in the Lower Cretaceous (Bell, 1946, p. 517). Berry (1929, p. 33) further concludes that the floras of the Kootenay and Lower Blairmore so resemble each other that no great time interval can separate them. Therefore on the basis of fossil evidence any unconformity between these two formations is to be considered a minor feature, probably taking the form of contemporaneous erosion.

Rocks of Blairmore age outcrop extensively in the mountains of west central Alberta and northeastern British Columbia. In the former place its equivalents are a series composed of the Cadomin, Luscar and Mountain Park formations, the last being the youngest formation. The Cadomin formation corresponds to the basal Blairmore conglomerate of the region south of Bow river, which includes Ribbon Creek area. The Luscar carries the commercial coal seams of the region. In northeastern British Columbia the nonmarine, coal-bearing Gething formation is the correlative of the Luscar and of lower Blairmore age; but rocks of upper Blairmore age may be marine. In northern Alberta rocks of Blairmore age are both nonmarine and marine. The Lower Cretaceous succession in these parts has been worked out by McLearn (1944).

In southeastern British Columbia, Rose divided a rock succession into two parts, naming the lower part the Elk conglomerates and the upper part the Flathead beds (Rose, 1918, p. 31). The Elk formation apparently comprises the conglomerate series that spans the Kootenay-Blairmore contact, and therefore possibly includes some Kootenay strata. It is well developed in Ribbon Creek area. Combined thickness of Elk conglomerates and Flathead beds is 6,500 feet.

Blairmore strata or rocks of equivalent age are encountered in deep wells drilled for oil and gas on the plains of central and southern Alberta. In some places these rocks are important reservoirs of oil and gas. Thin coal seams have been recorded in these rocks in drill holes in central Alberta.

In the Cut Bank oil field of Montana, the Kootenai is stated to be the equivalent of the Lower Blairmore member (Blixt, 1941, p. 338).

PLEISTOCENE AND RECENT

Pleistocene and Recent deposits are found almost entirely in the valleys of Ribbon Creek area. They consist of the Pleistocene glacial products, boulder clay, river terrace clay and silt, and occasional erratics; recent deposits are river gravels, sand, silt and clay, soil and talus. All these clastics are unconsolidated.

Boulder clay is found in the valleys and on some of the higher slopes below timber line. The hoodoos shown in Figure 2 have been carved from boulder clay. They occur in a narrow valley between two small ridges between Wind creek and West Wind creek. In the valley of Kananaskis river, terraces occur on the west side of the river and remnants of terraces on the east side. These appear to be remnants of glacial lacustrine deposits that accumulated when Kananaskis valley was dammed by ice east of Ribbon Creek area. Melt water collected behind the dam to form a large lake, in which considerable thicknesses of sediment were deposited. Later the ice dam melted, normal drainage was restored, and the river cut through the sediment to form the river terraces. A terrace is also present along Pigeon creek and is probably associated with similar terraces in the valley of Bow river, Glacial erratics occur at a height of approximately 7,500 feet. These erratics are essentially limestone boulders; they are too far removed from the Paleozoic ranges to have been derived in situ, and consequently are presumed to have been ice borne. It is doubtful if glacial ice reached above the 7,500-foot level, for on the top of Pigeon mountain, which has an elevation of 7,835 feet, no foreign pebbles, fluting, or other evidences of the passage of ice were observed.

Recent deposits in the form of stream gravels, sand, silt and clay are found in valley bottoms. These sediments are probably original materials derived from mountain slopes by erosion, and are also partly reworked glacial debris. Talus is abundant on many slopes, especially on those where Kootenay sandstones outcrop, and is often effective in concealing the underlying bedrock.

Chapter IV

STRUCTURAL GEOLOGY

REGIONAL STRUCTURE OF ALBERTA FOOTHILLS AND MOUNTAINS

A perusal of geological maps of Alberta shows that the foothills and mountains are comprised of a group of subparallel fault blocks, having a general southeast-northwest trend. In some of the blocks, strata are folded into anticlines; in others the strata dip westwards at varying degrees. Each fault block tends to override its neighbor, adjacent on the east. The fault planes which underlie the blocks, excepting in some few instances, dip westwards, and reveal the mountain building stresses to have operated from a southwestwardly direction throughout the greater length of the mountains. In some places, as in Crowsnest Pass area, the structural features trend north-south, thereby indicating relative movement of the rock masses was west-east. The stratigraphic displacement of the strata involved in these thrust faults is variable, and ranges from a fraction of an inch to as much as 13,000 feet. This latter displacement occurs along the eastern edge of the Rocky Mountains where Bow river issues from the front range. At this place Cambrian limestones are overthrust on to Belly River sandstones and shales. In many of the west-dipping fault blocks, the inclination of the strata connotes that the original structures were overturned anticlines, faulted on the east limb near the crest, for dips often approach horizontality at the summits of the ridges. In most instances erosion has removed the crest of the anticline, so that the remaining structure resembles a simple west-dipping fault block. Anticlines where present are as a rule faulted on the east limb, or asymmetrical with the east limb steeper than the west.

Visible east-dipping faults are rare in the mountains and foothills, but are probably more common in the foothills, particularly the eastern foothills of Alberta, than is generally believed. This type of fault may be attributed to underthrusts from the west, overthrusts from the east, or to adjustments which succeeded release of pressures after the raising of the Rocky Mountains. The last explanation is thought to apply especially to east-dipping faults in the limestone mountain ranges.

The rocks that were involved in the tectonic movements differed greatly in their ability to resist the deformation imposed on them by the enormous pressures of crustal adjustments. The most competent rocks are the thick-bedded Paleozoic limestones and dolomites, which transmitted stresses without they themselves undergoing much deformation. By comparison, rocks of the Mesozoic formations are incompetent. They have been thrown into folds of many sizes, and cut by faults varying greatly in throw. Of the Mesozoic succession, the Spray River and Fernie formations show the greatest amount of distortion, a consequence of their thin-bedded nature. The thick sandstones at the top of the Fernie and at the base of the Kootenay, the sandstone member in the Kootenay, and the conglomerate beds at the base of the Blairmore are among the most competent rocks in the Mesozoic succession. These members are not only less distorted, but have tended to protect from disturbance adjacent shales and argillaceous sandstones. Therefore, folding, faulting and crushing are not nearly so common or intricate in the Kootenay and Blairmore as in the Spray River and Fernie formations.

Most rock formations of Alberta plains, foothills and mountains thicken towards the west, thereby pointing to a source of sediments in the mountains of eastern British Columbia. Therefore absence of any of these formations in the foothills and mountains of Alberta is not attributable to nondeposition, but to erosion during and following the Rocky Mountain orogeny.

It is a common observation that in Alberta the exposed geological formations become older from east to west across foothills and mountains. Thus in the eastern foothills, Paskapoo rocks of Tertiary age are exposed; but progressing westwards towards the mountains, Edmonton, Bearpaw, Belly River, Wapiabi, Bighorn, Blackstone, Blairmore, Kootenay and Fernie rocks are successively encountered. Within the mountains the same generalization is true, and the east-to-west succession is from upper Paleozoic to Precambrian. Since there are numerous anticlines in the foothills and Rocky Mountains, they together constitute an anticlinorium.

