Scientific and Industrial Research Council Report No. 6

FOURTH ANNUAL REPORT
ON THE
MINERAL RESOURCES OF ALBERTA, 1922

PART I.

SAUNDERS CREEK and NORDEGG COAL BASINS, ALBERTA, CANADA.

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LETTER OF TRANSMITTAL

HONOURABLE HERBERT GREENFIELD,

Provincial Secretary,

Edmonton, Alberta.

Sir:—I have the honour to transmit herewith the Fourth Annual Report on the Mineral Resources of Alberta, Part I., entitled "*Saunders Creek and Nordegg Coal Basins,*" for the calendar year 1922.

This report deals with the geology of two important and distinct coal basins in central western Alberta about which little geological data was available. A geological map accompanies the report, and on it are shown the structure and areal distribution of the formations including the coal measures.

This field investigation has determined the age of the coal measures in Saunders Creek basin and the extent of these measures to the northwest. The map shows that both of these coal basins extend south of Saskatchewan river into an unprospected field.

It is the intention to extend the field survey on these coal basins westward to connect with the Bighorn coal basin, and northwestward to include the coal seams mined along the Coalspur branch and ultimately to Athabaska river.

All of which is respectfully submitted.

Yours truly,

JOHN A. ALLAN.

University of Alberta,

Edmonton, February 12, 1923.

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Saunders Creek and Nordegg Coal Basins, Alberta, Canada

BY

JOHN A. ALLAN AND RALPH L. RUTHERFORD

CHAPTER I.

INTRODUCTION

The importance of coal deposits in Alberta is emphasized by the fact that with the exception of natural gas, almost the entire mineral production within this province is represented by coal. The revenue from petroleum is very small, and with the exception of common bricks, the other clay products manufactured in Alberta are produced from clays imported from Saskatchewan.

Two years after the organization of geological survey work within the province, it was decided to investigate the geology of certain areas, particularly those in which coal mining development is going on. In the third annual report on the mineral resources of Alberta, 1921, observations and results were given of field investigations on the Drumheller coal basin, the largest domestic coal producing district in the province.

This is the fourth annual report on the mineral resources of Alberta and includes the results of field work carried out during the field season of 1922 and is divided into two parts. Part I. deals with the geology of an important area which contains two coal basins within the inner foothills of central western Alberta. These two basins are distinct and separate geologically. Part II. contains a discussion of a reported occurrence of iron ore on the north shore of lake Athabaska within Saskatchewan but tributary to Alberta.

Object of Investigation.—The inner foothills of Alberta contain coal measures of both upper and lower Cretaceous ages that are widely distributed throughout a greater part of the length of the province. Between North Saskatchewan river, west of Rocky Mountain House, and Athabaska river west of Edmonton, the coal measures are being mined in a number of districts. On the North Saskatchewan there are the Saunders Creek upper Cretaceous coal basin and the Nordegg lower Cretaceous basin. At the northern end along the Athabaska close to the front of the Rocky Mountains and behind the first range of mountains are the Brule lake and Pocohontas basins. Between these two rivers but nearer the latter, south and west from Edson, are the Coal Branch basin of upper Cretaceous age and Mountain Park, Cadomin and Luscar coal basins of Kootenay age.

As little attention has yet been given to the geology of this region, particularly to those measures containing coal seams of upper Cretaceous age, a field survey of this region was commenced in the summer of 1922, northwards from North Saskatchewan river. It will require at least two more field seasons to complete the geological study of this region.

Geographical Position.—The area discussed in this report and included on the accompanying map lies west of Red Deer and within townships 39 to 44 and ranges 9 to 16 west of the fifth meridian. The greater part of this area lies within the Clearwater forest in the Rocky Mountain Forest Reserve. It is reached by the Canadian National railway, Brazeau branch, which extends from Stettler, through Red Deer and Rocky Mountain House to Brazeau in the mining town of Nordegg. The Canadian Pacific railway has a branch line from Red Deer to Rocky Mountain House, a distance of 62 miles. The distance from Rocky Mountain House to Nordegg is 60 miles.

The southern boundary of the map area is North Saskatchewan river. The survey was not extended south of this river as it can not be forded with horses and there were no boats available as the current is very swift. The eastern edge of the map is mile 125 on the railway; this mileage is carried from Stettler. This position was chosen for the eastern boundary as it represents the most easterly foothills structure in the form of a fault with considerable displacement. This fault line, called the "First fault" has a northwesterly trend and defines the eastern boundary of the map. The northern boundary of township 43 between the first fault and Blackstone river represents the north limit of the map accompanying this report.

This area includes two quite different units, the foothills and an upland simulating a mountain range, an outlier of the Rocky Mountains with a basin to the west. The former has been designated the *Saunders Creek coal basin*, as that is the best known locality geographically, and the other more elevated unit is called the *Nordegg coal basin* as it includes the coal measures which are mined at Nordegg by the Brazeau Collieries.

The drainage system is represented by North Saskatchewan river in the south and its main tributary Shunda creek, formerly Mire creek, and the Blackstone and Nordegg rivers towards the north, both of which are tributary to Brazeau river that lies north of the area shown on the map. There are several smaller tributaries, many of which are subsequent streams, that is their positions have been determined by the character and structure of the underlying rocks.

Field Work.—The field work in the area dealt with in this report continued for almost three and a half months in 1922, between May 18th and September 7th. Besides supervising this field work, and spending some time in the field, the senior author carried out a survey of certain iron-bearing rocks on the north shore of Athabaska lake, the results of which are included in Part II. of the fourth annual report on the mineral resources of Alberta.

The field work in the area discussed in this report was under the charge of the junior author. The party consisted of six men for the first part of the season, and of four men for the remainder of the time. J. O. G. Sanderson acted as assistant field geologist and carried out his duties in a faithful and efficient manner. The other members of the regular party were W. DeMille, who looked after the pack train, and R. Lamb (recently appointed Rhodes scholar from Alberta) who ably performed the duties of cook. As it was found necessary to make a preliminary topographic survey of certain areas along the railway, Frank W. Marleau was engaged for two and a half months to obtain the necessary data, which he did in a capable manner. R. H. Pegrum was employed for a month as assistant to collect fossils and assist on the topographic work. His work was satisfactory. All men employed were students from the University of Alberta.

As the best rock exposures are usually found along the main drainage valleys, most of the season was spent in making careful and detailed observations, firstly along the Saskatchewan river from Rocky Mountain House westward through the gap to the Gap cabin in township 39, range 15; along the entire length of Shunda creek; along Nordegg river from its head to the Forestry Branch Aurora cabin in township 44, range 12; and along the entire length of Blackstone river. Sections were also examined along tributary streams of these rivers and on Lawrence creek, Chambers creek and Baptiste river in the area included on the accompanying map.

The area examined represents approximately 650 square miles, most of which lies within the Clearwater forest. The eastern boundary of the forest reserve is shown on map No. 2 which accompanies this report. The sectional maps, on a scale of three miles to one inch, published by the Topographical Surveys Branch, Ottawa, and the Clearwater Forest map prepared by the Forestry Branch, on the same scale, were used as a base map for the geological field work. The railway profile map was used for elevations along the railway from Rocky Mountain House west to Nordegg. Additional bench marks were obtained from mine plans belonging to the various companies operating coal mines, particularly the Brazeau Collieries; from an earlier Alberta Central railway survey (A.C.R.); and from plans of a survey along Nordegg river Additional elevations north of Ancona and east of Horburg were obtained from the Canadian National railway revision survey party, under the direction of A. J. Gayfer.

The lack of a topographic map prevented the publication of a geological map on a larger scale than one mile to one inch. The topography along the railway from Nordegg to Lamoral, and from Saunders creek north to the head of Baptiste river was worked out on 50-foot contour intervals and a scale of two miles to the inch by an aneroid and compass survey, but only the 200-foot contour lines are shown on the map. The contour lines between Ancona and Horburg were taken from the railway survey. An aneroid survey was carried throughout the entire area, but on account of varying climatic conditions, the results were not sufficiently accurate to include them on the map. The magnetic declination in this area varies from 26.5 degrees east at Horburg to 27 degrees at Nordegg.

Certain corrections in the position and course of streams, particularly north of Ancona, have been shown on the map accompanying this report. Some of the details for these revisions were obtained from Mr. A. J. Gayfer. Jackfish lake in section 6, township 41, range 11 is not drained by Jackfish creek into the Saskatchewan, but by a small stream to the north called North Jackfish creek, which enters Baptiste river about section 22, township 41, range 11. The position of Lawrence creek has also been corrected. Wicks creek which runs into Jackfish lake and Sunset creek one mile east of Ancona station, were named by the railway revision survey party. West of Saskatchewan river gap several small streams are shown on the map. The positions of Coal creek and Outcrop creek have been taken from detailed surveys made by Brazeau Collieries Ltd., and the names were given by the officials making the survey. The names of these creeks have not yet been passed by the Geographic Board of Canada.

The official name of the mountain range at Nordegg which is an outlier of the Rocky Mountains is *Brazeau range* after an official of the Hudson's Bay Company in charge of Rocky Mountain House in 1858-59. It was formerly called Brazeau's range on the Palliser map by Hector in 1859-60. The two highest points in this range north of Shunda gap are locally known as Mt. Coliseum and Mt. Shunda respectively, so these points have been so designated on our map. Plate I. (Frontispiece).

Acknowledgements.—The success in the results obtained by a field party, working particularly in a district where mining development is going on, is due in part to the co-operation received by those making the survey from mine officials and other individuals who from their observations or long residence in the district are able to give valuable information. The writers wish to thank in particular Mr. A. J. Gayfer of the engineering department, Canadian National railway for topographical and geological data and for co-operation in many ways; Mr. John Shanks, general manager, Mr. J. M. Stewart, mine manager, Mr. H. D. Moore, surveyor and other officials of the Brazeau Collieries for the use of mine plans and other valuable assistance; Mr. W. G. Pearson, mine manager and Mr. A. E. Williams, surveyor at Saunders Creek for the use of plans and drafting office; Mr. John Stevenson, mine manager at Saunders Alberta mine, Major E. F. Pullen at Alexo mine and Mr. J. McMillan at Harlech mine for their co-operation when obtaining data at these various mines; Mr. Conrad Bernhardt for valuable data regarding occurrences and locations of outcrops in heavily wooded districts; Mr. H. Evans, bridge engineer on the railway for his assistance in obtaining fossils from important localities; and Mr. Stewart Kidd, Nordegg, for his assistance and useful information on trails through this country. Our thanks is also rendered to the officials of the Forestry Branch for co-operation and assistance, especially Mr. J. Shankland, Nordegg, Messrs. Smith and J. l'Heureux at Rocky Mountain House and Shunda cabin respectively.

The writers gratefully acknowledge the time and consideration given by Professor E. W. Berry, Department of Paleontology, John Hopkins University, in determination of fossil plants sent from this field. Thanks are also due Assistant Professor P. S. Warren at the University for examining and determining invertebrate fossil material. In the office the efficient assistance given by Mrs. Vera V. Stover in the preparation of this report is much appreciated. Fuller details on the work carried out by the geological division are given in the third annual report of the Scientific and Industrial Research Council of Alberta for 1922.

Previous Work.—The earliest geological work that gives any detail on the rocks and structure in the area discussed in this report is that by Dowling[1] entitled "North Saskatchewan River Coal Areas, Alberta." This report was made shortly after the Canadian Northern railway (now the Canadian National railway) branch line had been built from Stettler, Alberta, for the purpose of getting the coal to market from the property at Nordegg owned by the company. This report consists of only three pages and deals in a very general way with the entire section from Rocky Mountain House to the present site of the Brazeau Collieries at Nordegg. Prior to this report Dowling[2] published a notice of discovery of a belt of Kootenay rocks which carries the coal now mined at the Brazeau Collieries.

Following Dowling, the next published geological information on a part of this area was given by Rose[3] as a result of a general reconnaissance on Red Deer, James, Clearwater, and North Saskatchewan rivers. Only a few paragraphs in this report by Rose deal with a description of the general structure from Rocky Mountain House up the Saskatchewan to near the mouth of Shunda creek in township 40, range 13.

In 1916 Stewart[4] discusses "Coal Mines of West Central Alberta," and gives a general description of Paleozoic and Mesozoic rocks in the vicinity of the Brazeau Collieries. The log of a drill core made by the Collieries company was examined by Stewart and published in full. A few notes are included on the geology at Saunders Creek coal mine.

Considerable private work has been done in the area in connection with development of various properties, and in the search for oil. These reports are not available to the public.

Bighorn range is another outlier of the Rocky Mountains which lies about thirty miles west of Nordegg. In 1911 Malloch[5] described in considerable detail the geology of the "Bighorn Coal Basin." Frequent reference will be made to the above report on account of the proximity of the Bighorn coal basin to the Nordegg and Saunders areas, and on the general similarity of stratigraphy and lithology.

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[1]Dowling, D. B.—Geol. Surv. Can., Summary Report, 1913, p. 150.
[2]Dowling, D. B.—Geol. Surv. Can., Summary Report, 1907, p. 147.
[3]Rose, Bruce—Geol. Surv. Can., Summary Report, 1914, p. 53.
[4]Stewart, J. S.—Geol. Surv. Can., Summary Report, 1916, p. 94.
[5]Malloch, G. S.—Geol. Surv. Can., Memoir 9E, 1911.

CHAPTER II.

GENERAL GEOLOGY

Regional.—The rock formations underlying the area shown on the accompanying map No. 2, belong to the Paleozoic and Mezozoic eras. Those of Paleozoic age, although minor in distribution, form the outstanding physiographic features of the area. The general geological features of this region are similar to those which occur along the front of the Rocky Mountains in Canada, and to the west of the generally flat-lying strata underlying the prairie steppes, forming what is generally known as the foothills.

In general the formations in the foothill areas consist of Jurassic and Cretaceous rocks with Tertiary formations overlapping to the east.

Geologically, the Saunders Creek and Nordegg areas differ from the average foothills belt in that there is a Paleozoic outlier of the Rocky Mountains, known as the *Brazeau range*, due partially to structural relations and to erosion, and bordered on the east and on the west by younger Mesozoic rocks of Jurassic and Cretaceous ages. West of Nordegg there is a second Paleozoic outlier of the Rocky Mountains known as the *Bighorn range*. In the next chapter an explanation is offered for the formation of these Paleozoic outliers.

Local.—In the area described in this report the Paleozoic rocks in the Brazeau range extend from Saskatchewan river in township 40, range 14, northwest to Blackstone river. To the north the Mesozoic strata encircle the Paleozoics and bear certain structural and stratigraphic relations to them. South of Saskatchewan river this Paleozoic block is seen to continue for some distance, but is reported[1], to extend south at least about 15 miles past the gap on Ram creek.

West of the Brazeau range the Fernie (Jurassic), Kootenay and Colorado formations occur in regular succession. East of the Paleozoic block which is defined on the east by the *Main fault*, the Fernie, Kootenay, Colorado and Montana formations occur badly broken, and folded. The amount of disturbance decreases towards the east.

A traverse up Saskatchewan river from Horburg to Saskatchewan gap shows, in general, a lowering stratigraphically from east to west. Although many minor reverses occur, the older rocks occur to the west. Between Saskatchewan gap and Gap cabin the formations occur in reverse order in respect to age. Traverses up Nordegg and Blackstone rivers also show that the formations become stratigraphically older to the west. Cross-sections Nos. 1, 2, and 3 show these relations.

[1]Dowling, D. B.—Geol Surv., Can., Summary Report 1913, p. 150.

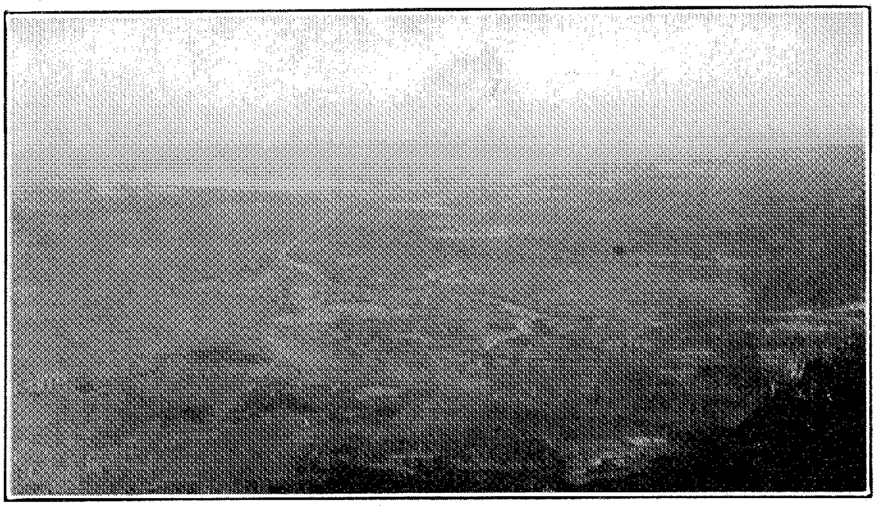

PLATE II.—Foothills from Brazeau range to Saunders Creek in vicinity of railway.