It was stated above that geological formations thicken from east to west; therefore, since older rocks are exposed in that direction, the thickness of rock which has been eroded increases from the eastern margin of the Alberta foothills westward. Thus in the front ranges of the Rocky Mountains, in places at least, all Mesozoic rocks, which have an aggregate thickness of approximately 20,000 feet, have been eroded. At the crest of the anticlinorium, Precambrian rocks are exposed, requiring the removal of an additional 10,000 feet or more of Paleozoic strata.

GEOLOGICAL STRUCTURE WITHIN RIBBON CREEK AREA

General Statement

The foothills of Alberta and the Rocky Mountains constitute a vast anticlinorium, and as such there are in it areas underlain by younger rocks and surrounded by older rocks. That is, inliers occur, one of which is the group of Mesozoic rocks underlying a large part of Ribbon Creek area and extending northwest through the valleys of Bow river and Cascade river. This inlier might be called the Cascade inlier. The strata of the inlier and subjacent Paleozoic rocks have been bent into the form of an asymmetrical syncline, named the Mount Allan Syncline. The west limb of the syncline is the steeper, and is truncated by a major fault, herein called the Paleozoic Thrust Fault (Cross Sections, Map 21). The eastern limb is also cut off by a fault, but this lies outside the surveyed area. The syncline and the fault are the only major structures in the area, and are considered separately below.

MOUNT ALLAN SYNCLINE

This is the dominant geological structure in Ribbon Creek area. It is named after Mount Allan where its structure is most obvious (Figure 8). The syncline arises in the southwestern corner of the map-area, and extends northwestwards well beyond its northern limit. Width of the syncline increases northwards and is defined on the west by the Paleozoic Thrust Fault, and on the east by the mountain range which extends from Fisher peak to Pigeon mountain. Erosion has removed much of the Mesozoic strata from the limbs of the syncline, so that the younger rocks, Blairmore and Kootenay, occupy the trough of the syncline, and the Paleozoic rocks form the eastern limb. All formations from Palliser to Blairmore are exposed on the east limb, but only Kootenay and Blairmore outcrop on the west limb, formations older than these being concealed by the Paleozoic overthrust fault block. Proof of existence at depth of the west limb is furnished by the slices of Rocky Mountain, Spray River, and Fernie formations along the Paleozoic Thrust Fault. The synclinal structure is well exposed in many of the valleys that streams have cut at right angles to the synclinal axis. West Wind and Ribbon creeks, Kananaskis river and a few small streams south of the river are largely responsible for excellent cross sections of the strata.

The syncline plunges northwestwards from the south end of the map-area at approximately 150 feet to the mile exposing younger strata along its axis from south to north. The plunge continues beyond the northern limits of the area. The surface trace of the synclinal axis follows a sinuous course owing to the high relief of the area. It parallels the Paleozoic Thrust Fault, and is nowhere in the area any great distance from it (Map 21).

The structure is narrowest at its southern end where it pinches out between Mount Hood and an unnamed mountain east of it. It widens rapidly at the south end, and has almost attained its maximum width in the vicinity of Fisher peak. The syncline was split into two unequal parts by the uplift of the above unnamed mountain, which is anticlinal in form. The eastern branch is the smaller, and is now represented by narrow bands of Spray River rocks in section 16, township 21, range 8. The western branch is the broader and contains Fernie and Kootenay rocks in addition to Spray River, since it has not been eroded to the same extent as the eastern branch.

The overturning of the west limb is a prominent and persistent feature, and the angle of overturn appears to increase with depth. It is not evident at the extreme south end, for there the west limb is concealed by the Paleozoic thrust block. Blairmore strata are usually not overturned, probably owing to their competent nature (Figure 9), and as a consequence the strain was taken up by the underlying Kootenay rocks. The inclination of the steep dip of the west limb is an index to the tremendous stresses involved, so that considerable deformation of the strata is to be expected. Upon examination they are found to be squeezed, contorted, tightly folded, and cut by faults of varying displacements. The deformation is greatest adjacent to the Paleozoic thrust block, and diminishes towards the synclinal axis, where its effects are little in evidence. The west limb has been cut by a west-dipping thrust fault which extends through most of the map-area, and has a stratigraphic displacement of only a few hundred feet. In places the fault may be a zone of small faults, having an aggregate displacement equal to that of the one main fault. This fault is shown to be continuous on Map 21, but additional data may show it to be two or more faults slightly overlapping.

The east limb of the syncline dips at angles ranging from ten to fifty degrees west. Locally, dips may exceed the larger figure, as at the south end where in one place the limb has even been overturned. Dips of the strata in the bottoms of the valleys of Evans-Thomas and Pigeon creeks, which are near the bottom of the syncline, average 25 degrees approximately. Eastwards and upwards along the sides of the syncline (and valley sides) the dip increases to 40 degrees or more. Then, near the tops of the eastern mountain ridges, the inclination of the strata lessens. South of Kananaskis river, the east limb dips more steeply than north of the river, probably owing to the narrowing of the syncline.

A small anticlinal fold is present high on the east limb. It begins as a flexure on the west slope of Mount McDougall in the west centre of township 22, range 8; and in the northwest corner of that township it has developed into a small anticline, which has at its crest an outlier of Spray River rocks. The anticline persists in a northwesterly direction for a short distance, but gradually loses its closure, so that, where it crosses Kananaskis river, it is a flexure. This flexure extends to the west slope of Mount Lorette and the top of Pigeon mountain; and the resultant low dips at these places have been factors in preserving the Spray River rocks, which are now present as outliers.

Several thrust faults of small displacement transect strata of the east limb. One of these faults begins north of the map-area entering it in section 12 of township 24, range 10. It passes southeast towards Mount Allan, of which it underlies the east slope, and the fault probably dies out immediately north of Kananaskis river. Traces of this fault appear sporadically, so that data regarding it are meagre. However, evidence points to a stratigraphical displacement of a few hundred feet, for there are no marked repetitions of strata. Another fault repeats part of the Fernie formation. It originates in section 33 of township 23, range 9, and extends southeast, almost to Ribbon creek. Displacement is apparently small for Spray River rocks are brought up against the Pigeon Creek member of the Fernie, which is thus repeated twice in outcrop. A fault which repeats part of the Spray River formation crosses Kananaskis river in section 35 of township 22, range 9. This fault is shown to cut the Paleozoic rocks (cross section JK, Map 21), but it may be wholly within the Spray River. Immediately east of this fault, and beginning near the bridge over Kananaskis river, a fault repeats the Rocky Mountain formation, and thereby accounts for a large area underlain by quartzites of that formation.

In the area south of Kananaskis river, at least two faults repeat sections of Kootenay rocks. One of the faults was observed in section 12, township 22, range 9, where it may repeat a small section of the coal measures which were examined and are described on page 54. The exact course of the fault is difficult to follow for lack of exposures, but it is presumed to be the same disturbance that was observed further south in section 6. The other fault in the Kootenay outcrop extends southeast from section 36, township 21, range 9. Critical data regarding it are indefinite, and it may extend farther southeast than shown. There are several other small faults in the Kootenay strata and also numerous folds, so that the structure is quite broken and complicated in places.