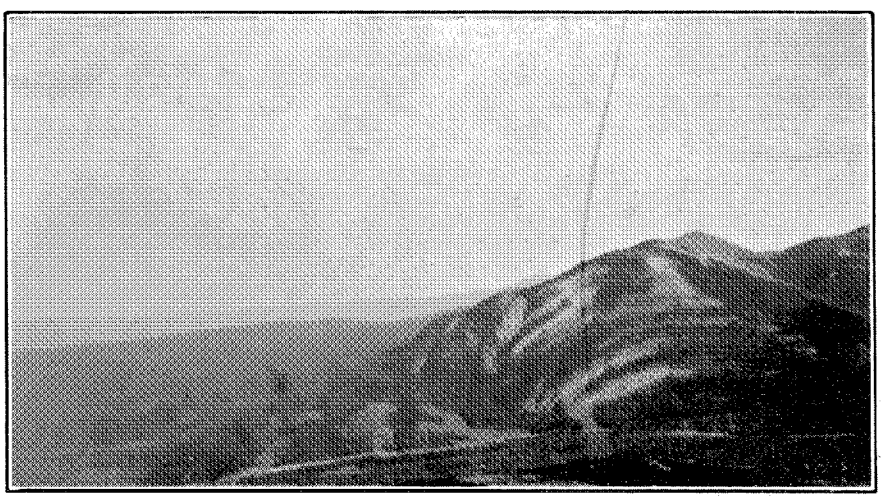

PLATE III.—Folded Paleozoic rocks in Brazeau range south of Shunda gap.

Lithology.—The Paleozoic rocks consist of limestones, dolomitic and argillaceous limestones, calcareous shales and siliceous shales. These members are characteristic of the rocks of Devonian and Carboniferous ages along the Bow or Athabaska rivers in the eastern ranges of the Rocky Mountains.

The Mezozoic rocks represented by Jurassic and Cretaceous rocks, are essentially sandstones, frequently argillaceous, a few conglomerate beds, siliceous shales, and true shales especially in the Colorado group. The Cretaceous and Jurassic are dominantly made up of siliceous material. As a whole the Mesozoic beds are much softer than the Paleozoic rocks so that much of the present physiography is the result of this fact.

The general soft character of the Mesozoic formations makes the tracing of formations and their correlation rather difficult, as the only places where anything like a complete or partial section is exposed along the cut-banks of the larger streams where erosion has been more rapid, such as Saskatchewan, Nordegg and Blackstone rivers (Plate II.). Over a large area between Nordegg and Saskatchewan rivers there are few exposures that can be definitely correlated stratigraphically. The most definite horizon marker in this entire area is the coal formation which is exposed on Lawrence creek in the southwest part of township 41, range 12.

The character of these formations will be more fully dealt with in the detailed description of the formations under Chapter V.

CHAPTER III.

STRUCTURAL GEOLOGY

Regional.—The general type of structure in the foothills belt of Alberta consists of a series of synclines, anticlines and faults with a tendency for lower beds to be brought up to the surface as one proceeds from east to west. In general the structure in the Saunders Creek and Nordegg areas agrees with this type. The most eastern structures are of lesser magnitude and the western ones are more pronounced from the standpoint of deformation.

The largest outstanding structural feature in this area is shown by the Paleozoic block, Brazeau range. In the foothills belt the first limestone block in most places between the International Boundary line and Athabaska river, is overthrust onto the Mesozoic formations from a westerly direction, giving a comparatively low angle overthrust plane dipping westward. In this area, however, this most easterly limestone block is in the form of a tight fold, with an axis dipping northwesterly and the axial plane dipping southwest (Plate III.). At Shunda gap the western limb dips to the southwest at about 12 degrees, while the eastern limb is much broken, varying from a perpendicular position to an overthrust position in some cases. The dip of the western limb increases towards the south and at Saskatchewan gap the beds are dipping at about 30 degrees southwest. Northward from Shunda gap towards Nordegg river the main fold does not appear to be so tight and it plunges under the Mesozoic beds between Nordegg and Blackstone rivers.

At Shunda and Saskatchewan gaps, the extent of over-thrusting of the Paleozoic rocks onto the Mesozoic formations has been small as compared with the overthrusting along the eastern boundary of the mountains in southern Alberta. At Saskatchewan gap the evidence of overthrusting is shown on the map and on cross-section No. 1. The Paleozoic rocks have been pushed eastward over the Fernie and lower Cretaceous formations. In general Brazeau range may be regarded as a tight fold which plunges towards the north and which becomes a recumbent fold closely related to an overthrust at Saskatchewan gap.

In the Saunders Creek and Nordegg areas the major structural line is the break along the front of Brazeau range, called the *Main fault* on the map, separating the Mesozoic and Paleozoic rocks. This major fault line has an approximate trend of north 45 degrees to 50 degrees west, and extends from Saskatchewan river north to Nordegg river, and in all probability to Blackstone and Brazeau rivers. The Blackstone structure section No. 3 shows several faults in the region where this fault would probably come if projected from the south, but the beds are so badly broken and folded that it cannot be definitely stated where the Main fault crosses the Blackstone. The topographic features indicate that this Main fault crosses the Blackstone just north of Nelson cabin in township 42, range 16. At this locality the Colorado is faulted up against Colorado measures.

Local.—Structurally the Saunders Creek and Nordegg areas can be considered in two parts, separated by the Main fault. Considering first the eastern part, it will be noticed from the structure sections that the folds become tighter and more closely spaced as one goes north from Saskatchewan river to the Nordegg and Blackstone. From the eastern boundary westwards the structures and displacements become more pronounced. The most easterly structure that is exposed on the Saskatchewan west of Rocky Mountain House occurs near the eastern edge of township 39, range 9, about mile 125.5 on the Canadian National railway, and is called the *First fault* on the map. Here the beds to the east have been raised with respect to those to the west. This structure apparently does not express itself to any perceptible degree in the physiography to the north or south of Saskatchewan river and can only be observed in a cut-bank 20 feet high on the north bank of the river. Compared to the structures to be found to the west, it is of no significance but its position as the first apparent break in the formations east of the foothills makes it rather more important.

On Nordegg river in section 8, township 44, range 12, a fault occurs along which the western beds have risen with respect to those on the east side. A lower series on the west side with a southwest dip of approximately 40 degrees is raised against a younger member on the east with a very gentle dip to the northeast. As no other structures are to be seen on either Saskatchewan or Nordegg rivers for some distance west of this fault, it would seem probable that the fault on the Saskatchewan could be projected to connect with the one on the Nordegg. The strike of this fault line agrees favorably with the strikes of the fault lines to the west, namely 45 to 50 degrees west. On the other hand, if the fault on the Nordegg corresponds to the one at mile 125.5 on the Canadian National railway, this fault is of a pivotal type. On Saskatchewan river the east side beds have risen while on the Nordegg the west side beds have risen relatively. This is not an unlikely explanation, but before this fault can be definitely regarded as pivotal, more data would have to be obtained but exposures are rare.

This fault is more important on Nordegg river than on the Saskatchewan as the beds west of the fault on the Nordegg have been uplifted and a coal series is brought to the surface which may at some time prove to be of commercial value. One exposed seam measures approximately 16 feet in thickness with its minor partings. This is the most easterly exposure of a possible commercial coal seam on Nordegg river, and no other coal seams are exposed for at least 15 miles to the west.

This fault on the Nordegg seems to be of a greater magnitude than that on the Saskatchewan, and is marked by the topography.

The geological relations of the formations resulting from this fault are shown on structure sections 1 and 2.

The second large structural break on Saskatchewan river occurs at mile 136 on the Canadian National railway, or near where the centre line of township 39, range 10, crosses the Saskatchewan. This break is called the *Second fault* on the map with this report. At this displacement the beds on the west side have moved up relatively to those on the east side, resulting in a western series dipping about 25 degrees west and striking approximately north 45 degrees west, while the east side beds dip very gently to the northeast.

This fault is important from a commercial standpoint as it brings to the surface the Saunders coal series which has been opened up in several places. This structure can be traced northwestward along the strike for several miles. Evidence of this fault is definitely shown at Jackfish lake, which is a strike lake formed on beds on the west side of the fault in section 1, township 41, range 11. The beds on the east side seem to be represented by a nearly flat-lying series which are exposed along the lower part of Lawrence creek in township 41, range 11.

North of Baptiste river the trend of the fault line seems to swing to the west at a greater angle than it has at Jackfish lake. Exposures on Nordegg river indicate that there is no faulting between the First fault in township 44, range 12, and section 12, township 43, range 15. At this point the beds on the west side are faulted up with respect to those on the east side, bringing lower beds, stratigraphically, on the west side in contact with younger beds on the east side. On Blackstone river the first fault above its confluence with Brazeau river occurs a few hundred yards below the mouth of Brown creek. From structure sections and general stratigraphic studies it appears that the same beds lie to the east of this fault on the Blackstone as on Nordegg and Saskatchewan rivers, so this break on the Blackstone is considered to be continuous to mile 136.5 on the railway.

This Second fault has a topographic expression known as the *Horburg ridge*, which is well developed in the southwest corner of township 40, range 10, and in the northeast half of township 40, range 11.

The Saskatchewan structure section No. 1 shows that the beds in the Saunders coal series are the lowest brought to the surface on the west side of the fault, and younger Montana beds (upper Saunders formation) form the gently dipping measures on the east side of the fault. On Nordegg river the beds on the west side of the fault are lower in the Montana group than the Saunders coal series as shown on structure section No. 2. The dip is here also steeper to the southwest than it is on Saskatchewan river. The dip to the northeast on the east side of the fault is approximately the same on Nordegg and Saskatchewan rivers.

Continuing north to Blackstone river, the beds on the west side of the fault belong to still lower formation than those on either the Nordegg or Saskatchewan. At this locality the uppermost beds in the Colorado formation (see structure section No. 3) is exposed at water-level, dipping about 40 degrees to the southwest, and on the east side the Saunders coal series appears at the base overlain by the upper Saunders formation. The dip of the beds on the east side of the fault on the Blackstone differs from that at the other two rivers as the beds dip at 55 degrees to the northeast at the fault, but flatten out to a very gentle dip before a point is reached where the Blackstone makes the sharp turn to the east in township 44, range 16. The elevation of the crossing of the fault line on the Blackstone is somewhat higher than on Nordegg river, and the elevation on the Nordegg is higher than that on the Saskatchewan.

Such being the case, it is evident that the amount of displacement at the Nordegg and especially at the Blackstone has been greater towards the northwest than towards the southeast, and beds, lower stratigraphically, are brought to the surface. The block of Cretaceous beds lying between the First and Second faults dips in general to the east. For the most part the dip is gentle except at the faults or near them, where the beds are sharply upturned. This is due to the fact that the sediments as a whole in this eastern part of the district are soft and did not transmit deforming forces over any great distance. It is to be noted, moreover, that these dips are greater towards the north, indicating more tight folding in this direction than towards the south.

Continuing west from the Second fault there are several other breaks before the Paleozoic block is reached, but for various reasons it is much harder to connect up the structures between the main rivers. One reason is that the amount of deformation increases towards the west, and as a result much more crushing and distortion of the beds has taken place, producing a fault zone rather than a fault plain. Such fault zones are so different from place to place that attempts to connect them up lead to extreme conjectures. Furthermore, towards the west the lower part of the Cretaceous, especially the Colorado formations, form a large part of the underlying beds. These beds are shaly and deformation extends through the entire mass. On account of the numerous minor structures west of the Second fault the broad structural details will be described as they were observed along Saskatchewan, Nordegg and Blackstone rivers.

On Saskatchewan river west of the Second fault, beds of upper Montana age dip about 25 degrees to the southwest close to the fault. This dip does not continue far to the west as the beds are nearly flat-lying at the west side of township 40, range 11, between Lamoral and Ancona (Plates XIV. and XV.). West of Sunset creek the same strata begin to rise towards the southwest and the Saunders coal series is again brought to the surface in section 11, township 40, range 12. This coal series continues to rise and is mined at Saunders Creek station by the Bighorn and Saunders Creek Collieries Ltd.; at West Saunders by the Saunders Alberta Collieries Ltd.; and at Alexo by the Alexo Coal Co. Ltd. The beds from Saunders creek east to the fault form a gentle syncline, the dips on the west limb average from 6 to 10 degrees northeast. The highest elevation on the west limb of the syncline occurs in the northeast corner of township 40, range 13, and in the southeast quarter of township 41, range 13. This upland forms what is known as the *Saunders ridge*, and it is the second physiographic prominence west of Rocky Mountain House. West of Saunders creek the beds begin to flatten out as the crest of an anticline, and are again nearly horizontal at the mouth of Shunda creek and west for about one mile in the central part of township 40, range 13 (Plate IV.). Continuing westward the beds dip at about 20 degrees southwest and the coal series disappears beneath the level of Saskatchewan river in approximately the southeast quarter, section 17, township 40, range 13. Between this point and Saunders creek the structure is a broad anticline with the western limb steeper than the eastern limb, so that the axial plane of the fold dips to the northeast.

It has already been stated that three mines are operated on the coal series on the east limb of this anticline. The Harlech Coal Company has opened a mine on the west limb of this structure, about one mile east of Harlech station. Within about half a mile west of the point where the coal series on the west side of the anticline dips below the level of Saskatchewan river, the same coal series reappears overturned and with a steep dip to the southwest. Between these two exposures of the coal series the rocks belong to the upper Saunders formation, which is younger than the beds in the coal series. The structure is a closely folded assymmetrical syncline with a steeper dip on the west limb of the fold. This synclinal structure continues northwest across the railway between Harlech station and the coal mine, and gives rise to many miscellaneous exposures of rock and coal that occur to the west and northwest of the Harlech mine in township 41, range 14, but this structure does not extend to Nordegg river. There is evidence of minor faults and slips along both limbs of the syncline, but especially on the west side.

Immediately west of the overturned coal series in the syncline on Saskatchewan river the beds are older and therefore lower stratigraphically. These are in contact with the Colorado formations, and it is believed are separated from them by a fault. The Colorado shales and sandstones are badly broken and folded and outcrop along the steep cut-banks for a distance of about three miles to the west. Some large structures but many minor ones occur within this distance. Approaching the Paleozoic block and the *Main fault* the Colorado beds in places dip vertically and at many points are slightly overturned, dipping about 85 degrees to the southwest. West of the basal Colorado beds, Kootenay and Fernie formations occur all overturned with a dip of about 85 degrees to the southwest. Here the *Main fault* occurs with the Paleozoic rocks slightly overthrust on the Mesozoic formations. This relation is shown in structure section No. 1 and on Plate V.

On Nordegg river west of the Second fault the beds on the east limb of the structure dip at about 40 degrees to the southwest and belong to the basal formation in the Montana group which is older than the coal series. This westward dip flattens out upstream, and at the mouth of Colt creek in sections 34 and 35 (approximately), township 42, range 15, the beds are nearly flat and the

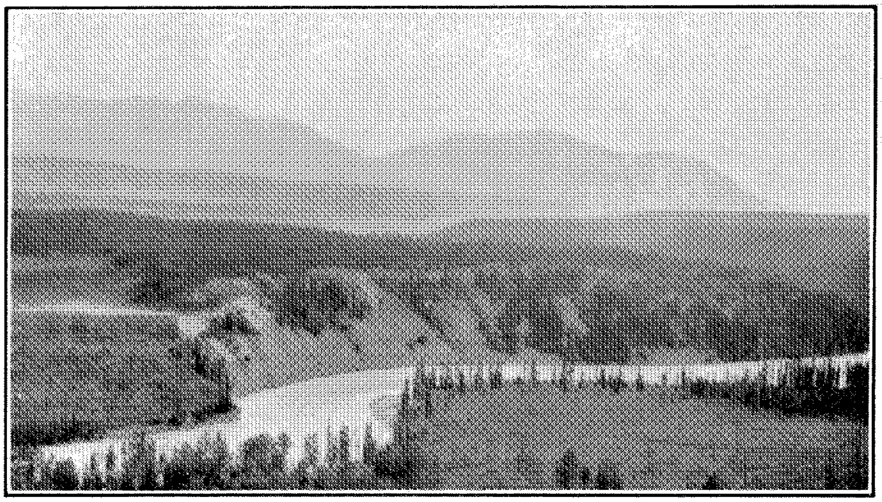

PLATE IV.—Saskatchewan River at mouth of Shunda Creek, looking southwest to the gap at right. Exposure consists of upper shale members in the lower Saunders formation.