PALEOZOIC THRUST FAULT

This fault delimits the Mesozoic formations on the west side of Ribbon Creek area, since it has cut off the west limb, and has caused Paleozoic rocks, usually Devonian, to partly override Kootenay strata. The stratigraphic displacement along the fault is 8,000 feet or more. The fault can be traced throughout the length of the map-area from Mount Hood to Wind ridge. Its trace follows along the base of the limestone cliffs; consequently it is sinuous owing to the combined effect of the moderate westward inclination of the fault plane and to differential erosion of the overthrust limestone block. Dip of the fault plane ranges from 30 to 75 degrees westwards, but 45 degrees is considered to be an average. In the valley of Ribbon creek it is 35 degrees, but elsewhere measurements will probably differ since the fault plane is a smooth uneven surface with local variations in dip. It has, in one outcrop, undulations measuring five to eight feet from crest to crest and an amplitude of approximately one foot.

Occasionally a slice of rock formation, younger than Devonian, has been carried up along the fault plane. One such mass of Rocky Mountain quartzite was observed on the southeastern slope of Mount Kidd. Palliser (Devonian) limestones lie above the quartzite, and Kootenay strata below. The Palliser-Rocky Mountain contact is covered, but the Rocky Mountain-Kootenay fault plane was exposed by trenching. It is quite undulating, and has an average dip of 30 degrees west. The rock surfaces on each side of the fault are both slickensided, the quartzite on the surface, and the Kootenay shale below to a thickness of one inch. Below the one-inch band the rocks are crushed to a depth of about two feet, but otherwise unaltered. Other slices are present east of Mounts Evans-Thomas and Hood. At Mount Evans-Thomas a slice each of Spray River siltstone and Fernie shale are exposed along the fault plane, with the latter on the east. Each slice involves a few hundred feet of section. The slice of Fernie formation consists of the concretionary shale zone. The slice of Spray River persists southwards, and is joined by another of Rocky Mountain quartzite. These two continue to Mount Hood. At this place fossil evidence shows the FLEMINGITES zone to be present in the slice of Spray River. The Spray River rocks are separated from the Kootenay by two feet of black gouge, which is taken to indicate that major movement took place along this surface, rather than along the Rocky Mountain-Spray River fault plane, which has smooth undulating surfaces. The Palliser-Rocky Mountain contact was not observed, since it tends to be concealed by the fall of rock from the steep faces formed by the Devonian (Palliser) limestones.

Strata above and below the fault plane show evidence of the enormous stresses involved. The Palliser limestones above are intricately folded in proximity to the fault. At Wind ridge they are brecciated. By comparison the underlying Kootenay rocks show much greater effects, being faulted, folded, crushed and overturned for some distance from the fault, almost to the axial plane of the Mount Allan syncline in some instances (Cross Sections, Map 21).

MISTY RANGE ANTICLINE

This structure extends from the Highwood-Elbow area into Ribbon Creek area; but only a small part of it lies within the northern area.

This Paleozoic anticlinal uplift, which appears at the south end of the map sheet, is faulted on its eastern side. This fault is considered to be that which brings about a repetition of Spray River rocks on the west slope of Fisher peak. The anticline exposes Paleozoic rocks and plunges sharply northwards, disappearing below the valley floor in section 16, township 21, range 8. At the north end of the anticline, Spray River rocks and Rocky Mountain quartzites are faulted and tightly enfolded into a complex association. This anticlinal uplift extends southwards in Highwood-Elbow area (Allan and Carr, 1947, Map 20), where it includes such mountains as Tombstone, Rae and Mist, and plunges out southwards, in township 18, range 17, just as sharply as at its northern end. This uplift serves to separate the Cascade and Highwood coal basins. Since the northward plunge of the anticline in Ribbon Creek area is very steep, stratal dislocations do not extend far north of its northern extremity. Consequently faults associated with it die out rapidly northwards.

TRANSVERSE FAULTS

A few faults which are at considerable variance with the regular northwest-southeast trend of the strata were observed in the area. In all cases the stratigraphic displacement is small. Small transverse faults having a displacement of only a few feet in an east-west direction were seen in Spray River strata exposed along Evans-Thomas creek in section 18, township 22, range 8. The faults seemingly occur in groups, and their aggregate displacement may be greater than that which can be ordinarily observed. The largest transverse fault observed is present on Ribbon creek in section 2, township 23, range 9. Here the transverse movement was recognized by relative positions of the Rock Creek member of the Fernie and the uppermost Spray River beds. These strata of diverse age outcrop opposite each other along Ribbon creek, thereby indicating a fault with a downthrow to the north and a stratigraphic displacement estimated to be 100 feet. Further small faults of this type were noted in the Kootenay strata of the east slope of Mount Allan. The transverse faults were probably caused by differences in the intensity of lateral stress.

Chapter V

ECONOMIC GEOLOGY

Coal

INTRODUCTION

Ribbon Creek area comprises the south end of the Cascade coal basin, a synclinal structure that extends for approximately forty miles northwest of the area. It lies within the Cascade Coal Area as approved by the Statutes of Alberta (Allan, 1943, p. 161). Coal mines presently active in the coal basin are located along Ribbon creek, and at Canmore and Anthracite. The site of Bankhead, an abandoned mining town, is located in the northern half of the basin.

Coal was discovered in the Cascade basin in 1883, and subsequently a few mines were opened. One of these was probably on the northeast slope of Wind ridge, located just outside the north end of Ribbon Creek area, and there, two seams 12 and 15 feet thick were prospected. McConnell (Dawson, 1886, p. 133) reported that these seams were traceable southwards towards Kananaskis river. This is one of the earliest references to the coal measures of the Ribbon Creek area.

First detailed information regarding Ribbon Creek area was recorded by Dowling (1909, p. 78), who reported three measured sections along Ribbon creek and on Mount Allan. These sections contain twenty-three coal seams. Of these, sixteen were considered to be workable and to contain an aggregate of 89 feet of coal. The seams had been uncovered by prospectors. Their exact location, position in the Kootenay stratigraphic column and the intervals between them have not been recorded. Periodically, prospecting has since been carried on in the area. In 1916, G. W. Pocaterra prospected extensively along Evans-Thomas creek. Brazeau Collieries, which operate at Nordegg, took an interest in Ribbon Creek area in 1924, but at that time carried no development beyond the prospect stage. However, in 1947 this same company renewed its activities in the area by undertaking a core-drilling program on their Ribbon Creek holdings. This was soon followed by the opening of a strip mine, and in 1948 an underground mine was commenced. The more important of the coal prospects that were observed in the present surveys are shown on Map 21.