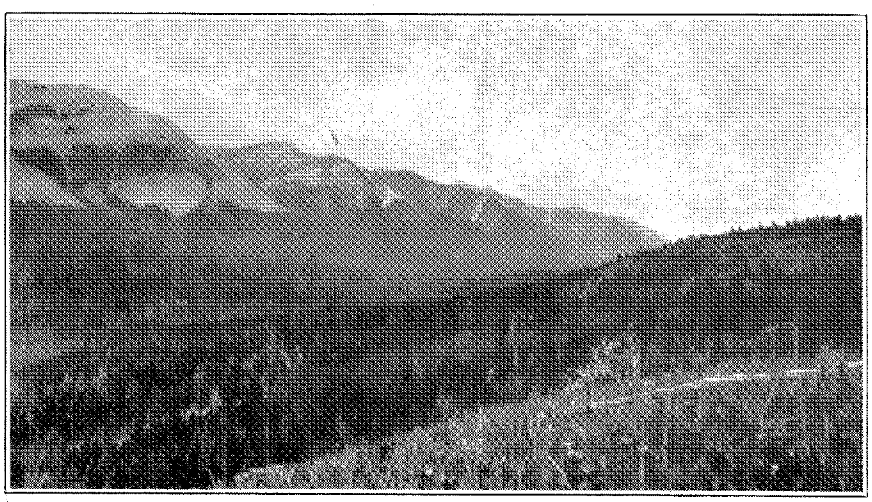

PLATE V.—Looking northwest from ridge between two deep valleys east of Saskatchewan gap, shows position of fault contact between Colorado beds underlying the valley and Paleozoic rocks in Brazeau range.

coal series outcrops at water-level. Upstream from the mouth of Colt creek the beds rise rapidly with a dip to the northeast, and again expose the formation below the coal series. This structure continues westward along the river until another fault is reached in section 29 (approximately), township 42, range 15.

The coal series which forms the basin of the syncline at the mouth of Colt creek is the same as that exposed both at Saunders creek and immediately west of the Second fault at mile 136.5 on the Canadian National railway. As Saskatchewan river has eroded deeper than the Nordegg and the coal is below the grade of Saskatchewan river at the base of the syncline, it would seem that the structure from Nordegg river to Saskatchewan river is a pitching syncline. The pitch is to the southeast and the folding is tighter on the Nordegg than on the Saskatchewan. The west side of this syncline on the Nordegg is bounded by a fault which is not sharply defined but which consists of a series of drag folds and smaller breaks. It would thus appear that the anticlinal structure forming the *Saunders ridge* becomes broken by a fault on Nordegg river.

From this fault westward to the headwaters of the Nordegg many faults and folds occur in the Colorado formations of even greater magnitude than those previously described, but a continuous exposure of the beds is lacking. The structure seems to represent a series of irregular closed folds and faults that result in a general westerly dip to the formations. These dips would average from 30 to 40 degrees. The *Main fault* on the Nordegg between the Paleozoic and the Cretaceous formations is not clearly exposed so that only its approximate position can be determined. No evidence of overthrusting was observed on this river.

To continue a discussion of the structure on Blackstone river in the eastern part of the area mapped, it is well to repeat that the Second fault is exposed near the mouth of Brown creek. West of this fault the beds dip to the southwest and the uppermost beds in the Colorado are exposed at the water-line. As one proceeds upstream the exposure shows a rise stratigraphically in the section through the lower Montana beds. At the mouth of Chungo creek, in section 18, township 43, range 16, the Saunders coal series is exposed for a short distance and then becomes faulted off against Colorado beds. The structural relations show that the Colorado beds have been thrust over the Montana beds, forming a high point of land, known locally as *Grass mountain*. From this fault southwest up the Blackstone to the mouth of Lookout creek, in the eastern part of township 42, range 17, the structure is complex, but as the main formation involved is the Colorado, it is difficult to ascertain which of these structures are purely local and which are regional. One structure that appears to be prominent is a faulted zone in section 19, township 42, range 16, near Nelson cabin. This zone appears to be the most crushed and broken part of the section, and has been interpreted as the position of the Main fault that runs along in front of the Paleozoic rocks to the south. From this structural break eastwards to the fault at the mouth of Chungo creek, there are many folds and faults involving a repetition of parts of the Colorado beds. From this zone westward to the mouth of Lookout creek the beds in general dip from 40 to 85 degrees to the southwest. The dip increases to the west and in many places the beds are nearly perpendicular or steeply dipping to the southwest as they are at the mouth of Lookout creek.

The main structural features have been described in the area included on the accompanying map lying east of the *Main fault*, which defines the eastern side of Brazeau range that is made up largely of Paleozoic rocks. It now remains to describe the structure of the western part of the area up to and including the older Paleozoic rocks.

In general the structure to the west of the Main fault is simpler than to the east. Although many smaller structures occur, the formations of different ages are not placed in juxtaposition.

The formations as a whole are dipping to the southwest in conformable succession as a portion of the west limb of the big Paleozoic folded block shown in structure section No. 1. In general there is no repetition of formations, but a gradual rise stratigraphically as one proceeds west from the Main fault, across the strike. This rise is through Paleozoic rocks of Devonian and Carboniferous ages, overlain by Mesozoic rocks represented by Fernie, Kootenay and Colorado formations. The dip of the formations at Nordegg is 12 degrees to the southwest in the Brazeau Collieries coal mine, and this is representative for the immediate vicinity of Nordegg.

As previously mentioned the Paleozoic block has steeper dips in the Saskatchewan gap. West of the main block there is an uparching of the Paleozoics in sections 4 and 5 (approximately), township 40, range 14. This anticlinal structure in the Paleozoic rocks also affects the overlying Mesozoic formations with the result that Fernie and Kootenay beds are pinched into a syncline on Dutch creek, and are much broken and folded to the west of the anticline.

Northwest of Brazeau Collieries coal mine at Nordegg the same general structure continues into township 41, range 16. The strike of the beds seems to change considerably from the head of Shunda creek towards the Blackstone, as the Paleozoic rocks disappear below the Mesozoic formations on the west near the headwaters of Nordegg river. Between the head of the Nordegg and Nelson cabin on Blackstone river the Mesozoic formations on the west swing round to meet the Mesozoic beds that occur along the front of the Paleozoic block to the south.

To summarize the structure in the Saunders Creek and Nordegg areas, the most pronounced structural feature is the *Main fault* with a northwesterly trend separating Paleozoic from Mesozoic formations and extending throughout the greater part of the area in a northwesterly direction; to the north this fault separates the Cretaceous rocks only. This main structural line divides the area discussed in this report. The eastern part contains many faults and folds with more open structure on Saskatchewan river, and more closely folded structures to the north on Nordegg and Blackstone rivers. To the west of the main fault line the general structure is a southwesterly dipping block which shows a rise in the stratigraphic succession from Paleozoic into lower Mesozoic formations up to and including Colorado beds. The steepness of the dip of this block is greater in the south and becomes flatter towards the north. In the south the Cretaceous beds are more crushed and broken than towards the north.

CHAPTER IV.

PHYSIOGRAPHY

Regional.—The general type of topography that characterizes the foothills belt in Alberta is that of a series of parallel ridges of Mesozoic rocks, chiefly Cretaceous. These ridges result from differential erosion of various members in the formations, and owe their initial direction to the underlying structure which is usually a series of folds and faults. In general the mean altitude increases from east to west as also do the relative elevations of the various physiographic forms above their respective valleys adjoining them. This increase in elevation to the west is due primarily to the fact that the beds to the west have been pushed up further, and, secondly, the underlying formations to the east are as a rule younger than those to the west, and on the whole are softer and yield more readily to erosion. Thirdly, the structures are fewer to the east and the dips are as a rule, much more gentle than those to the west.

The Saunders Creek and Nordegg areas are in type, very much like foothills in physiographic appearance, but differ in some respects that will be mentioned later.

As this area has not yet been topographically mapped, it is impossible to deal with the physiography in as detailed a manner as would be desired. From observations made and from elevations of a few bench marks obtained from various mine and railway surveys, it is possible to point out the general physical features, bearing in mind that any comparative altitudes given are only approximate.

As in the consideration of the structural features, the area was considered in two main parts, namely the area to the east of the Main fault and that to the west, so in the case of the physiography it can best be understood by describing these two divisions separately.

Local.—On the whole the eastern part which represents the Saunders Creek area, is of low relief, and such higher uplands as do occur are bounded by gentle slopes. There are two main ridges, namely, the *Horburg ridge* and the *Saunders ridge*.

The Horburg ridge is the first indication of foothills on approaching the mountains from the east. It owes its origin to structural features along the Second fault and has been described in Chapter III. The underlying formations are of Montana age, and in general consist of poorly cemented sandstones alternating with clay shales. Along the main drainage slopes such as the Saskatchewan which cuts across this ridge at the southern end, there are exposures of rock . The sides slope off gently to the east and to the west, and are covered with vegetation. This ridge trends approximately north 45 degrees west, and can be traced northwest into township 41, range 12. To the north the character of this ridge changes somewhat, in that it is made up of a number of parallel ridges, formed by differential erosion on various members in the underlying formations that are dipping to the southwest.

The next prominent upland to the west has been called *Saunders ridge*, as it is well developed north and west of Saunders creek, especially in the northeast corner of township 40, range 13, and in the southeast corner of township 31, range 13. This ridge has a trend of north 45 to 50 degrees west and is formed on the northeasterly dipping beds between the Stolberg anticline and the Ancona syncline.

On Nordegg river it is not possible to recognize any particular height of land as the continuation of the Horburg ridge or the Saunders ridge. The folding is closer than to the south, and a series of ridges occur. Between the west side of township 43, range 14, west of Stevens creek, and the Paleozoic rocks near the head of Nordegg river, there are several high points of land and ridges with a general trend of north 45 to 50 degrees west.

South of Blackstone river there are many ridges, and undoubtedly some of these are continuous to Nordegg river, but further physiographic details cannot be given without the aid of a topographical map. In the area traversed by this stream, the foothills type of topography begins about the center of township 44, range 16. At the mouth of Lookout creek the average altitude of the higher points is approximately 1,000 feet above the river levels.

To review the physiography in the eastern area, east of the Main fault, there are many parallel ridges on Nordegg and Blackstone rivers, that become lower to the east. In the southern part north of the railway there are two main ridges, but in no place do these rise abruptly from the general level of the land.

Considering now the district to the west of the Main fault, there is a different type of physiography. The general structure, as was pointed out in Chapter III., is a westerly dipping block of Paleozoic and Mesozoic rocks made up of members of different hardness. The Mesozoic rocks on the whole are softer than the older formations, and are more maturely dissected than the underlying formations which consist largely of limestone.

The highest altitudes in the area are in the "Brazeau range", which has a general trend of north 45 degrees west. This range is an outlier of the Rocky Mountains, consisting largely of Paleozoic rocks similar to those in the regular ranges of the mountains to the west. The range has been cut transversely in two places, one, the Saskatchewan river gap, and the other, the Shunda gap.

The headwaters of Shunda and Lookout creeks occur in a valley that is almost as low as the general level of land east of Brazeau range. This valley owes its origin to the removal of a large amount of Cretaceous sediments, especially belonging to the Colorado formation, by glacial and other forms of erosion. This valley extends from Nordegg townsite northwest to Blackstone river and is about 2,000 feet below the top of the range. The sides of the valley slope gently and are largely covered with vegetation so that few outcrops occur. This valley is drained out through the Shunda gap by Shunda creek, and to the north by Lookout creek into Blackstone river.

North of the railway in Shunda gap, the two highest points are known as Mt. Coliseum, 6,612 feet, and Mt. Shunda, 6,670 feet above sea-level. These are shown in the frontispiece, Plate I. The former is so-called because of its shape. It is flat-topped for about two miles, and a large amphitheatre has been eroded on the west side opposite the town of Nordegg. The latter, Mt. Shunda, is named after Shunda creek (Plate VI).

Brazeau range is smaller and lower than the Bighorn range that lies 30 miles to the west and which is also an outlier of the Rocky Mountains proper. To the northwest, Brazeau range terminates between Nordegg and Blackstone rivers. The continuation of this range, south of Saskatchewan river, has not been determined. South of Shunda gap the general elevation of the range is about the same as that north of Shunda gap.

Relation of Drainage to Topography.—There is a certain relationship between the topography and the drainage systems in the area shown on the accompanying map. It seems to be a general fact that wherever the folding is relatively close the streams cut across nearly at right angles to the strike. The Saskatchewan flows northeast from the gap to the mouth of Shunda creek. A similar trend is followed by Shunda creek from Shunda gap to Harlech. The Nordegg flows northeast from its headwaters down to the mouth of Wawa creek near the east boundary of township 43, range 15. Blackstone river has also a general northeast trend from the mouth of Lookout creek in township 42, range 17, to a point in township 44, range 16, where it makes a sharp bend to the east. All of these rivers, at the points referred to, follow a northeasterly trend where the topography is most accentuated.

The Saskatchewan river east of the mouth of Shunda creek from the center of township 40, range 13, flows a little south of east as far as Lamoral in townships 39 and 40, range 11, where the trend follows the strike of the formations. This change in trend is due to the sharp upturning of the beds to form the west side of Horburg ridge. East of Horburg in township 39, ranges 8 and 9, the river again follows the strike of the formations, due to the structure on the west side of the *First fault* (Plate VII). Although geological evidence was not obtained in the field, yet it appears that the general northwest trend of Chambers creek in townships 40 and 41, range 10, is due to the underlying structure.

One other drainage feature worthy of notice is the occurrence of several springs which deposit calcareous tufa along the side of the Saskatchewan valley between Ancona and Jackfish creek. These springs are situated along the contact of the glacial deposits derived from the Paleozoic limestones in Brazeau range, and the base of the syncline that lies between Horburg and Saunders ridges.

Nordegg river below the mouth of Wawa creek, has an easterly trend where the beds are nearly flat-lying. In township 44, range

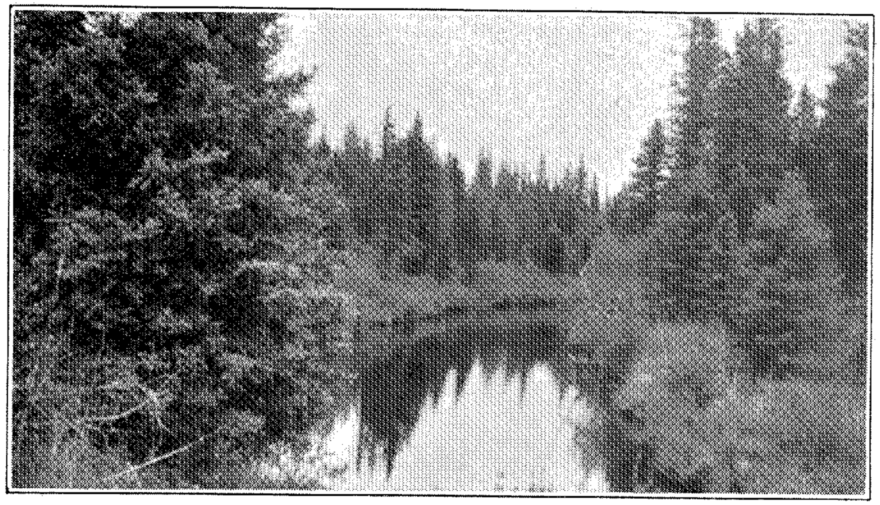

PLATE VI.—Shunda Creek near Harlech, showing thickly wooded character of this district.

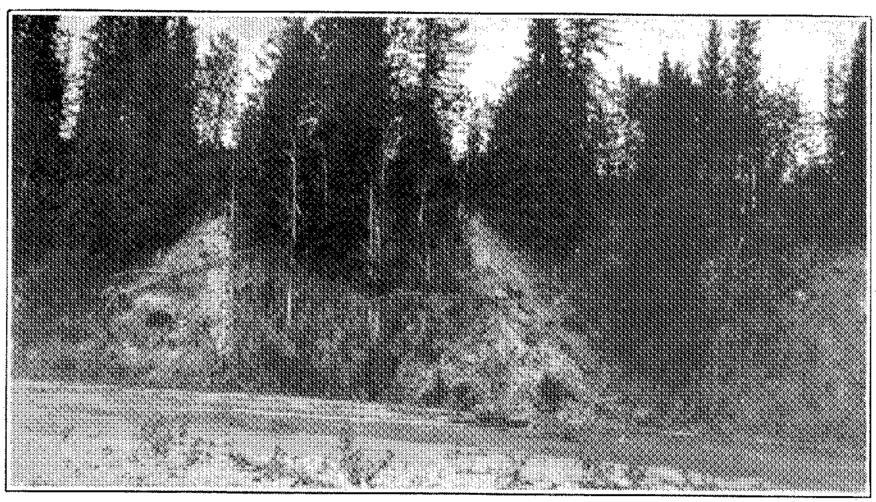

PLATE VII.—Steeply dipping beds in upper Saunders formation on Saskatchewan River at First fault.

12, the trend of the river is northeast across the strike of the underlying beds that have a general southwest dip on the west side of the First fault, and southeast on the east side of the fault. The stream has tended to cross dipping beds in general at right angles to the strike. East of this structure the beds are again nearly flat-lying and the river flows due east as far as the center of township 44, range 11, where our traverse ended.

Blackstone river from the big bend in township 44, range 16, flows almost straight east to its confluence with Brazeau river in township 44, range 15, and the underlying beds are lying in an horizontal position. Thus it appears that in the area shown on the accompanying map the rivers tend to cross the folded and faulted zones at right angles to the strike, and on the flat-lying beds the channels tend to have a general straight easterly course.

CHAPTER V.

DESCRIPTIVE GEOLOGY

GENERAL STATEMENT

The consolidated rocks in the area dealt with in this report range in age from Devonian to upper Cretaceous. No attempt was made to subdivide the Paleozoic formations as their distribution is local. Triassic rocks were not definitely recognized in the area but a series of very thick shaly limestones is believed to belong to this age. The Jurassic is represented by a thin series of beds which can be correlated with the Fernie formation farther south in Alberta. The lowest division in the Cretaceous is the Kootenay formation, which is overlain by a thick series made up largely of marine shales representing the Colorado group. In the Saunders Creek and Nordegg areas it was not possible to recognize any beds that could be correlated with the Dakota formation in other parts of Alberta. The writers believe that the Dakota as described in the Bighorn range to the west and also in southwestern Alberta, is not represented in this area.

The beds in the Colorado group have a wide distribution in this area. In the Bighorn range, 20 miles west of Nordegg, the nearest district that has been studied geologically in detail, Malloch[1] has subdivided the Colorado beds into three formations, Blackstone, Bighorn and Wapiabi, respectively, in order of age. The writers have not attempted to show the distribution of these formations on the accompanying map.

The Montana group is not complete in the Bighorn basin as a large part of it has been removed by erosion. In the area included on the map east of Brazeau range, the Montana beds have a wide distribution. On lithological characteristics and for convenience of description the rocks in the group have been subdivided into the *lower Saunders formation* and the *upper Saunders formation*, separated by a thinner member called the *Saunders coal series.* These formations lie conformably upon the Colorado members and may be correlated with the *Belly River series* in other parts of Alberta. In this report these formations are considered as representing the Montana group because the term *Belly River* is regarded as unnecessary and for the most part difficult to define.

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[1]Malloch, G. S.—Bighorn Coal Basin, Geol. Surv. Can., Memoir 9E, 1911.

TABLE OF FORMATIONS

Era	Period	Group	Saunders Creek and Nordegg — Formation	Bighorn Coal Basin (Malloch) — Formation
Cenozoic	Quaternary		Glacial and river drift	Glacial and river drift
	Tertiary	Laramie		
Mesozoic	Upper Cretaceous	Montana	Upper Saunders formation Saunders Coal series Lower Saunders formation	Brazeau
		Colorado	Wapiabi Bighorn Blackstone	Wapiabi Bighorn Blackstone
		Dakota	?	Dakota
	Lower Cretaceous	Kootenay	Kootenay	Kootenay
	Jurassic		Fernie	Fernie
	Triassic		Upper Banff shale	Upper Banff shale
Paleozoic	Carbon-iferous		Pennsylvanian Mississippian	Rocky Mountain quartzite Upper Banff lime-stone Lower Banff shale
	Devonian		Lower Banff lime-stone Intermediate lime-stone	Lower Banff lime-stone Intermediate lime-stone

PALEOZOIC FORMATIONS

Distribution and Stratigraphic Relations.—The Paleozoic rocks occur only in the Brazeau range in the Nordegg area. Plates I. and III. show the general appearance of these rocks. On account of the massive character of the formations and their structural arrangement these limestones and shales form a prominent escarpment along the eastern side of the range (Plate IV.). On the westerly flank of the range the slope is more regular as it corresponds to the general dip of the beds. Transverse valleys two to three thousand feet deep have been cut through the range by the north Saskatchewan river and Shunda creek. Along the sides of these valleys, and particularly in the water gaps, most extensive exposures of the Paleozoic rocks occur. Between Nordegg station and the eastern side of Shunda gap at mile 169, the harder limestone members in these formations form a series of small hummocky ridges which in places still show glacial smoothed surfaces.

Field observations between the railway and Saskatchewan river indicate that there is a break between the Paleozoic and Mesozoic rocks. In the two previous chapters on structural and physiographical features, fuller details are given as to the distribution of these rocks.

Lithological Character.—The character of the rock of this age in Brazeau range is similar to that observed in rocks of the same age along the eastern face of the Rocky Mountains between Athabaska river and the International Boundary line. Limestone predominates but the more massive members are interbedded with thin-bedded and even shaly limestones and shales.

No attempt was made to subdivide the Paleozoic rocks into the formations recognized in other parts of the Rocky Mountains. Along the Bow valley where the type sections were described, the following formations are noted[1]: Intermediate limestone and Lower Banff limestone (Devonian); Lower Banff shale (Lower Carboniferous); Upper Banff limestone and Rocky Mountain quartzite (Upper Carboniferous); and Upper Banff shale (Permian or Triassic).

In a quarry about one and a half miles east of Nordegg, bluish to dark grey, massive bedded limestones occur containing numerous crinoid stems, and brachiopods. These are coarsely crystalline and emit a strong sulphurous odour when struck with a hammer. They are correlated with the Intermediate formation. Higher in the series there are massive beds of greyish limestone which can be recognized by two characteristics. Some of the beds are dolomitic with irregular shaped light grey segregations of dolomite, other beds are markedly cavernous and dolomitic. Many of the cavities show the outline of shells that have been removed, some are lined with a black substance which in most cases proves to be dried up bitumen. These limestones were originally bituminous, and metamorphism resulting from mountain-building forces has left small particles of bitumen in the altered rock. This formation corresponds to the Lower Banff limestone which is upper Devonian in age.

The following f ssils collected from this formation about two miles east of Nordegg station and determined by Assistant Professor P. S. Warren at the University of Alberta, show that these beds belong to the Upper Devonian:

Productella coloradensis, Kindle
Schizophoria striatula (Schlotheim)
Schuchertella cf *chemungensis* (Conrad)
Camarotoechia cf *endlichi* (Meek)
Pugnax pugnus (Martin)
Spirifer disjunctus, Sowerby.

The lower Carboniferous or Mississippian is represented by the Lower Banff shale formation which consists of shales and shaly limestones. Fossils collected from the south slope of Mt. Coliseum in Shunda gap have been determined by Assistant Professor P. S. Warren at the University of Alberta, as follows:

Zaphrentis, sp.
Crinoid fragments
Productus sp.

[1]Geol. Surv. Can., International Geol. Congress, Guide Book 8, Part II., 1913, p. 169. (The order of Mississippian and Pennsylvanian is reversed by mistake).

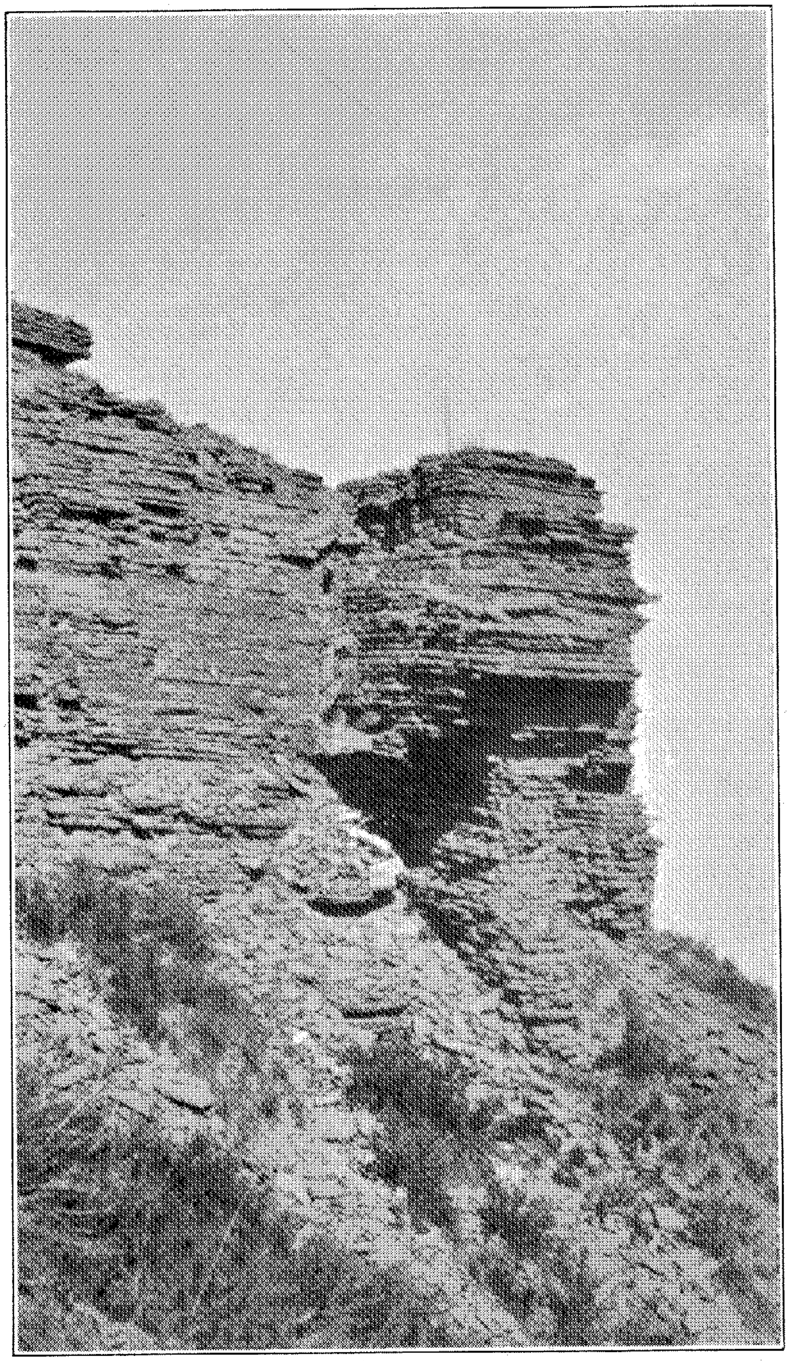

PLATE VIII.—Thin-bedded Upper Banff limestone in Shunda gap.

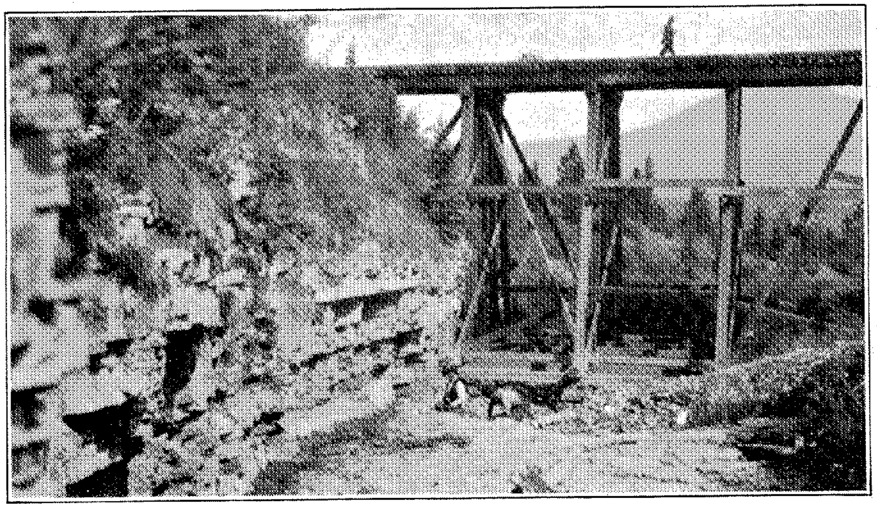

PLATE IX.—Phosphatic beds in Martin Creek at Nordegg.

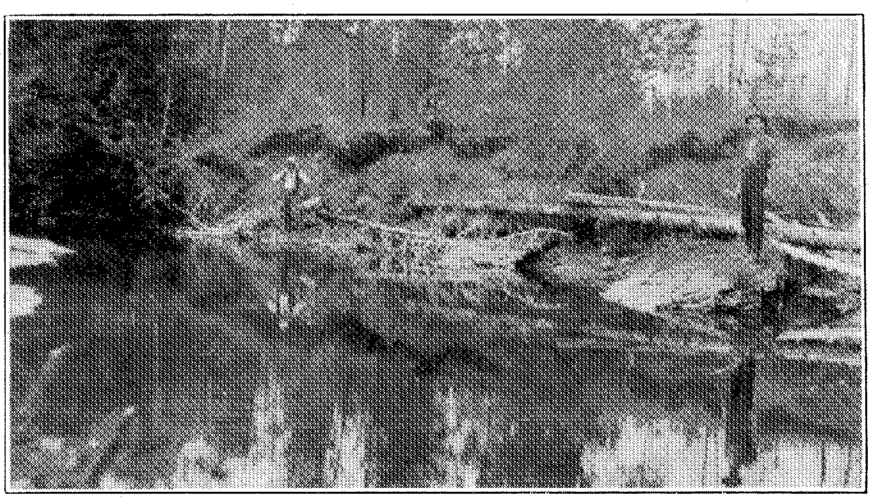

PLATE X.—Outcrop of coal seam in Nordegg River at mouth of Colt Creek.

Camarotoechia mutata (Hall)
Spirifier striatiformis, Meek
Reticularis cf. *setigera* (Hall)
Eumetria cf. *verneuiliana* (Hall)
Athyris lamellosa (Léveillé)
Composita cf. *subquadrata* (Hall)

The top of Mt. Coliseum and the continuation of the range south of Shunda gap consist of more massive-bedded limestones and interbedded hard and soft thin beds of limestone (Plate VIII.). A prominent escarpment occurs around the top of the portion of the ridge called Mt. Coliseum. This escarpment is shown in Plate I. Some of the beds are highly fossiliferous, containing crinoid stems, corals, bryozoans and brachiopods. These members correspond to the Upper Banff limestone formation which is upper Carboniferous or Pennsylvanian in age.

There are highly siliceous beds in the upper part of this formation and even cherty beds, but no true quartzite was observed which could be correlated with the Rocky Mountain quartzite which is the uppermost formation in the Carboniferous along the Bow valley, and elsewhere in the front ranges of the Rocky Mountains in southwestern Alberta. The writers cannot say that this quartzite formation does not occur in the Brazeau range, but if it is present, it is represented by quite a thin member.

It has been previously stated that no attempt was made to determine the thickness of the respective formations. The total thickness of the Paleozoic formations exposed in Brazeau range is under five thousand feet.

TRIASSIC (Upper Banff shale)

Immediately under the Jurassic beds there is a series of dark, almost black thin bedded limestones that are lithologically similar to the Upper Banff shale formation in the vicinity of Bow valley. This similarity is further borne out by the fact that some of the beds are slightly phosphatic. The phosphate content in samples collected is less than one per cent. so they are not of commercial value. There is a good exposure of these beds in Martin creek which passes under the railway about one hundred yards east of Nordegg station (Plate IX.).

The Upper Banff shales were formerly regarded as Permian in age, but in later years this formation has been placed in the Triassic. Tentatively at least, the beds which occur in Brazeau range and which bear a similarity to the Upper Banff shales are regarded as of Triassic age.

JURASSIC (Fernie)

Distribution.—In this area the name *Fernie* is given to a formation, on account of its stratigraphic position rather than lithologic similarities that it has to a formation in other areas of the Alberta foothills which has been called Fernie. The Fernie formation is most widely distributed as a belt which is fairly uniform along the west side of Brazeau range, extending northwest from Saskatchewan river in range 14, to a small lake at the head of Nordegg river in township 41, range 16. Northeast of this point it cannot be traced but it undoubtedly extends for some distance until faulted off by the Main fault which allows the Colorado beds to be faulted up against Colorado beds on Blackstone river.

Two other minor occurrences are exposed at the east side of Shunda and Saskatchewan gaps respectively. These exposures are relatively small, having resulted from deep erosion in these two gaps. The beds are steeply dipping to the southwest in these two localities, having been overturned.

Stratigraphic Relations.—The bottom of the Fernie has not been determined as there is no marked boundary between it and the older formations. More detailed paleontological study may, however, enable one to place the base at a definite horizon. The top of the Fernie is marked by a conglomerate bed which has been arbitrarily chosen as the upper limit separating it from the coal-bearing Kootenay measures.

Lithologic Character.—In most of the foothills area that has been described, the Fernie is as a rule termed a shale formation. The Fernie formation in the Nordegg area consists chiefly of sandstone and other arenaceous beds with a minor amount of shale. In Shunda gap the lower members in the Fernie consist of alternating beds of limestone and sandstone fifteen to twenty feet thick. The sandstone members become thicker and the limestone members thinner and more arenaceous towards the top of the formation. The upper part of the Fernie consists of sandstones and black shales. The top in Shunda gap section is marked by a bed of conglomerate fifteen to thirty-five feet thick.

The best exposure of the Fernie observed in this area occurs on Dutch creek, a small tributary of the Saskatchewan at the west end of the gap. This exposure shows especially the upper part of the Fernie and its gradation into the Kootenay. The top is marked by a conglomerate made up of small well-rounded pebbles, many of which are chert and dolomite. The conglomerate varies from 15 to 35 feet in thickness and is underlain conformably by dark shales and sandstone.

A section on Dutch creek shows the upper part of the Fernie as follows:

35	feet	Conglomerate mixed with coarse sandstone.
5	"	Sandstone, hard medium-grained, grey.
5	"	Shales with interbedded sandstone bands.
40	"	Black ribboned, siliceous shale, interbanded with sandstone bands up to one foot in thickness.
46	"	Hard, grey, fine-grained sandstone with a few shaly bands about the middle.
130	feet	total section exposed.