The coal seams of the Ribbon Creek area belong to the Kootenay formation, which is considered to be Lower Cretaceous in age. The coals rank from low volatile bituminous to semianthracite, and are therefore of high quality. The coal seams of the area vary in thickness from a fraction of an inch to thirty-four and one-half feet. Though the seams are distributed throughout the 3,400 feet of the formation, those of commercial importance, that is, those three feet or more thick, appear to be restricted to the lower 1,200 feet. The coal seams have been brought to the surface on both east and west limbs of the Mount Allan syncline; but the best prospects for commercial development are located on the east limb, since strata of the other limb are badly deformed. Any coal seams examined on the west limb occur close to the Paleozoic Thrust Fault, and are crushed, thinned, and distorted.

Opportunities for development of the coal seams by underground or surface methods are more limited in Ribbon Creek area and north of it, than in the areas of Kootenay outcrop in the mountains and foothills to the south. In the Highwood, Oldman and Crowsnest areas, the coal measures are exposed in several parallel bands that have been produced by faulting and folding, thereby providing many opportunities for development by underground or strip mines. In Ribbon Creek area only one band of Kootenay is present, and its simple, synclinal form limits the number of locations favorable for mine sites.

The width of the area underlain by Kootenay rocks varies from almost zero at the south end of the map-area to 3 miles in the vicinity of Mount Allan. The width is constricted in the Kananaskis valley and again north of Mount Allan. North of the map-area its width is further reduced. The factors that determine the width of the Kootenay outcrop are the moderately low dip of the east limb of Mount Allan syncline, which is 15 to 25 degrees, and the amount of erosion this limb has undergone. In Kananaskis valley a relatively moderate amount of erosion has reduced appreciably the width of the area in which Kootenay formation is bedrock. The narrowing of the Kootenay band by erosion of the east limb is partially compensated for by erosion of the western overthrust limestone block, which to some extent overrides the west limb of the syncline. To illustrate this point, it may be noted that additional Kootenay strata have been revealed on the west side of the syncline in the valleys of Kananaskis river and Ribbon and Rocky creeks. Narrowing of the band of Kootenay rocks at the south end of the map-area has been brought about by the Misty Range uplift, which was discussed above (p. 47).

The coal seams of Ribbon Creek area fall into two natural, geographical divisions, namely, one north of Kananaskis river, and the other south of that river. These are called the Northern and Southern Portions, and will be dealt with separately.

NORTHERN PORTION

This area comprises that part of the band of Kootenay rocks lying north of Kananaskis river, and extending to the north boundary of the map-area.

The centre of the band is covered with non-coal-bearing Kootenay and Blairmore rocks, so that coal seams have been brought to the surface only along the eastern and western margins. On the western margin the only promising seams observed are on Mount Kidd close to the limestone overthrust block at an elevation exceeding 7,000 feet. The thickest seam there is three feet, and its continuity is in doubt since the strata in that vicinity are contorted and faulted. Any development on the west limb might encounter similar, unfavorable, structural conditions. Furthermore, excepting in a few instances, as in the valleys of Kananaskis river and West Wind creek, the west limb has the disadvantage of being exposed at high elevations; consequently it is not easily accessible.

The eastern margin of this portion has numerous outcroppings of coal. The most complete record of the sequence of the coal seams is that described in the type section of the Kootenay formation on Mount Allan given above (p. 32). The lower 1,200 feet of the section has 14 seams aggregating 58.5 feet of coal, and of this 52.1 feet are contained in seven seams of three feet or over. The important part of the coal-bearing section is illustrated in Figure 13, C. The uppermost seam is close to 24 feet thick, though the exact thickness was not determined on account of the heavy cover of wash and debris. The coal at the surface is crushed and weathered. The seams dip westward at angles from 20 to 30 degrees, and appear not to be complicated by minor faults or folds. Their unbroken condition is attributed to their position (which is well up on the eastern limb of the syncline and at some distance from centres of intense stress) and to their intercalation between thick sandstone members, which has tended to protect the coal seams from deformation.

Approximately one-half mile southeast of the above stratigraphical section, a very thick coal seam outcrops in a small gully (Figure 10). This is considered to correspond to the 24-foot seam in the above section, as it occurs under the same stratigraphical conditions. Details of this seam are given below.

	Thickness Feet
Sandstone, fine-grained, shaly habit, not measured	
Coal, bright, broken into small angular fragments	3.5
Shale, dark grey	0.9
Coal, friable at top, angular fragments	5.8
Shale, coaly, shiny (blackjack)	1.3
Coal, friable in part, remainder chunky	8.0
Shale (blackjack)	0.5
Coal, friable and chunky	10.8
Shale	1.2
Coal, chunky	2.5
Shale, base concealed	
Total	34.5

Shale partings account for nearly four feet of the seam, leaving about 30 feet of coal. A good portion of this thickness promises to contain chunky coal.

A 19-foot seam of coal, very hard and blocky in the lower 15 feet, occurs in the northwest quarter of section 28, township 23, range 9. At this locality there are ten seams aggregating 47.4 feet of coal in 900 feet of section, and four of the seams totalling 41 feet of coal are over three feet in thickness. A fault exists at the top of the section, but the displacement is considered to be very small since there is no marked repetition of beds and coal seams. Details of this section are as follows:

	Thickness Feet
Sandstone, forms waterfall, rudely bedded, dark grey, about	30.0
Fault	
Shale and sandstone, interbedded dark grey and black shale and brown weathering, fine-grained sandstone	60.0
Coal, crushed in part, but some pieces of bright coal up to 6 inches long	10.2
Shale, black, few ironstone concretions and thin-bedded sandstone beds	53.0
Sandstone, fine-grained	10.0
Coal, partly crushed, with one 2-inch shale parting three inches from top	4.5
Shale, dark grey, concealed in part	17.5
Coal	0.3
Shale and sandstone, partly concealed; black, sandy shale and fine-grained sandstone	44.0
Sandstone, medium-grained, dark grey	12.0
Shale and sandstone, dark shale and brown weathering sandstone	16.0
Sandstone, medium-grained, forms series of small falls	72.0
Shale, dark grey, with large yellow weathering concretions	27.0
Coal, fragmentary, bright, hard, pieces up to 3 inches long	1.8
Sandstone, thin-bedded with some shale interbeds	26.0
Coal, hard, bright, angular fragments	1.9
Shale, with some sandstone bands; large ironstone concretions near top	70.0
Coal, crushed	1.4
Shale, dark grey	15.0
Coal	0.5
Shale and sandstone, dark sandy shale with sandstone interbeds up to 3 feet thick	110.0
Coal, crushed, friable, weathered	7.3
Shale, with brown weathering sandstone beds up to 1.5 feet thick; few thin ironstone bands	30.0
Coal	0.5
Shale, dark grey, with sandstone bands increasing in number near top	82.5
Coal, very hard, bright, blocky in lower 15 feet, upper four feet crushed and friable	19.0
Shale, with interbeds of fine-grained, brown weathering sandstone	115.0
Concealed by wash and soil	60.0
Sandstone, dark grey, coarse-grained, rudely bedded; basal Kootenay sandstone	50.0
Conformable contact	
Sandstone, thick-bedded, brown weathering, medium-to fine-grained (Fernie formation).	

The above section is shown graphically in Figure 13, D.