Another section of the upper part of the Fernie was measured in the walls of a canyon on a small creek about two miles west of Dutch creek. The section is as follows:

25	feet	Conglomerate mixed with coarse sandstone.
30	"	Hard, well-cemented medium-grained yellow sandstone.
10	"	Shaly sandstone.
20	"	Hard, well-cemented medium-grained yellowish sandstone.
15	"	Dark siliceous shale with sandstone bands up to one foot in thickness.
25	"	Hard yellowish sandstone.
10	"	Laminated siliceous shales.
3	"	Sandstone, hard, grey.
10	"	Dark siliceous shales with bands of fine-grained sandstone up to one foot in thickness.
148	feet	total section exposed.

This is the thickest continuous section of the Fernie from the conglomerate at the top that was observed in the Nordegg area.

There is a fossil-bearing horizon, in dark shales about 175 feet above the top of the conglomerate, but in this report these beds are placed at the base of the Kootenay.

Special reference should be made to the conglomerate at the top of the Fernie as it is a distinctive key bed in the Saunders Creek and Nordegg areas. This conglomerate is of special importance from an economic standpoint as it is an aid to prospecting for coal or tracing out the continuity of the formations over any distance. It is about the only hard member in the upper Fernie or the Kootenay measures. In areas where inclined beds are eroded, this member forms a resistance layer and is shown in the topography. This conglomerate can be traced from Saskatchewan river northwest through the townsite of Nordegg to a small lake at the head of Nordegg river. Although muskeg is widespread along the floor of Shunda valley northwest from Nordegg, small exposures of conglomerate can be observed in several places. From this horizon marker the base of the Kootenay coal measures is indicated in places where outcrops are scarce.

The thickness of the conglomerate varies from place to place. It is seldom less than fifteen feet thick and is more often about twenty-five feet, with a maximum of thirty-five feet. This member consists of a mixture of conglomerate bands with hard light grey coarse sandstone. The average size of the pebble is from one-half inch to one inch in diameter. In some places the conglomerate phase dominates, in others sandstone forms the main mass. The pebbles of the conglomerate are mainly of quartzite, dolomite and chert of various colors, cemented together by finer sand grains and amorphous silica. The stratigraphic position of such a conglomerate as this offers considerable contrast to the position of a conglomerate described in various reports on the geology of districts within the foothill belt[1].

In the Crowsnest coal field and areas north to Bow river, the top of the Kootenay formation is marked by a conglomerate similar in many respects to the one found here at the top of the Fernie. In other areas no conglomerate is reported to occur at or near the base of the Kootenay. In the Saunders Creek and Nordegg areas it has been shown that there is a conglomerate at the base of the Kootenay, but no such member at the top of this formation. The conglomerate is placed at the top of the Fernie as no line can be drawn between this fragmental bed and the true Fernie below. There is generally a sharper change from the conglomerate to the Kootenay beds above.

Thus while similar practices may be used when considering the extent of commercially important Kootenay measures in widely separated districts, it must be borne in mind that the stratigraphic position of this good key conglomerate bed has changed from the top of the Kootenay in southern areas, to the bottom in the Nordegg area.

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[1]See table of formations, pages 37 and 45.

Much geological field work will have to be carried on between Bow river and North Saskatchewan river in the foothills belt before it can be ascertained where the conglomerate at the top of the Kootenay pinches out, and where the one at the base of the Kootenay or at the top of the Fernie, begins to become a distinct member.

The two partial sections of the Fernie given above and measured at points only two miles apart, illustrate the variable nature of the lithic units, and the lack of persistency in thickness laterally. These two measurements, taken approximately two miles apart in a straight line, emphasize the fact that accurately measured sections are of little value in the correlation of the members in the Fernie formation even within a short distance, and are of less value for correlation with other areas where the Fernie has been studied.

The Fernie formation in this area appears to be made up of three general types of sediments: conglomerates, coarse sandstones and sandy shales; black shales with bands of sandstone up to two feet in thickness; and alternating beds of limestone, calcareous and siliceous shales.

The Fernie marks a gradation from marine conditions at the base, represented mainly by calcareous sediments, through a marine phase represented by black shales interbanded with marine sandstone beds, up to brackish water or continental deposits represented largely by sandstone. The lithic members of the lower Fernie are more persistent laterally than the upper ones. From lack of exposures it cannot be said that the middle shale members persist over any great distance, but the physiography would indicate that these soft members do extend from Saskatchewan river to the railway. The upper part of the formation has many bands that are lenticular, but the conglomerate is on the whole quite persistent laterally.

From the assumed base of the Fernie to the top of the conglomerate, the thickness represented is between 250 and 300 feet. On the average it would appear that 250 feet is a better figure for the thickness of the Fernie in this area. Stratigraphic relations as exposed on both sides of the Brazeau range show that the formation cannot be over 300 feet thick.

Fossils have been found in a number of horizons in the Fernie but these have not yet been fully determined. From specimens collected on Dutch creek on the west side of Saskatchewan gap, Professor E. W. Berry has determined *Podozamites*, probably *lanceolatus*. Belemnites are the most common fossils in the Fernie in this area but other mollusca include *Corbicula*, *Pleuromya*, *Cyprina* and *Trigonia*. There is a fossiliferous bed of shale at least two feet thick outcropping on a steep cut-bank on the north side of Saskatchewan river at the east end of the gap. There is a difference of opinion as to the exact determination of these fossils but according to G. H. Girty, T. W. Stanton and E. W. Berry at least some of these are a rather peculiar type of fish scale.

Comparative Table of Fernie Formation in Various Areas Described

Locality	Reference	Thickness	General Character
Flathead Coal Area, B.C.	J. D. MacKenzie, Geol. Surv. Can., Memoir 87, 1916, p. 25	1,000 feet (partial section)	Mainly brownish sandstone and greyish shales; no fossils; limits not defined (Lower Jurassic).
Crowsnest Pass, Alberta	F. H. McLearn, Geol. Surv. Can., Sum. Rept., 1915, p. 111		Basal rock is conglomerate over one foot thick, made of fragments of cherty limestone, fossiliferous limestone, and calcareous quartzite; dark shaly sandstone; six-foot bed shell limestone 100 feet from base; uppermost beds are thin-bedded arenaceous shale grading up into Kootenay sandstone.
Crowsnest Coal Field, Alberta	Bruce Rose, Geol. Surv. Can., Sum. Rept., 1916, p. 109	700 to 800 feet	Principally a shale formation of black, fissile, marine shales grading into shaly sandstones at the top; thin band of conglomerate (one to three feet thick) marks its contact with the Paleozoic; contact with Kootenay not well marked.
Banff, Alberta	John A. Allan, Geol. Surv. Can., Sum. Rept., 1912, p. 173	1,000 feet near Exshaw	Dark brown and black siliceous shales; some beds carry many ammonites; one bed carried many reptilian bone fragments.
Old Man River, Alberta	J. S. Stewart, Geol. Surv. Can., Sum. Rept., 1914, p. 47		Mainly calcareous shales, with belemnites; some beds show indications of hydrocarbons; no dividing mark with Kootenay.
Moose Mountain District, Alberta	D. D. Cairnes, Geol. Surv. Can., Memoir 61, 1914, p. 32	100 to 250 feet	Upper part consists of thin bedded brown sandstones, grey shales grading down into black finely-bedded clay shales.
Crowsnest and Flathead Coal Areas, B.C.	Bruce Rose, Geol. Surv. Can., Sum. Rept., 1917, Pt. C, p. 30c	3,000 feet in Elk valley, and 700 to 800 feet in Crowsnest valley	Dominantly brown-black and grey-black, thinly laminated, fissile shales; 50 to 100-foot bands quartzite near the base of formation; is conformable with Devono-Carboniferous below and the Kootenay above; shales become arenaceous towards the top into the Kootenay.

(Continued on next page)

COMPARATIVE TABLE OF FERNIE FORMATION IN VARIOUS AREAS DESCRIBED—*Continued*

Locality	Reference	Thickness	General Character
Highwood Coal Area, Alberta	Bruce Rose, Geol. Surv. Can., Sum. Rept., 1919, p. 15c		Shales and quartzite at base; no fossils.
Upper Elk Valley, B.C.	J. R. Marshall, Geol. Surv. Can., Sum. Rept., 1920, Pt. B., p. 8b	900 feet (partial section)	Thin-bedded, dark grey, platy and fissile shales.
Coal Fields of Manitoba Saskatchewan, Alberta and Eastern B. C.	D. B. Dowling, Geol. Surv. Can., Memoir 53, 1914, p. 26	1,560 feet at Fernie	A general paper, gives character in various places; original area, Fernie, B. C., has 1,060 feet over 500 feet of sandy argillites; on Red Deer river in mountains exposures contain many belemnites; at head of Ram creek a thin limestone bed carried reptilian bones.
Bighorn Coal Basin	G. S. Malloch, Geol. Surv. Can., Memoir 9E, 1911, p. 29	722.5 feet (partial section)	Dominantly soft dark and black calcareous shales, thickens to the south; limits not defined.
Saunders Creek and Nordegg Coal Basins, Alberta	This report	250 to 300 feet	Upper part dominantly sandstone; middle part dominantly dark shales; lower part limestone, shale and sandstone interbedded; fossil belemnites and other mollusca.

Conclusions.—From the foregoing comparative table certain general features concerning the Fernie appear to be shown. The Fernie section in the Nordegg area is much thinner than that in the Bighorn district twenty miles west. This suggests a thinning of the formation to the east. In other parts of Alberta, it is evident that when successive sections of the Fernie are exposed from east to west, there appears a rapid thickening of the section westward and a corresponding thinning eastward.

Lithologically, the Fernie formation in the nearest area previously examined, which is the Bighorn district, is most like that of the Nordegg area. To the south, there appears to be a larger amount of dark marine shales in the various Fernie sections studied.

From a standpoint of the total thickness of the Fernie formation, there is a belt, in general, parallel to the average strike of the Rocky Mountains and the outliers, in which the Fernie has an approximate thickness of 200 to 300 feet. To illustrate this point the following data seem to be significant:

Northeastern Montana, Ellis formation, thickness 300 feet[1].
Sweet Grass Hills, Montana, Jurassic, thickness 200 feet[2].
Moose Mountain district, Alberta, Fernie, 250 feet[3].
Saunders Creek and Nordegg areas, Alberta, Fernie, thickness 250 feet.

A line joining these districts would run approximately north 30 to 45 degrees west.

In the several localities in Alberta where the Fernie formation occurs the most frequently noted fossils are belemnites. These are quite abundant in the shale members in the Nordegg area. Reptilian remains are also noted in several other localities, but these have not yet been found in this area.

The most outstanding lithologic feature in the area mapped is the conglomerate member which occurs at the top of the formation. This conglomeratic bed probably represents a coarse phase of the sandstone members that have been commonly used in other districts to indicate the close of Fernie time and the beginning of Kootenay deposition.

One other lithologic feature of significance especially in the shale members of the Fernie formation, is the apparent rapid thickening westward.

In the Saunders Creek and Nordegg areas the total thickness of shales in the Fernie is between 75 and 100 feet, while the section in the Bighorn district given by Malloch shows over 460 feet of black shales.

In the comparative table of Fernie sections, the Elk Valley section shows 3,000 feet of beds chiefly shales, but the Crowsnest Valley section shows only 700 to 800 feet of Fernie beds. Such rapid changes in thickness may be due to submarine erosion in the Jurassic seas in the eastern part. This type of erosion has been cited as the probable cause of the thinness of this shale series in Sweet Grass hills[4]. Much more paleontological evidence will have to be obtained before these various Fernie sections in Alberta and beds of similar age in Montana, can be definitely correlated.

[1]U. S. Geol. Survey, Prof. Paper 120, 1919, p. 29.
[2]Bull. Geol. Soc., Amer., Vol. 32, No. 4, 1921, p. 468.
[3]Geol. Surv. Can., Memoir 61, 1915, p. 32.
[4]Kemp, J. F., and Billingsley, P., Bull. Geol. Soc., Amer., Vol. 32, No. 4, 1921, p. 468.

CHAPTER VI.

DESCRIPTIVE GEOLOGY (Continued)

KOOTENAY FORMATION

General Statement.—In the Saunders Creek and Nordegg coal basins it is doubtful whether the Dakota formation which is so strongly developed in southern Alberta, is here represented. There appears to be no break in the beds that can be taken as the dividing line between the Kootenay and the Dakota. If the latter is present, the conditions of deposition are very similar to those in the upper Kootenay. The formations are essentially the same, except for the presence of coal in the Kootenay.

The name *Kootenay* has been given to the lowest coal-bearing formation in this area, because of lithologic similarities and stratigraphic relations to the so-called Kootenay coal series in other parts of Alberta and in Montana.

Distribution.—The general distribution of the Kootenay is approximately the same as the Fernie that is stratigraphically below it. This formation lies to the west of the Fernie behind the Paleozoic block, and to the east of the Fernie in front of the Brazeau range.

The principal area in which the Kootenay is the under-lying formation is a belt extending north from Saskatchewan river, through township 40, range 15, just west of Nordegg townsite at the Brazeau Collieries, thence northwest along the valley of Shunda creek and the headwaters of Lookout creek. It is faulted off by the Main fault in township 42, range 16, as is the Fernie formation. The western boundary of the Kootenay along Saskatchewan river was not determined, but the formation extends to the Gap cabin at least, and possibly farther. The surface is thickly veneered with well sorted silts, sands and clays of glacial origin. The eastern boundary of the formation occurs about one mile east of Outcrop creek, but a narrow band extends about three miles farther east and a mile north of the river. The formation is exposed on Dutch creek. This badly broken zone has been caused by a low anticline in the Paleozoics on the west side of Brazeau range.

Besides these occurrences the Kootenay forms the underlying rock in two other small areas, namely at Shunda gap and at Saskatchewan gap to the east of the Main fault. At Shunda gap only a small section is exposed, but the contact with the overlying Colorado beds was not observed on account of muskeg and forest growth along Shunda creek (Plate VI.). This small exposure, however, shows the nature of the basal Kootenay at this locality.

At Saskatchewan gap a larger section is exposed, owing to deeper erosion by Saskatchewan river. This section is over-ridden by the Paleozoic block a short distance north of the river, so that the areal distribution of the Kootenay to the east of the fault is relatively small.

The possibility of Kootenay rocks being present on the upper part of Nordegg river in the northeast corner of township 41, range 16, must not be overlooked. Although no exposures have so far been observed in this place that would indicate Kootenay, yet there seems to be a general tendency for Kootenay beds to be exposed in such places where main water channels erode headwards from the east side into the Paleozoic limestones. The lack of exposures upstream from Sunbeam cabin on Nordegg river prevents a positive statement regarding the presence or absence of Kootenay at this particular place.

Stratigraphic Relations.—The Kootenay formation grades upwards into the Colorado formation. Owing to the soft nature of the Colorado and the Kootenay it is hard to find a distinct dividing line in this area. As none of the exposures examined show the upper part of the section, the true nature of the uppermost beds in the Kootenay is as yet unknown. The lower limit of the Kootenay has been arbitrarily placed at the top of the conglomerate which has been included in the Fernie formation. This conglomerate might be considered as the basal bed in the Kootenay as it does not mark a time break in sedimentation, but the line of contact at the top of the conglomerate is more distinct than that at the bottom. It indicates a coarse phase in the general series of highly arenaceous sediments that occur above the marine Fernie shales and below the coal measures of the Kootenay. As the exposures indicate a larger amount of sandstones below than above the conglomerate, and the conglomerate is merely a coarse phase of the sandstones, the conglomerate has been arbitrarily placed in the Fernie formation.

Lithologic Character.—A complete section of the Kootenay formation is not exposed in the area examined, but from such as do occur and from the effect on erosion on these members, certain general characteristics for the whole formation may be deduced, and part of the section recorded in detail.

Lithologically the Kootenay consists of sandstones, carbonaceous shales, and clay shales which on the whole are relatively soft as all members are eroded at approximately the same rate. The non-resistant character of the formation is indicated by a long gentle valley in which are the channels of the upper part of Shunda and Lookout creeks. The bottom of this valley is underlain by Fernie, Kootenay and lower Colorado formations. Throughout this valley the only evidence of harder members is caused by the conglomerate at the top of the Fernie. The Kootenay beds have eroded about as fast as the lower Colorado beds which are essentially soft shales.

As indicated on the map the Kootenay forms the underlying formation throughout the greater part of township 40, range 15. The upper members of the Kootenay have been eroded off and only a part of the formation remains. Near Brazeau Collieries two diamond drill holes have been put down, and one of the logs recorded and described by Stewart[1]. This bore hole shows the relative positions of the coal seams to one another, but does not show how near the top or base of the formation the coal is, as the drilling was started part way down in the Kootenay section. The surface elevation of No. 1 bore hole is 4,446 feet, and No. 2 bore hole is 4,492 feet above sea-level. No. 2 log shows the penetration of 700 feet below the lowest commercial seam, now being worked by the Brazeau Collieries. As the beds dip at 12 degrees to the southwest, the actual thickness below the coal as shown by this log would be about 670 feet.

From observations made on the Kootenay in other parts of the area, especially southeast of Brazeau Collieries, on several small creeks tributary to the Saskatchewan, it would appear that this lowest commercial seam (No. 2) should be less than 670 feet above the conglomerate at the top of the Fernie. The log does not indicate that the conglomerate was reached.