The 24-foot seam of the Mount Allan Kootenay section is apparently represented by the 10.2-foot seam of the above section (Figure 13). Since the seam is 34.5 feet thick one-half mile southeast, it shows a thickening in a southerly direction.

A prospect sunk below water level along West Wind creek in section 6, township 24, range 9, about 25 years ago is reported to have followed a six-foot seam. Lumps of coal, some fifteen inches long and ten inches wide, won at that time, are still hard and unweathered. This seam is called the Wind Mountain seam by MacKay, and is shown on his cross sections to be about 450 feet above the base of the formation (MacKay, 1935, Cross Section QR).

The following section was measured in the open pit of the strip mine located in the northeast quarter of section 3, township 23, range 9, and operated by the Kananaskis Exploration and Development Company, a subsidiary of Brazeau Collieries. The section is also shown graphically in Figure 13, B.

	Thickness Feet
Sandstone, dark grey, coarse-grained, cross-bedded, fractured	8.0
Coal, friable, crushed, with 3 shale bands; two, each 1-inch thick, and the other 3 inches thick	6.1
Shale and sandstone, dark grey shale and shaly sandstone	20.0
Shale, dark grey	23.0
Shale, black, coaly in centre	2.5
Shale, dark grey, sandy in lenses	64.5
Coal, friable to chunky	2.2
Sandstone, fine-grained, thin, shaly streaks, medium to dark grey	6.0
Shale, dark grey, sandy, becoming coaly in lower part	0.6
Coal, blocky, hard	4.0
Shale, black	0.7
Coal, blocky in places, friable to chunky in others	14.3
Shale, black, blackjack in places	2.5
Coal, friable, approximately	4.0
Concealed, traces of coal present in this interval	107.5
Sandstone, coarse-grained, rudely bedded, cross-bedded, top concealed; basal Kootenay sandstone	10.0

Conformable contact

Sandstone, brown weathering, fine-grained to medium-grained, base concealed (Fernie formation).

There are 30.6 feet of coal in the 276-foot section. The coal is present in five seams, of which four are three feet or more in thickness. Two of the coal seams, the 14.3-foot seam and the 4-foot one above it, are extracted by open pit methods (Figure 12). Operations are under way for recovery of the coal by underground methods. The seams are shown in Figure 11. It was found that the 0.7-foot shale parting wedged out after driving underground for about 50 feet, so that the two seams may be considered one. The coal is for the greater part blocky and hard, and is ranked as semianthracite. The seam dips 18 degrees west and strikes north 47 degrees west. It is faulted at the upper end of the open pit, but the displacement is probably not great. The base of the seam has been determined to be 124 feet above the Fernie-Kootenay contact.

A few thin coal seams were observed at the headwaters of Marmot creek in section 15, township 23, range 9. The thicknesses range from one to two feet. The seams occur at the base of the upper sandstone member of the Kootenay, in which no thick seams were observed elsewhere in the area.

SOUTHERN PORTION

This portion of Ribbon Creek area is that extending from Kananaskis river to the southern boundary of the area. Access to it is easiest from the north end, that is from Kananaskis river by way of the valley of Evans-Thomas creek.

In general the rocks in the Southern Portion have suffered more from the stresses of mountain-building movements than have those north of Kananaskis river. The syncline is narrower, and the strata show the results of this compression. Folding and faulting are common in some of the east and northeast trending ridges that lie east of The Wedge and Mount Evans-Thomas. The deformation has left its mark upon many of the coal seams, which are friable and powdery, at angles steeper than average.

On the whole this Portion is not as accessible as the northern one, but such a generalization should not preclude the development of its coal resources. Large bodies of coal are present, and many of these may be as easily worked as those in the northern portion. Deformation of strata is, however, more general in this area, and consequently a development program should be preceded by an intensive study of structural conditions.

Kootenay outcrops are sparse along Kananaskis river, and only one of those encountered showed any coal. This one is located in legal subdivision 1, section 22, township 22, range 9, on the south bank of the river at water's edge. The seam is but 2 feet thick, overturned to dip 63 degrees west, and strikes north 32 degrees west. The coal is crushed and friable. The steep dip of this seam and the containing rocks is assumed to indicate proximity to a fault.

The best section of Kootenay coal measures in the Southern Portion is exposed on a small gully that joins Evans-Thomas creek. The locality is in the northeast quarter of section 12, township 22, range 9. The section is detailed below. It is shown graphically in Figure 13, A.

	Thickness Feet
Shale and sandstone, not measured	
Coal, weathered, powdery	1.0
Concealed	100.0
Coal	2.2
Shale	5.0
Coal	2.1
Shale	3.2
Coal	1.2
Shale and sandstone, mostly concealed	44.0
Coal, powdery, weathered, partly covered	6.8
Shale, dark grey, sandy, with sandstone; partly concealed	98.0
Coal, powdered	2.7
Shale, sandy, dark grey, blocky	14.5
Coal, powdered	2.5
Shale and sandstone	31.0
Coal, weathered, dirty	2.6
Concealed, shale in part	22.0
Coal, shale parting of about 1 foot	2.5
Shale and sandstone	78.0
Fault	
Coal, bright, fragmentary	3.2

	Thickness Feet
Shale, grey, sandy	14.0
Coal, hard, blocky, clean	4.0
Concealed, shale in part	16.5
Coal, with 3 shale partings of 4 to 6 inches each	3.3
Shale and sandstone, concealed mostly	80.0
Coal, with two 5-inch shale breaks	2.0
Concealed	13.5
Coal, bright, blocky, with two shale partings of 2 inches and 3 inches each	3.2
Shale and sandstone, mostly concealed	115.0
Coal, friable in places, 3 feet of dirty coal 3 feet from bottom	18.8
Concealed, grey shale outcrops in places	29.0
Coal, weathered, dull, with two 0.2-foot shale partings at 4 and 5 feet from bottom	13.8
Shale, black, sandy, partly concealed	8.0
Coal, fragmentary	0.6
Shale, black, sandy, blocky	1.5
Sandstone, shaly, fine-grained	3.0
Shale, dark grey to black	3.8
Coal, hard	0.7
Shale, black	1.0
Coal, crushed	0.5
Shale, black, sandy	3.5
Coal, hard, blocky, bright	4.5
Shale, black	5.0
Sandstone, cherty, dark grey, medium-grained to coarse-grained resistant, more or less regularly bedded, basal Kootenay sandstone	44.0

Conformable contact

Sandstone, brown weathering, medium-grey, fine-to medium-grained, more or less regularly bedded above, more evenly below (Fernie formation).

In the above 810-foot section there are 20 seams having an aggregate thickness of 78.1 feet of coal. Eight of these seams are three feet or more thick and aggregate 57.6 feet. The 18.8-foot seam is close to 120 feet above the base of the Kootenay. Some bands in it are crushed and friable; the remainder of the seam is bright and chunky. The bottom seam, 4.5 feet thick, is lower in the Kootenay section than any other seam observed in the area, its base being only 49 feet above the base of the formation. The coal is remarkably hard and bright, though it is exposed at the surface. The average dip of the coal seams is 20 degrees west, and strike is north 18 degrees west. The measures are traversed by a fault that dips about 55 degrees west, as measured in outcrop. Cross section LM (Map 21) has been drawn approximately through these measures.

A coal seam, 36 feet thick, was noted and examined at the top of a ridge in legal subdivision 6, section 6, township 22, range 8. The coal is powdery at the surface, but becomes granular at a depth of one foot. Six inches of shale are present six feet from the top. Rock outcrops in the vicinity indicate a sharp kink or drag fold in the strata, so that the unusual thickness of the seam may be caused by an accumulation of coal at the bend. The hanging wall dips from 65 to 80 degrees west, and the foot wall at 70 degrees west. A few hundred feet southeast of this point the strata form a small anticline with limbs dipping 24 degrees west and 40 degrees east, and this structure appears to be related to the drag fold. It is possible that a considerable body of coal lies close to the surface here, and if so, recovery by stripping may be economically feasible. The seam is exposed on the flat top of a saddle, so that moisture could penetrate it. It is possible therefore that the coal is weathered for some distance below the surface.

One-quarter mile southeast of the above locality, approximately in legal subdivision 2 of the same section, a coal seam had been prospected, but has long since been covered by cavings. It was partly dug out, and is at least eight feet thick. The coal is hard and bright, and a sample taken for analysis shows it to be low volatile bituminous, though weathered. The attitude of the seam was not ascertained.

Another abandoned prospect was observed in section 29, township 21, range 8, near the crest of a high, north-trending ridge. The seam is 12 feet thick, and has a 2-inch shale break four feet from the top. The coal is crushed and weathered at the bottom of the trench, four feet below the surface. The seam dips 75 degrees west and strikes north 40 degrees west. The steep dip in this part of the syncline is indicative of a fold or fault, but lack of outcrop precluded a more exact determination. The seam is thick enough, and the dip steep enough to warrant consideration for recovery of the coal by stripping methods.

The Kootenay coal measures outcrop along Evans-Thomas creek, but evidences of coal are generally concealed by forest cover or debris. In legal subdivision 6, section 29, township 21, range 8, a seam was opened by a tunnel a number of years ago by G. W. Pocaterra. Since the tunnel had caved, details of the seam could not be obtained, but it is reported to be 18 feet thick (Pocaterra, 1948). Strata in the vicinity of the adit show some deformation. The seam is close to the base of the Kootenay.

A number of seams outcrop on the divide in the west half of section 5, township 21, range 8. The seams are usually thin, and the coal is powdery and weathered. The thickest seam observed consists of 8.6 feet of coal and 1.5 feet of shale, the latter occurring 3.4 feet from the top of the seam. The seam dips steeply, namely, 75 degrees west. The ridge on which the seam occurs is steep on both sides, thereby limiting the amount of available coal. The amount of coal available may not warrant development.

CORRELATION OF COAL SEAMS

Within the Kootenay formation of Ribbon Creek area, the basal sandstone beds constitute the only reliable marker. These beds are persistent and identifiable, and can be used as a datum for the determination of the stratigraphic position of other beds. Since the basal sandstone is variable in thickness, the base of the member, that is, the Fernie-Kootenay contact, is used as the principal datum. Further investigations in the area may reveal other marker beds, but none were established by the present surveys, possibly because rock outcrops are too discontinuous to prove the existence of any other bed or beds having any great lateral extent.

In Figure 13 the principal measured stratigraphic sections of the area are shown graphically. Some correlations between coal seams may be made on the basis of stratigraphic position. The 18.8-foot bed in stratal Section A may correlate with the 4-foot and 14.3-foot seams of Section B, and with the group of three beds at the base of Section C. If this correlation is correct, then the lateral extent of this coal horizon is at least ten miles.

Stratigraphic sections C and D are approximately one-half mile apart, so that some seams should be common to both sections. The 19-foot seam at the base of Section D was not seen in the other measured section, since the horizon there is under a heavy overburden. The 24-foot seam near the top of Section D is believed to be that which outcrops in a small gully about one-half mile southeast; there it is 34.5 feet thick. Two other possible correlations are shown, but it is noteworthy that seemingly a number of the seams do not persist for great distances.

Correlations of coal seams and coal horizons of Ribbon Creek area with those in the adjoining Canmore and Highwood areas were attempted, but results are divergent and confusing. Within Highwood-Elbow area, on a ridge above Pocaterra creek and at a location approximately ten miles southeast of Ribbon Creek area, numerous coal seams are present in the lower 1,400 feet of the measured Kootenay section (Allan and Carr, 1947. p. 61). The upper part of the formation is missing, so that the existence of coal seams in this part of the Kootenay is unknown. It is noteworthy that the coal seams occur at intervals commencing just above the basal Kootenay sandstone. This same state exists in Ribbon Creek area, though the coal zone apparently is not quite as thick as in the Highwood-Elbow area. The distribution of coal seams in the Canmore area does not coincide with that of the Ribbon Creek area (MacKay, 1935, Cross Sections OP, QR). In the Canmore area, coal seams are dispersed at irregular intervals throughout the whole formation, and moreover the lowest seams are approximately 450 to 700 feet above the base of the formation.

STRIP MINING POSSIBILITIES

The possibilities for the recovery of coal by removal of the overburden are more limited in Ribbon Creek area than in the region to the south, since only one band of Kootenay rocks is present there, whereas as many as ten bands are present in the foothills and mountains between Highwood river and Crowsnest pass. Moreover, though coal-bearing Kootenay beds are present on both east and west sides of the Ribbon Creek band, the western measures can be almost eliminated as a source of coal. The eastern margin offers most of the prospects. Along most of the eastern margin, the coal seams dip west, whereas the slope of the terrain is east; and therefore the depth of cover above a coal seam increases rapidly as the seam is denuded. Some good strip mining prospects do however exist in spite of the somewhat adverse structural conditions. A few have already been mentioned and others are described below.

The ridge that lies between Pigeon and Wind creeks is one of the most promising in which to search for strippable coal seams. The ridge plunges northwest, so that older and older beds are exposed progressively in that direction. Since the strata dip westwards, they more or less parallel the west dip of the ridge (Map 21, CD). Therefore, as coal seams successively approach the surface along the crest of the ridge, there should be places where the cover is thin enough for profitable recovery of coal. The ridge is sufficiently well timbered to obscure bedrock, so that no seams were seen. The removal of cover by bulldozer and the exploration of the bedrock by diamond drill may result in the discovery of large quantities of easily recoverable coal.

Another part of the area that holds opportunities for stripping propositions is the basin of Marmot creek. Heavy timber conceals almost all the lower coal-bearing Kootenay rocks, so that discovery of the seams rests with trenching operations or diamond drilling. In this basin the surface dips eastward at low angles, and at variance with the dip of the strata. Yet one or more thick, strippable seams could conceivably be profitably worked.