The most continuous and largest exposure of the Kootenay measures occur east of the Main fault on the north side of Saskatchewan river. The measures here are overturned, dip steeply to the southwest and are overridden by the Paleozoics as shown by structure section No. 1.

On account of the large amount of compression the relative thickness of the lithic units cannot be measured directly, because the shale members and softer beds have been folded and crumpled into many small structures. No attempt has been made to show the detailed structure of this formation in structure section No. 1. Certain general features are nevertheless shown in this exposure. The conglomerate below the Kootenay is the first member to stand out in the river cut-bank. The succession to the east of this is the Kootenay formation rising stratigraphically from west to east.

The following columnar section of the Kootenay exposed at this locality on Saskatchewan river gives a total thickness for this formation of not more than 800 feet. This appears to be rather thin as the bore hole record near Brazeau Collieries gives a partial

[1]Stewart, J. S.—Geol. Surv. Can., Summary Report, 1916, pp. 96-99.

section of 1,200 feet. The basal beds of the Colorado occur to the east of this section so that there is apparently, an entire Kootenay section represented, but perhaps thinned considerably due to deformation.

200 feet		No exposure, presumably soft sandstone and shales.
40	"	Black and dark green fissile shales, several members contain plant remains.
35	"	Coarse light grey massive sandstone, some beds well cemented, some poorer.
225	"	Chiefly dark grey and black shales with bands of grey and buff sandstone up to 6 feet thick, many minor folds.
—		*Coal*, thickness ? (inaccessible).
75	"	Alternating beds of massive sandstone, clay shales.
—		*Coal*, 10 to 15 feet thick.
50	"	Alternating sandstones, siliceous clay shales and carbonaceous shales.
—		*Coal* seam, 3 feet (plus) thick.
35	"	Alternating bands of hard light grey sandstones, siliceous shales and carbonaceous shales.
—		Beds of platy shales with fish scales.
100	"	Soft shales, no good exposures.
—		Fernie conglomerate.
800 feet		approximately.

Observations made on the basal Kootenay exposures at several points illustrate the variable nature of the lithic units in a short distance laterally. At Shunda gap approximately 130 feet of basal members are exposed. These consist of clayey and carbonaceous shales and sandstones in about equal amounts. These beds occur in bands alternating with each other and varying in thickness up to 10 feet. In a small creek in section 6 (approximately), township 40, range 14, the basal Kootenay beds contain several massive sandstone members ranging from 15 to 25 feet in thickness. In the immediate vicinity of Brazeau Collieries such hard massive sandstones are apparently absent as there is no indication of the same in the topography.

These partial sections show that any given complete section of the Kootenay for one locality would be of little use for correlation with partial sections a few miles distant as the character of the beds changes rapidly laterally.

The main key horizons within the Kootenay are the two seams of coal that are mined by the Brazeau Collieries. These are known as No. 2 (lower) and No. 3 (upper) seams, averaging respectively about 7 feet and 15 feet in thickness. These seams are separated by about 125 feet of sediments. Besides these two commercial coal seams, several other small ones occur in the Kootenay ranging from an inch in thickness up to two or three feet. More detail will be given regarding the coal seams in the chapter on economic geology.

Besides the coal seams as horizon markers, one other set of beds that appear to be quite widely distributed is a series of black fissile carbonaceous shales that carry fruit-like fossils, but these have not yet been determined. These have been found in the Kootenay lower shales both east of the Saskatchewan gap, and at several places west of the gap, and indicate an horizon lower than the coal measures but about 100 feet above the base of the Kootenay.

The Kootenay beds consist of a lenticular series of alternating sandstones, clay shales, carbonaceous shales and coal seams. They are of continental origin and were deposited in brackish or fresh water. The formation as a whole weathers uniformly and only occasionally does a harder sandstone member stand out on the weathered surface.

Age and Thickness.—From the stratigraphic position and the fact that the Kootenay carries coal similar to the Kootenay measures in other areas, it has been placed as lower Cretaceous in age. Plant remains are abundant in the beds both above and below the coal horizons. The following fossils collected from the mine at the Brazeau Collieries have been determined by Professor E. W. Berry:

Ginko artica Heer
Torreya dicksoniana Heer
Onychiopsis goepperti (Schenk) Berry
Sciadopitytes olafiana (Heer) Florin
Sagenopteris nervoca Fontaine
Arthrotaxopsis grandis Fontaine or *Cyparissidium gracile* Heer.

From previous considerations of distribution, stratigraphic relations, and other observations made in the field, it would appear that the maximum thickness of the Kootenay in this area is about 1,500 feet, but 1,000 feet is probably nearer to the average thickness. The most complete section exposed does not show more than 800 feet between the definite Colorado beds and the Fernie beds, but as previously stated this section at the Saskatchewan gap may have been thinned by deforming processes.

The following comparative table will illustrate the resemblances and differences that the Kootenay in the Nordegg area shows to the same formation in other parts of Alberta:

COMPARATIVE TABLE OF KOOTENAY FORMATION FROM VARIOUS AREAS IN ALBERTA AND BRITISH COLUMBIA

Locality	Reference	Thickness	General Characteristics
Flathead Coal Area, British Columbia	J. D. MacKenzie Geol. Surv. Can., Memoir 87, 1916, p. 26	1,100 feet	Sandstones, shales and coal seams; sandstones are grey and dark grey, medium to fine grained; coal measures in lower 300 feet of section; sandstones usually thick bedded, up to 9 feet.
Crowsnest Pass, Alberta	Bruce Rose, Geol. Surv. Can., Sum. Rept., 1916, p. 109	450 feet	Alternating sandstones, shales and coal seams; sandstones massive, crossbedded, coarse, whole formation of subaerial deposition; coal seams distributed throughout entire section as measured; no thick seams within 100 feet of base of formation.
Moose Mountain District, Alberta	D. D. Cairnes, Geol. Surv. Can., Memoir 61, 1914, p. 31	340 feet	Include several coal seams; at top of formation a dark coarse sandstone bed 10 to 30 feet thick underlain by dark shales and sandstones and interbedded coal seams; bed of hard sandstone 35 to 75 feet thick below.
Crowsnest and Flathead Coal Areas, British Columbia	Bruce Rose, Geol. Surv. Can., Sum. Rept. 1917, Pt. C, p. 30c	3,200 feet on Elk river; 1,100 feet in the Flathead basin	Alternating sandstones and shales and interbedded coal seams; also considerable conglomerate towards top of section; sandstones coarse, crossbedded and ripple marked; succession varies from place to place.
Upper Elk Valley, British Columbia	J. R. Marshall, Geol. Surv. Can., Sum. Rept. 1917, Pt. B, p. 8	3,500 feet	Basal member coarse, massive, crossbedded sandstone; black shales and coal seams interbedded above basal members.
Bighorn Coal Basin, Alberta	G. S. Malloch, Geol. Surv. Can., Memoir 9E, 1911, p. 31	3,600 feet (plus)	Black shales, shaly and siliceous sandstones, coal seams and a few beds of conglomerate; sections vary rapidly from place to place; some fossil beds but stratigraphic position not constant.

These comparative notes illustrate the rapid thinning of the Kootenay measures from west to east, all the way along the front of the Rocky Mountains. Practically all reports that deal with the Kootenay formations in other areas mention this rapid change.

The nearest described area to the Saunders Creek and Nordegg districts is the Bighorn coal basin. Malloch states that the thickness of the Kootenay in that basin is 3,600 feet and that much thicker sections occur to the west. In the Nordegg area the maximum thickness cannot exceed 1,200 feet and is more likely to be nearer 1,000 feet. East of Nordegg and just east of the Paleozoic block the indications are that the series is less than 1,000 feet thick (estimated thickness is 800 feet).

Moreover, it must be borne in mind that the beds placed in the Kootenay in the Nordegg area may include 200 to 300 feet of beds placed in the Dakota in the Bighorn range. This would mean a thinning of the Kootenay to about one-fourth between the Bighorn basin and the Brazeau range.

As the Dakota formation is defined and described in most reports dealing with the Cretaceous on this general foothills belt, it would appear that it should be present in a more determinable manner in the Nordegg area. A comparative table of the Dakota in various parts of Alberta and British Columbia is given below.

COMPARATIVE TABLE OF DAKOTA FORMATION IN FOOTHILLS AND MOUNTAIN BELTS IN ALBERTA AND BRITISH COLUMBIA

Locality	Reference	Thickness	General Characteristics
Flathead Coal Area, British Columbia.	J. D. MacKenzie, Geol. Surv. Can., Memoir 87, 1916, p. 29.	2,000 feet (estimated)	85 feet basal conglomerate with chert and quartzite pebbles; sandstones and shales above.
Crowsnest Coal Field, Alberta.	Bruce Rose, Geol. Surv. Can., Sum. Rept. 1916, p. 110.	2,000 to 3,000 feet	Red and green shales and interbedded grey sandstone beds, conglomerate 15 to 20 feet thick at base of formation; pebbles of conglomerate of pre-Cambrian or Cambrian rocks; conglomerate becomes more sandy to the east, some conglomeratic bands higher in series, especially to the west.
Moose Mountain District, Alberta.	D. D. Cairnes, Geol. Surv. Can., Memoir 61, 1914, p. 29.	900 to 1,700 feet	Upper part light colored sandstones, shales, and clays; green, blue and grey are dominant colors; lower beds are darker in color, carry more shales, coarse sandstone and a conglomerate 10 to 30 feet thick forms the base.

(*Continued on next page*)

COMPARATIVE TABLE OF DAKOTA FORMATION IN FOOTHILLS AND MOUNTAIN BELTS IN ALBERTA AND BRITISH COLUMBIA—*Continued*

Thickness	Reference	Thickness	General Character
Disturbed Belt, Southern Alberta.	J. S. Stewart, Geol. Surv. Can., Memoir 112, 1915, p. 28.	1,200 feet	Shales and sandstone, plant remains in certain beds; conglomerate at the base.
Crowsnest and Flathead Coal Areas, British Columbia.	Bruce Rose, Geol. Surv. Can., Sum. Rept. 1917, Pt. C, p. 31c.	6,500 feet	Conglomerates at several horizons especially in lower part of series; upper part mainly green or reddish shales, some coal bands in lower part.
Bighorn Coal Basin, Alberta.	G. S. Malloch, Geol. Surv. Can., Memoir 9E, 1911, p. 39.	1,800 feet	Basal member is white quartzite sandstone; shales above this have a reddish or yellowish color, some plant remains.

In many reports dealing with the prairie areas adjacent to the foothills certain beds are ascribed to the Dakota formation. These beds are as a rule studied from well logs for in most cases the beds are not exposed.

The most outstanding lithic member of the Dakota in most of the foothills belt is a basal conglomerate. This member is very pronounced in southwestern Alberta, but appears to become thinner and changes to a sandstone towards the east and north. In the Bighorn coal area this basal conglomerate is not reported as being present, but in its place a massive sandstone is used as the basal member of the Dakota. The section on Saskatchewan river given on page 43 shows a massive sandstone member about 500 feet from the base of the Kootenay. This may be the equivalent of the basal sandstone as described in the Bighorn area. If such is the case, there is then a possibility that about 250 feet of beds above the sandstone member in the Nordegg area may be correlated with the Dakota to the west.

In the opinion of the writers the Dakota, as recognized in other districts in Alberta is missing from the Saunders Creek and Nordegg areas. It is possible that the upper 200 to 250 feet of the Kootenay in the area mapped, corresponds to the Dakota horizon in the Bighorn area where it is represented by 1,800 feet of strata. If this is the case these measures thin very rapidly towards the east. Concealed structural relations, however, may be the reason for such apparent thinness of the so-called Dakota in the Saunders Creek and Nordegg areas. In southern Alberta the comparative table shows that the thinning from west to east is almost as rapid as that indicated for this area and the Bighorn basin.

In considering the direction of a belt of equal thickness for the Kootenay as was done in the case of the Fernie, it would seem that the trend of such a belt is roughly parallel to the trend of the foothills. In the Sweet Grass hills the Kootenay is reported to be 450 feet thick and the Dakota is missing[1]. Thus a line drawn

[1]Sweet Grass Hills, Montana, Bull. Geol. Soc. Amer., Vol. 32, 1921, p. 471.

northwest from a point somewhat west of the Sweet Grass hills, east of Moose Mountain district, to the Saunders Creek and Nordegg areas, would roughly represent the position of a belt of equal thickness of the Kootenay measures. The thickening to the west is more rapid than that of the Fernie. The Fernie shows a rapid westward thickening of the shale members especially. The Kootenay shows a rapid increase in the amount of arenaceous and coarser materials, and also in many cases an increase in the number and thickness of coal seams.

COLORADO GROUP

General Statement.—In the Bighorn area, Malloch[1] has divided the Colorado beds into three formations, namely *Blackstone*, *Bighorn* and *Wapiabi* in order of age, based primarily on lithologic differences. In this report these formation names have been retained, although a complete section was not observed. From general similarities shown by various sections, it would appear that such a division as suggested by Malloch would apply fairly accurately to the Colorado beds in the Nordegg district. On account of intense deformation resulting in a badly broken series in this area, it seems advisable in the following discussion to describe the Colorado as a unit rather than in three divisions. In southern Alberta the Colorado group is represented by the *Benton* formation.

Distribution.—The Colorado members form a belt extending from North Saskatchewan river in sections 12 and 13, township 41, range 15, northwest to Nordegg river in township 42, range 16, and then northwest to Blackstone river in the central part of township 43, range 16. This main belt is joined south of the Blackstone by another belt of Colorado rocks which extends southwards, and west of the Paleozoic block. As was stated in the structural discussion these two belts of Colorado come together at the north end of the Paleozoic block and continue as a faulted and folded series, northwest across Blackstone river (Plate XI.). On Saskatchewan river east of the Main fault in front of Brazeau range, Fernie, Kootenay and Colorado rocks occur in regular stratigraphic succession.

The eastern border of the Colorado belt is defined by the Third fault with rocks of Montana age to the east. On Nordegg river the eastern edge of the Colorado is faulted against the Montana beds, while the western edge is marked by the Main fault.

On Blackstone river the Colorado is overthrust on the Montana at the mouth of Chungo creek in section 18, township 43, range 16. Along the Main fault at Nelson cabin lower Colorado beds on the west of the fault are in contact with younger ones at the east side of the Main fault.

Lithological Character.—As the Colorado members are badly broken and deformed, it is difficult to say what part of the section one is dealing with when an exposure is examined. Approximately

[1]Malloch, G. S.—Bighorn Coal Basin, Geol. Surv. Can., Memoir 9E, 1911, p. 23.

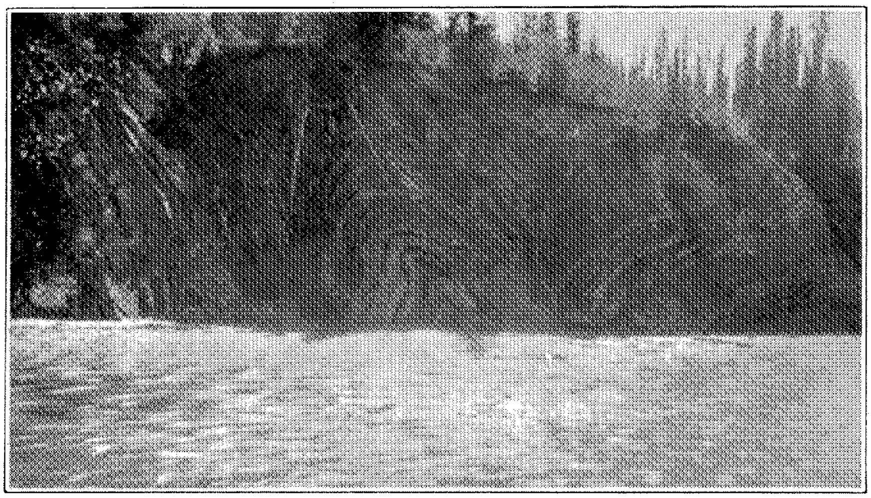

PLATE XI.—Folded and faulted Colorado beds near Main fault on Blackstone, looking east.

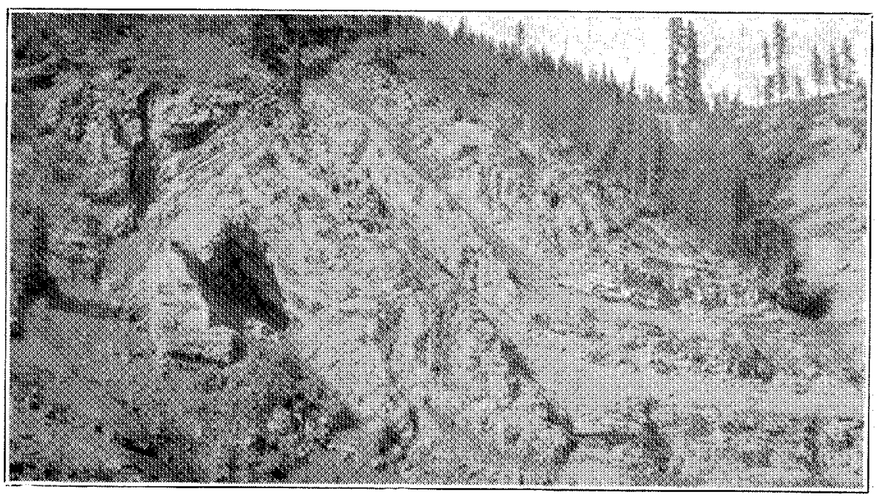

PLATE XII.—Tightly folded Colorado beds on Blackstone River about three miles east of Nelson cabin.

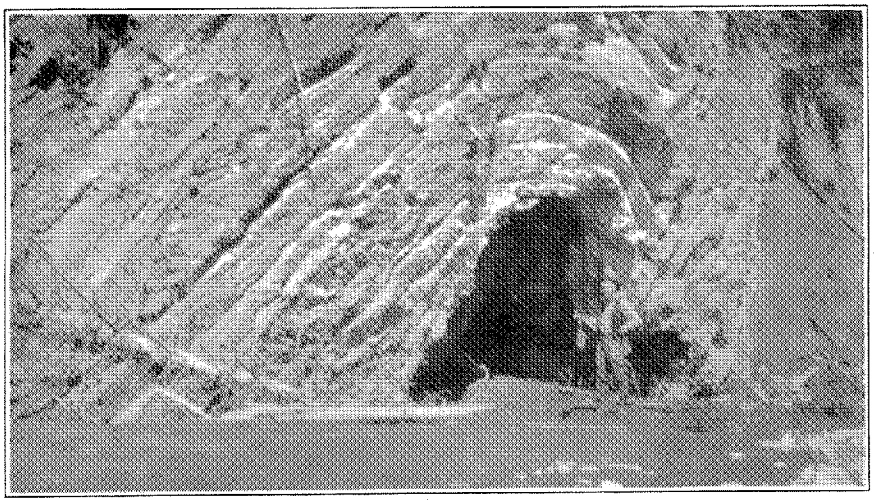

PLATE XIII.—Folded sandstone member in Colorado on Blackstone, south of Nelson cabin.

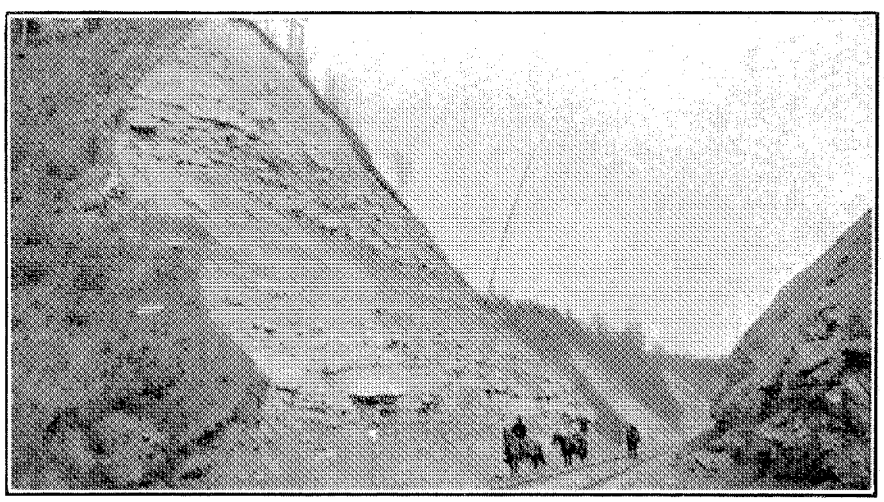

PLATE XIV.—Upper Saunders formation one mile east of Ancona.

two-thirds of the formation is shale and the remainder is made up of interbedded shales and sandstones. The formation as a whole is soft and has been effected by many small folds and displacements during mountain-building movements (Plate XII.). The valley shown in Plate IV. is underlain by soft-weathering Colorado beds. A general principle in geology is that soft and shaly formations break and fold into numerous minor structures, rather than form large regional structures, during orogenic movements. Such a principle is well illustrated by the Colorado formations in this district.

In the area mapped the best exposures are on the Saskatchewan and Blackstone rivers. On Nordegg river there are exposures but much of the section is covered with vegetation. On the Saskatchewan the section is well exposed, but harder to study as part of it is on the south side of the river that could not be reached. and a considerable part of the section on the north side is inacessible on account of the steepness of the river cut-bank. The Blackstone exposes almost a complete section between the mouths of Lookout and Chungo creeks (Structure Section No. 3).

The lower Colorado beds consist dominantly of black marine shales and correspond to the "*Blackstone formation*". A section of approximately 600 feet of shales is exposed on the south side of Saskatchewan river. The lower 400 feet are uniform in character and appear to be black, fissile and thin-bedded. The upper 200 feet appear to be harder and weather to dark green and brown. As this section is exposed on the south side of the river it was not possible to reach it and to examine it for fossils. Malloch gives a thickness of 1,060 feet for the Blackstone formation.

The intermediate beds of the Colorado group consist of interbanded shales, sandstones and conglomeratic sandstones. The beds vary in thickness up to about 30 feet. Sandstone beds of this thickness are quite common and well exposed in the Blackstone river section (No. 3). On account of deformation it cannot be said how thick this intermediate series is in this area. Malloch gives 390 feet for the thickness of the "Bighorn formation" which is well exposed in the Bighorn mountains. The indications are that this formation is at least 390 feet and perhaps even thicker in the Nordegg area. The conglomerate bands are coarse light grey sandstones with patches of pebbles scattered through them. These pebbles vary in size but would average about one half inch in diameter. The general appearance of these conglomeratic sandstone bands is quite different from the Fernie conglomerate. This middle formation is quite noticeable in the vicinity of the Blackstone and Nordegg rivers as the hard bands are shown in the physiography (Plate XIII.).

General relations indicate that there is another series of beds above the Bighorn formation consisting chiefly of black marine shale. This would correspond to the "Wapiabi shales" of the Bighorn district. This formation, however, includes several thin beds of sandstone which are in some cases conglomeratic.

It is possible that future field investigations might show that some of the lower beds of the Colorado as shown on the Blackstone section No. 3, correspond to the Dakota as described in other parts of Alberta. Malloch states that the Bighorn formation is in many respects like the Dakota in the Bighorn basin.

A general description of the Colorado as a group in this area is all that can be given at the present time. The series begins with dark shales somewhat siliceous changing upwards into thinly bedded, black, fissile, marine shales carrying a marine fauna in some places. Such characteristics dominate throughout the lower 600 feet to 1,000 feet. Above these members the series begins to exhibit an alternation of black siliceous shales and strong well cemented sandstone-conglomerate and sandstone bands for several hundred feet. Black fissile marine shales interbedded with sandstone, in places conglomeratic, form the next member. The top of the series is exposed for a distance of 100 feet on Blackstone river and consists of siliceous shales containing many concretions.

The most distinct horizon markers in the Colorado are two bands of conglomerate in the black shales. The conglomerate weathers to a reddish color and consists of pebbles that are uniform in size, averaging about one half an inch in diameter. This conglomerate is very similar to a bed that occurs in the Benton formation along Highwood river and in southwestern Alberta. The exact horizon of this distinct type of sediment has not been definitely located. It appears to occur somewhere in the upper part of the Blackstone formation.

Further paleontological work would assist in correlating partial and broken sections of the Colorado members.

The best exposures of the Colorado on Blackstone river are at a point that is important from the structural aspect. This position is near the end of the Paleozoic block and deformation has disturbed the natural stratigraphic sequence (Plate XI.). To the east of the Paleozoic block these beds have been intensely squeezed and broken. It is anticipated that future investigation on Brazeau river to the northwest of this area will reveal a less disturbed section of the Colorado, and that it will be possible to work out the stratigraphy in greater detail.

Age.—The general lithological character of the beds in this area, their stratigraphic relations to lower and higher series, and the marine fauna place them as Colorado in age. They correspond in general to what is usually called the "Benton formation" in other parts of Alberta. These beds are probably the time equivalent of what Cairnes has called the "*Claggett and Niobrara-Benton*" in the Moose Mountain district. The marine shale phases are similar to the Benton but the presence of a large number of sandstone and siliceous beds in the middle member in the Nordegg area does not seem to correlate with the general lithological character of the Benton in southwestern Alberta. Fossils collected on Blackstone river above Nelson cabin from a horizon well up in the Colorado, have been determined by Dr. T. W. Stanton as *Inoceramus* sp., *Scaphites* sp., and fish scales (probably *Hypsodon*).

CHAPTER VII.

DESCRIPTIVE GEOLOGY (Concluded).

MONTANA GROUP—INTRODUCTION

General Statement.—The formations in the Montana group are widely distributed in the eastern part of the Saunders area. Because of the great thickness here exposed, it has been given a local name, the *Saunders group*, and is divided into three parts, *Upper Saunders formation* and *Lower Saunders formation* separated by the *Saunders coal series.*

With more extended field work it may be necessary to designate the upper and lower Saunders formations with separate formation names, but in this report, based on preliminary field work over a limited area, it was considered advisable to use the classification shown on the accompanying map. The lower Saunders formation in all probability corresponds to what Malloch has called the "Brazeau formation" in the Bighorn basin. As the section is incomplete in the Bighorn area, the above divisions have been adopted for the Saunders Creek and Nordegg areas. Furthermore, it is the opinion of the writers that there is a continuous and very thick series of formations of similar origin from the base of the Montana group up to and possibly including the basal member in the Tertiary, which in central Alberta is called the "*Paskapoo formation*".

In the area shown on the accompanying map the Montana group forms a belt extending from Saskatchewan river northwest to Nordegg river. The western boundary is marked by a faulted contast with the Colorado beds. On the east the First fault, as described in the chapter on structure, is considered the eastern boundary of these formations. Good sections of the Montana beds were examined and measured on the Saskatchewan, Nordegg and Blackstone rivers. The relation of the various formations along these rivers is shown in structure sections Nos. 1, 2 and 3.

The Montana beds lie conformable on the upper shale members of the Colorado, and the contact is marked by a change in lithology. The upper limit has not yet been determined but it seems probable from relations further east than the boundary of this area, that beds later than upper Montana in age were deposited, but have been removed by subsequent erosion.

In general the Saunders group consists of sandstones, clay shales, and coal seams. The coal seams of commercial thickness occur well up in the series. These relations and the lithologic variations can best be considered separately.

LOWER SAUNDERS FORMATION

Distribution.—This formation is not as widely distributed as the upper Saunders formation, but sections exposed on the rivers give a good opportunity to study the lithological characters. On Blackstone river in the western part of township 43, range 16, between the mouths of Chungo and Brown creeks, there is exposed almost a continuous section. The coal seams are exposed at the mouth of Chungo creek, and the base of the lower Saunders formation is in contact with the top of Colorado beds (Wapiabi shales) at the mouth of Brown creek. Before describing the lithology, it seems advisable to consider the thickness of the lower Saunders formation along this section.

Thickness.—The thickness of the lower Saunders formation has been obtained graphically. Near the mouth of Chungo creek, the beds are dipping at about 15 degrees to the southwest, and at the base of the formation close to the mouth of Brown creek the dip is about 45 degrees to the southwest. Taking the average dip as 25 degrees, the thickness is 5,500 feet. This is a minimum thickness for the formation as no allowance was made for the extra thickness that would result if the fall in the river between these points were considered in the calculation. If a section were exposed so as to allow a vertical measurement, in all probability it would measure over 6,000 feet as the average dip taken is really a little below what the field evidence seems to show. It would seem that 5,500 to 6,000 feet is a conservative estimate for the thickness of the lower Saunders formation on Blackstone river. A section of these beds measured in detail, would be of little use for correlation purposes as the lithic units are known to vary rapidly in lateral directions. Especially is this true of certain beds within the formation that are quite lenticular.

Lithology.—A generalized section on Blackstone river shows that the lower members consist of alternating beds of sandstones and shales. Both the sandstone and shale members range up to over 50 feet in thickness. The sandstones are fairly well cemented light grey to buff in color and of medium grain. Scattered lenses of conglomerate frequently occur associated with the sandstone. Crossbedding is prevalent, but the curve of the crossbedded structure is usually short, averaging about 10 inches in length. The interbedded shales are quite siliceous and break into angular blocks in contrast to the general fissile and platy nature of those in the underlying Colorado group. These shales frequently weather to dark browns and greens, resembling in this respect shales of so-called Dakota age in other parts of Alberta.

These lower beds represent the fluctuating changes in sedimentation that followed the period of deposition of the uppermost beds of Colorado age. They also bear a strong lithic resemblance to much of the material found within the middle Colorado (Bighorn formation), and were it not for stratigraphic relations evident in the field they might easily be confused with the latter.

Alternating beds of sandstone and beds of shale 50 feet in thickness prevail in the lower 400 to 500 feet of the formation.

Rising stratigraphically the units become thinner and the amount of sandstone increases over the shale. Such conditions prevail through the lower 2,000 feet with about 50 per cent. clay shale at the base and about 75 per cent. sandstone at the top.

In the central part of the section sandstone is still the dominant member. The beds average up to 10 feet in thickness and the clay shales become very siliceous. Above these beds clay shales again become very prominent and represent about 50 per cent. of this portion of the formation.

About 1,800 feet from the top of the formation a few small coal seams occur, ranging up to one foot in thickness. These are overlain by massive sandstones and clay shales which continue to the top of the formation, where they are in contact with coal seams of commercial thickness. The upper part of the formation differs from the lower in that the sandstones are coarser grained, more highly crossbedded, and lenticular in lateral extent. Many beds of sandstone enclosing clay pellets occur in this part of the formation. Beneath coal seams it is customary to find clay shales forming the larger percentage of the formations, while above the coal as a rule soft sandstones predominate.

The upper limit of the lower Saunders formation has been placed at the horizon where coal seams of commercial thickness occur. Lithologically, this is the most dominant change that is expressed in either the lower or upper Saunders formations, so that the series of beds containing coal seams has been taken as the division between the upper and lower Montana formations.

In no other part of the area that has been mapped was the entire lower Saunders formation observed. Approximately the upper 1,000 feet of this formation are exposed on Shunda creek (Plate V.), and Saskatchewan river along the eroded Stolberg anticline west of Saunders ridge. Along the railway the exposure of this formation extends from a point half a mile west of Saunders station, west to mile 163 about two miles east of Harlech mine.

Exposures of lower Saunders formation in this part of the area show similar lithological characters to the Blackstone section. These beds represent approximately the upper 1,000 feet of the formation and consist essentially of coarse to fine grained, massive light grey sandstone beds, frequently lensed and crossbedded on a large scale. Sedimentary dips up to 10 degrees are common.

The coarse grained sandstones are as a rule more lenticular than the fine grained ones, which are usually more persistent laterally. Clay shales form about 50 per cent. of the beds, are dark grey in color and are interbedded with sandstones. Clay pellets and plant remains are quite commonly associated with the sandstones. The lateral and vertical variations in the various members in the formation illustrate very definitely the futility of any attempt to correlate from place to place by use of detailed sections. The dominant color of the lower Saunders formation is light grey and buff. The clay shales are dark grey in color but form a small part of the whole formation, so that the color of the sandstones predominate.

Age.—Fossil plants collected in sandstone members near the top of the formation from a rock cut on the railway at mile 157.5, have been examined by Professor E. W. Berry. Those determined are *Sequoia heterophylla* Velen., and *Androvettia* sp.? *Cyacadocarpus*, a new species of cycad fruit was collected from a rock cut about a mile west of Stolberg. *Sequoia heterophylla* Velen. was also collected from beds on Baptiste river in the southwest corner of township 42, range 12. In the same beds there are many fragments of dicotyledons that were not determinable.

From the stratigraphic position and preliminary paleontological evidence the lower Saunders formation is lower Montana in age and are correlated with the lower Belly River beds in central Alberta and with the Allison formation in the Crowsnest district. The beds are of brackish and fresh water origin and carry animal as well as plant fossils at various horizons.

The Saunders coal series includes beds that separate the upper and lower Saunders formations. Coal series are not often accepted as good dividing lines but in a series of fresh water sediments such as are represented by the Saunders group, coal seams mark a much greater change in conditions of deposition than that represented in a change from clay shale to sandstone. A fuller description of the coal series will be given in the chapter on economic geology.

UPPER SAUNDERS FORMATION

This part of the Montana group forms the uppermost formation over the larger part of the area in the Saunders district. As shown on the accompanying map, these beds occupy the belt east of the Main fault.

As in the case of the lower Saunders formation, the best exposures of the upper Saunders formation are on Blackstone river. The thickness of the beds above the coal measures has been estimated from a continuous section that is exposed on the Blackstone downstream from the Second fault, a short distance below the mouth of Brown creek. This exposure begins with beds dipping at 75 to 80 degrees to the northeast and gradually flattening out to nearly horizontal position.

Taking the average dip and the strike as north 32 degrees west, this exposure shows approximately 6,000 feet of beds. This figure may appear large but from observations made in this area the figure does not seem too great as a minimum average dip was used in all cases.

The lower part of this section begins with light grey massive sandstones and coal seams interbedded with clay shales. The members are comparatively thick; the sandstone members vary up to 100 feet and the shale beds to 50 feet in thickness. Plate XV. shows these characteristics in the formation exposed along the Saskatchewan east of Ancona.