In Kananaskis valley, the upper part of the Kootenay formation has been eroded into the coal-bearing shale member. Therefore, coal seams should lie close to the surface in the valley and also at low angles, since stratal dips decrease towards the centre of the syncline. The flatness of the valley floor is another factor that favors the valley as a site for strip mines. Unknown conditions are the thickness of the gravels, sands and clays which fill the bottom of the valley, and the positions of faults which probably cross the valley. The valley fill appears to be less on the south side of Kananaskis river, and exploration should commence there.

On the ridges south of Kananaskis river, many seams dip steeply, or are thickened by folding, and should provide strippable coal deposits. A few were observed and described above; undoubtedly others will be discovered by more detailed structural surveys.

Phosphate Rock

There are two horizons in the Rocky Mountains at which phosphate rock often occurs. These are the topmost beds of the Rocky

Mountain formation and the basal beds of the Fernie formation. The phosphate horizon of the Rocky Mountain formation, if present in the Ribbon Creek area, was not observed, being either concealed by stream gravels or by debris from the Spray River formation. Samples of the uppermost exposed Rocky Mountain beds were collected, but any tested for phosphates yielded only traces of that substance.

The other horizon occurs in the lower 6 or 7 feet of the Fernie formation. It consists of black, platy shales containing numerous shiny, black fragments that appear to be fish remains. The horizon does not appear to be everywhere present in the area, but its extent may prove to be greater than was determined from the limited number of outcrops observed. A sample taken from this horizon on Pigeon creek was analysed for phosphoric acid by the Industrial Laboratories, University of Alberta, and yielded 3.05 per cent. $P_2 O_5$. The percentage is too low for the rock to have commercial value at this time. Another sample from a zone of large spheroidal nodules at approximately the same horizon on Ribbon creek, gave only 0.98 per cent. $P_2 O_5$.

Building Stone

Few rocks in the Rocky Mountains are suitable for building stone, as mountain-building movements have made them hard, brittle and too broken for this purpose. Spray River rocks alone have been used to any extent in construction. A number of buildings in Banff have been constructed from this rock, which was quarried in the vicinity. The rock is usually a dark blue grey to grey on a fresh surface, but weathers a reddish brown. The rock has several good features, among which are great strength, even jointing and regular bedding. The beds separate readily, and vary in thickness up to two feet or more.

Spray River siltstones outcrop in numerous places in the valleys of Pigeon, Marmot, Ribbon, and Evans-Thomas creeks, and at several places they are favorably situated with regard to transportation. Along Marmot creek, the siltstones dip from 10 to 15 degrees, but elsewhere in the area inclinations are greater. The exposures of Spray River along Pigeon creek and in the vicinity of it appear to warrant first consideration, should the utilization of these rocks for building stone be undertaken.

Gravel

Gravel in large quantities is present in the area. It occurs in stream beds, and on dry deltas, flood plains and river terraces. Cobbles and boulders are often mixed with it in stream beds, so that the separation of gravel in these deposits may not be economic. Flood plains such as those near the confluences of Evans-Thomas and Ribbon creeks with Kananaskis river contain gravels which are fairly well assorted as to size. The river terraces along Kananaskis river offer the best possibilities for well sorted gravels which are not too large for road metal.

Chapter VI

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Appendix I (1944); pp. 77. (Not available for distribution.)

Appendix II (1944); pp. 115 with maps. (Not available for distribution.)

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No. 8—Asphaltic Road Oils from Alberta Bituminous Sand, by K. A. Clark, Canadian Chemistry and Process Industries, Vol. XXIX, September, 1945, pp. 616-618.

No. 9—Research and the Coal Industry in Canada, by W. A. Lang, Trans. Canadian Institute of Mining and Metallurgy, Vol. XLIX, 1946, pp. 51-62.

No. 10—Recent Work of the Research Council of Alberta, by E. Stansfield, Bulletin Canadian Institute of Mining and Metallurgy, No. 406, February, 1946, pp. 121-128.

No. 11—Some Recent Conceptions of Coal Structures, by A. McCulloch, Canadian Chemistry and Process Industries, November, 1947.

No. 12—Elimination of Water from Wet Crude Oil Obtained from Bituminous Sand by the Hot Water Washing Process, by K. A. Clark and D. S. Pasternack, Part I—Continuous Settling at Atmospheric Pressure, Part II—Continuous Settling Under Pressure; Evaporation. Canadian Chemistry and Process Industries, January, 1948, and November, 1947.

No. 13—The Oil-Sand Separation Plant at Bitumount, by K. A. Clark, Western Miner, August, 1948.

No. 14—The Fuel Reserves of Alberta, by W. A. Lang, Trans. Canadian Institute of Mining and Metallurgy, Vol. LII, 1949, pp. 15-22.

No. 15—Geology of Kootenay Coal Measures in Southwestern Alberta, by M. B. B. Crockford, Bulletin Canadian Institute of Mining and Metallurgy, No. 443, March, 1949.

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No. 5 (1948); Poplar Market Survey, by A. Stewart, A. R. Brown and D. E. Armstrong.

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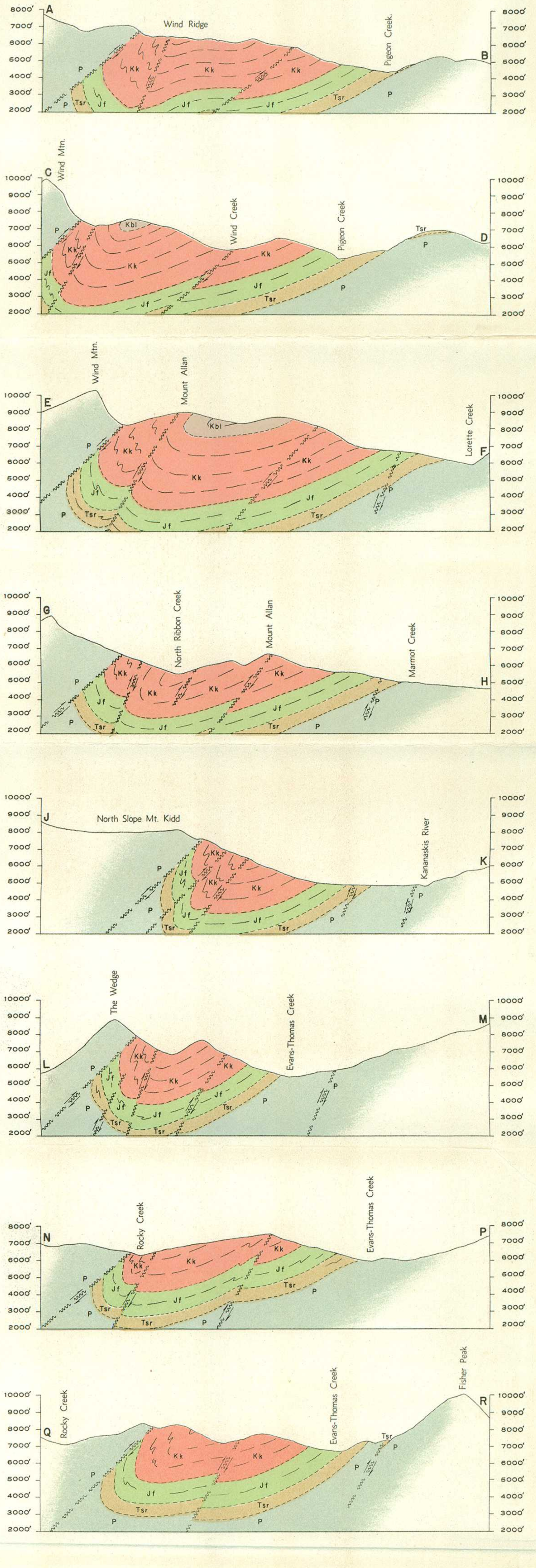
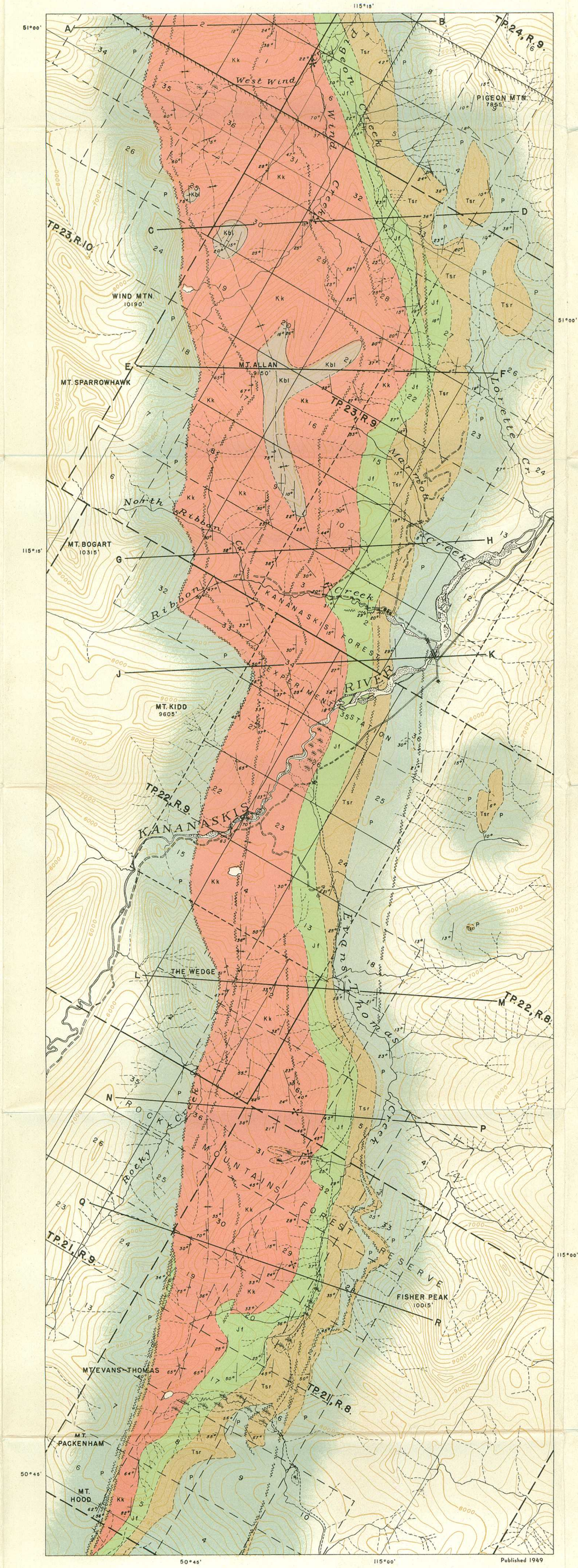
RESEARCH COUNCIL OF ALBERTA
GEOLOGICAL SURVEY

STRUCTURE SECTIONS

Horizontal and Vertical Scales
same as Scale of Map





Published 1949

MAP 21

RIBBON CREEK AREA

WEST OF FIFTH MERIDIAN
ALBERTA

Scale, 1 inch to 1 mile

1 0 1 2 3

Approximate magnetic declination, 23° 00' East

LEGEND

MESOZOIC

CRETACEOUS

LOWER CRETACEOUS

Kbl	BLAIRMORE FORMATION: grey and greenish grey sandstone; grey, green, and maroon arenaceous shale; conglomerate; nonmarine.
Kk	KOOTENAY FORMATION: coarse, grey sandstone, fine silty sandstone; dark grey, and black shale; conglomerate; coal seams; nonmarine.

JURASSIC

Jf	FERNIE FORMATION: dark grey, and brown arenaceous shale; black shale; light grey calcareous sandstone; dark grey sandstone; brown-weathering concretions; marine.

TRIASSIC

Tsr	SPRAY RIVER FORMATION: thin-bedded, dark grey, arenaceous, argillaceous and dolomitic siltstone; shale; sandstone; dolomite; limestone; marine.

PALEOZOIC

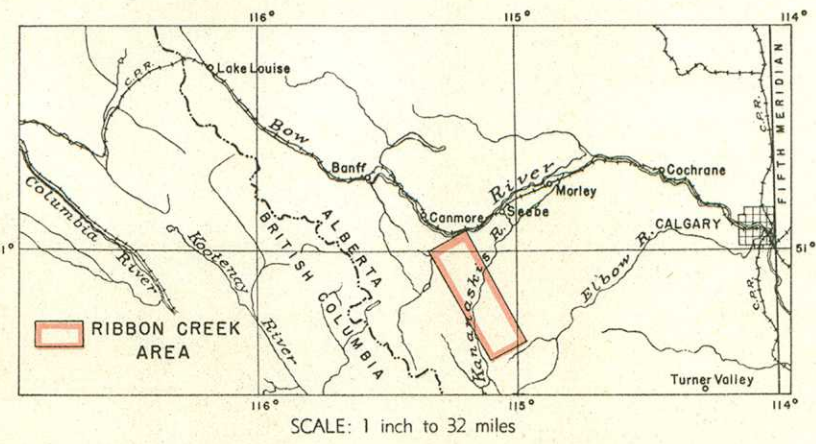
P	UNDIVIDED: grey limestone; dark grey, and black dolomite; quartzite; grey, and black calcareous shale; marine.

Geological boundary (defined, approximate)	⁓ - -
Bedding (inclined, vertical, overturned)	
Fault	⁓⁓ ⁓⁓
Synclinal axis	—+—
Coal mine	⚒
Coal prospect	✕
Road well travelled	═══
Road not well travelled	== == ==
Pack trail	- - - - -
Bridge	
Buildings	■■■
Forestry cabin	☗
Forest Experiment Station boundary	— — — —
Forest Reserve boundary	
Township boundary (surveyed)	━━━
Township boundary (unsurveyed)	━ ━ ━
Section line (surveyed)	———
Section line (unsurveyed)	— — —
Sand or gravel	
Intermittent stream	- - -
Fall	F
Marsh	
Contours (interval 200 feet)	9000
Height in feet above mean sea-level	10015'

Geology by M. B. B. Crockford 1947, 1948.

Base map compiled from surveys of the Topographical Survey of Canada, the Dominion Forest Service, and from Aerial Photographs.

To accompany Report 52.



SCALE: 1 inch to 32 miles