These thick members consist of sandstone, coarse grained, light grey and buff in color. The cementing material is not as strong as it is in the massive sandstone members in the lower Saunders formation. In many cases lenses of conglomerate occur within the sandstones. Frequently the sandstone member begins with a layer of clay pellets cemented with sandstone.

Rising stratigraphically the amount of clay shale increases and sandstone diminishes. This is represented in Plate XIV. The upper part of this formation is dominantly clay shale interbedded with fine grained argillaceous sandstones, and occasionally large lenses of coarser sandstone occur with sedimentary dips as high as 10 degrees. Some of these lenses have a lateral extent of about 200 feet. The upper limit of this formation has not yet been determined in these areas, as the top of the exposure does not reveal any marked change in lithology.

Age.—The following fossil plants have been determined by E. W. Berry from a preliminary examination.

Pinus sp., Nordegg river

Arundo groenlandica Heer?, Nordegg river.

Platanus sp., Blackstone river below Brown creek

Platanus sp., near head of Lawrence creek close to the trail

Invertebrate fossils are represented by *Unios* and *Campeloma*, on Blackstone river below Brown creek, *Viviparus* at several localities in eastern part of area, and *Goniobasis* along the river south of mile 137.

Stratigraphically this formation represents a continuation of similar deposition to the older formation below the coal measures. The basal members are Montana in age, but the upper part of the 6,000 feet of beds may represent the time equivalent of the early Tertiary beds of other areas to the east. More extended field work is essential for the determination of the age of the uppermost members.

SUMMARY OF MONTANA FORMATION

Certain general characteristics of the whole Montana group are apparent in this area. The formations are made up essentially of continental deposits, and a rather marked repetition of similar conditions of deposition is shown in both the upper and lower Saunders formations. On the whole the lower beds are better cemented, perhaps this is due to the greater weight of the overlying formation. Both, however, begin with thick sandstone members averaging up to 75 feet in thickness. These are interbedded with clay shale beds averaging 30 to 40 feet in thickness.

Rising stratigraphically in both the lower and upper formations, the relative amount of clay shale increases, and the sandstone members become finer grained, more argillaceous and thinner, decreasing to 10 or 20 feet in thickness. The upper members in both formations frequently contain large lenses of coarser sandstone, with smaller lenses of conglomerate and clay pellets enclosing plant and animal remains. The lower formation closes with the coal measures but the uppermost beds in the upper Saunders formation have been eroded away, so that a comparison cannot be made for the final stages.

On the whole the units do not persist in character and thickness over any great distance laterally, and detailed correlation from place to place is difficult as the only horizon marker in the whole group is the coal.

In considering the age of the Saunders group, the relations to similar formations in other areas can best be brought out in tabular form. These formations in the Saunders area correspond to the Belly River series in most of the foothills areas already described, but may include some later formations which are represented in the outer foothills areas.

COMPARATIVE TABLE OF MONTANA FORMATIONS IN ALBERTA

Locality	Reference	Thickness	General Characters
Crowsnest Coal Field, Alberta.	Bruce Rose, Geol. Surv. Can., Sum. Rept. 1916, p. 113.	2,500 to 3,000 feet partial section.	Chiefly a sandstone formation; basal members massive, light grey, crossbedded sandstone; becomes more shaly above this basal 250 feet; coal seams at top; age, Belly River.
Disturbed Belt, Southwestern Alberta.	J. S. Stewart, Geol. Surv. Can., Memoir 112, 1915, p. 35.	3,000 feet (estimated)	Dominantly fine grained sandstones, light grey in color, interstratified with irregularly bedded shales; coal seams at several horizons but most persistent coal seams near the top, patchy conglomerates common also clay pellet zones; age, Belly River.
Moose Mountain District, Alberta.	D. D. Cairnes, Geol. Surv. Can., Memoir 61, 1914, p. 25.	1,025 feet	Mainly light colored sandstones, shales, and clays; some marine beds in places but dominantly fresh water, becoming brackish towards top and bottom; age, Belly River.
Bighorn Coal Basin, Alberta.	G. S. Malloch, Geol. Surv. Can., Memoir 9E, 1911, p. 37.	1,700 feet partial section.	Alternating beds of black and brown shale with greenish grey sandstones; lower beds similar to Kootenay and Bighorn formations.

The above table shows the general similarity of the lower Montana beds throughout the foothill belt of Alberta. They do not, however, correspond to the entire Saunders group but only to the lower Saunders formation. The Montana group has been described in many parts of Alberta to the east and south of this area. In most localities it includes an upper marine member, the Bearpaw shales. This shale series is usually followed by other fresh or brackish water deposits, as the St. Mary's River formation in southern Alberta or the Edmonton formation in the northern and central parts of the province.

There are no marine beds in this area that would correspond to the Bearpaw formation. While marine conditions were existing in central and southern Alberta, near-shore, brackish or fresh water deposits were being formed in the Saunders Creek area.

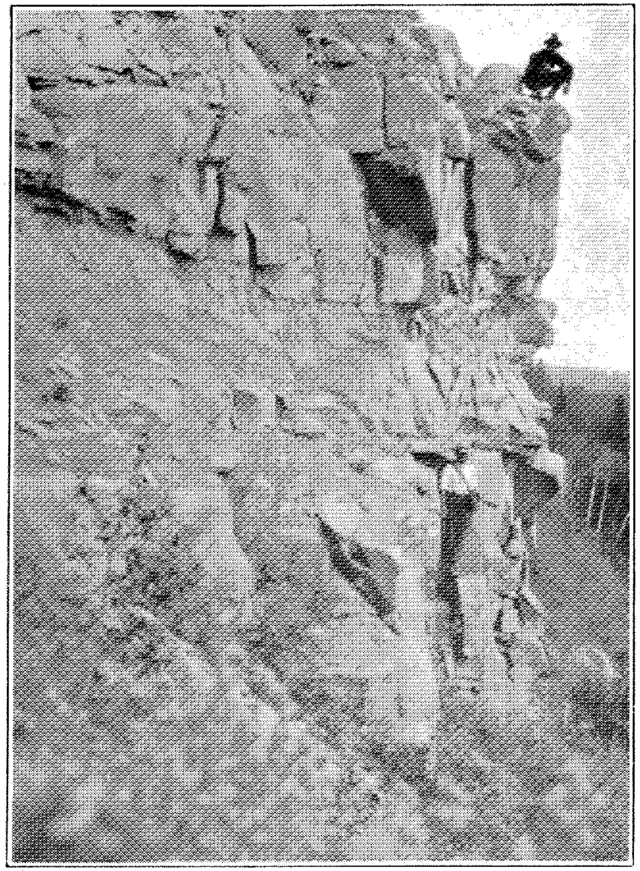

PLATE XV.—Massive bedded sandstones in upper Saunders formation, one and a half miles east of Ancona.

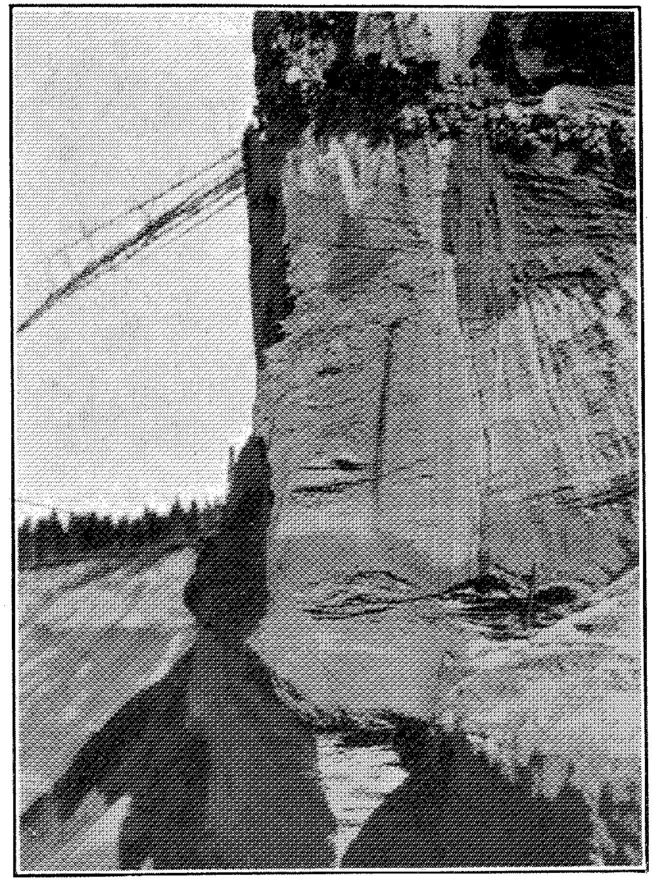

PLATE XVI.—Crossbedded sands and gravel of glacio-lacustrine origin about 100 feet thick, one and a quarter miles southwest from Ancona.

This accounts for the Saunders formations being continental in origin throughout with an approximate thickness of 12,000 feet, while the time equivalent to the southeast is represented by an alternating series of marine and fresh water beds.

QUATERNARY FORMATIONS

PLEISTOCENE AND RECENT

The results of glacial activity in this region are apparent. On the top of Mt. Coliseum at an elevation of over 6,600 feet above sea-level, or about 2,800 feet above the present level of Saskatchewan river, there are small well smoothed pebbles of rocks foreign to this district which indicate that piedmont glaciers at one time covered Brazeau range.

Beds of glacial gravel cemented into conglomerates by calcareous materials occur along the Saskatchewan valley both to the east and to the west of the gap. The pebbles are chiefly limestone and quartzite, varying in size up to five inches in diameter. On Coal creek north of the trail and 125 feet above the level of the Saskatchewan, there is an exposure of bedded conglomerate lying in horizontal position on steeply dipping Cretaceous beds. When the glaciers melted, these gravels were left on the floor of a lake that occupied the valley of the Saskatchewan and which was formed by the drainage to the east having been dammed up.

Saskatchewan gap and Shunda gap show evidence in their steep-sided outline of having been deepened and widened by the eastward movement of valley glaciers through the Brazeau range from the Cordilleran ice sheet. Harder members in the Paleozoic formations in Shunda gap have been smoothed and striated by ice. The broadly rounded outline of Shunda valley northwest from Nordegg has resulted from glacial erosion. Plate II. shows the broad Shunda basin between Brazeau range and Saunders ridge that has been effected by glacial erosion.

Post-glacial erosion has removed glacial markings from the softer Mesozoic rocks. Glacial debris is widely distributed along the Saskatchewan valley as gravels, sands and silts of glacio-lacustrine origin. The presence of extensive and pronounced terraces west of Rocky Mountain House, and particularly west of mile 125, suggests that the drainage courses were blocked during the retreat of the ice sheet. It would seem that there were two such lakes in the Saskatchewan valley as the debris east of the gap is coarser than that west of the gap which consists of yellowish silts. Furthermore, the uppermost terrace of sand and gravel east of the gap is at least two hundred feet lower than the highest silts west of the gap. Plate XVI. shows a section nearly 100 feet in thickness of crossbedded glacio-lacustrine sands and thin beds of gravel on Saskatchewan river one and a quarter miles southwest of Ancona.

Numerous calcareous springs occur along the Saskatchewan valley on the contact of the Cretaceous rocks with the overlying gravels and fine sands. Several strong springs occur along the face of the terrace escarpment south of Ancona.

Recent river gravels and flood plain deposits are confined to a narrow strip along the streams so their distribution is not shown on the accompanying map.

CHAPTER VIII.

ECONOMIC GEOLOGY

A geological survey of this district is commercially important as it includes two coal basins, namely the Nordegg and the Saunders Creek coal basins. The former contains the Kootenay coal measures of lower Cretaceous age from which bituminous steam coal is produced, and the latter contains semi-bituminous coal seams in the Saunders coal measures of upper Cretaceous age. The general characteristics of the coal seams in these two basins will be discussed separately, but no attempt will be made to give detailed descriptions of the coal seams nor the variations within the seams as this report deals specifically with the distribution of the coal bearing formations.

KOOTENAY COAL MEASURES

In Chapter VI. the character of the rocks in the Kootenay formation is discussed. The maximum thickness of the formation in the Nordegg district is 1,500 feet, but the average thickness is not more than 1,000 feet. In the Bighorn coal basin twenty miles west of the Nordegg coal basin the formation is 1,800 feet thick.

There are several coal seams in the Kootenay in the lower part of the formation, but only two seams of commercial importance have been developed up to the present time. These two seams are mined by the Brazeau Collieries at Nordegg and have been designated No. 2 (lower) seam, and No. 3 (upper) seam.

Two diamond drill bore holes were put down by the Brazeau Collieries about a mile west of the outcrop of the coal seam at the mine entrance to test the continuation of the coal measures. The position of these holes is shown on the map. The core samples from No. 2 test hole which is 1,200 feet deep were examined and recorded by J. S. Stewart of the Geological Survey of Canada[1]. A summary of the log to the lowest coal seam is as follows:

Surface elevation 4,492 feet.

284	feet	Shale and sandstone interbedded,	
1	"	*Coal*, No. 5 seam,	
4	"	Shale,	
5	"	*Coal*, No. 4 seam,	
89	"	Sandstone, massive bedded,	
15	"	*Coal*, No. 3 seam,	
101	"	Sandstone and dark carbonaceous shale,	
7	"	*Coal*, No. 2 seam,	
78	"	Shale with thin beds of sandstone,	
1	"	Coal	No. 1 seam
7	"	Sandstone	
1	"	Coal	
2	"	Shale	
1	"	Coal	

[1]Stewart, J. S.—Geol. Surv. Can., Summary Report, 1916, p. 94.
Allan, J. A.—2nd Ann. Rept. Min. Resources, Alta., 1920, p. 62.

The three thin layers of coal within twelve feet of starta correspond to No. 1 seam, and may be represented in other localities by a single seam or they may only represent lenses. In any case they are of no economic importance. The section of Kootenay beds measured at the east end of Saskatchewan gap and given on page 43 shows only one seam of coal below the thick seam.

Seams No. 2 and No. 3 are of commercial importance and appear to be wide spread in their extent. Both of these seams are worked by the Brazeau Collieries Ltd[1]. The coal seams in the locality were discovered in 1911 under the direction of Mr. M. Nordegg, after whom the town has been named. Development began in 1911 on the outcrops of the seams in the south side of the valley of Shunda creek, and the coal seams have been mined for a distance of about two miles from the outcrop. The mine is located in the northwest quarter section 22, township 40, range 15. A record daily output of 2,400 tons was reached last summer. Due to the kindness of the officials of the company, J. Shanks, general manager, J. M. Stewart, mine manager, and H. G. Moore, mine surveyor, much information on these two coal seams was obtained from the present workings and from survey plans. The probable outcrops of No. 2 and No. 3 seams between mine entrance and Saskatchewan river, have been surveyed by H. G. Moore, and permission was given to include this data on the accompanying map.

No. 2 seam varies from 6 to 7 feet in thickness and has a sandstone roof and shale pavement. No. 3 seam is 100 to 125 feet higher in the formation with shale roof and pavement. The roof conditions are better in No. 3 seam than in No. 2 which consists of sandstone. The thickness of the coal ranges from 14 to 15 feet, but on account of the intense deformation to which the coal has been subjected and minor folds and faults causing duplication, the seam thickens in places to nearly 30 feet. Deformation has crushed the coal so that when mined it is in small lensy fragments.

South of the mine entrance the measures have an average strike of north 32 degrees west and a dip of 12 degrees southwest. The seams are mined up the dip so that the removal of the coal is by gravity. There are many local faults and irregularities in the seams and these increase towards the southeast. On the Saskatchewan valley where the measures are exposed on Outcrop and Coal creeks the dip is not so regular as at Nordegg and much more repeated folding has taken place. As the present workings are extended to the southeast more irregular structures can be expected.

East of Saskatchewan gap where the Kootenay outcrops below the overturned block of Paleozoic rocks the measures are badly crushed and deformed. There are three coal seams exposed, the center one ranges from 10 to 15 feet in thickness and is of commercial importance. Access to the locality is difficult and the coal would have to be hoisted to the surface. These factors will prevent commercial development of the measures at this point in the near future.

On Coal creek there are at least two coal seams exposed but

[1]Annual Report, Mines Branch, Alberta, 1921, p. 199.

these appear to be higher stratigraphically than No. 3 seam. In order to work out the detailed geological structure of the measures along the Saskatchewan valley it will be necessary to have a topographic map available.

Northwest from Nordegg to the head of Lookout creek, the coal measures have been eroded much lower so that the coal seam would have to be developed by shafts and the drainage of mine workings would be difficult. Such conditions will prevent the exploitation of the coal seams in this direction for some time to come.

SAUNDERS COAL MEASURES

This series of beds separates the upper and lower Saunders formations in the Montana group which is upper Cretaceous in age. The coal seams[1] are geologically much younger than the Kootenay coal measures that belong to the lower Cretaceous.

It is not necessary to repeat here the distribution of these measures throughout the Saunders Creek coal basin, as they separate the upper and lower Saunders formations which have been discussed in Chapter VII. Referring to the map, the structure is synclinal between mile 136 and Saunders Creek, then anticlinal to about mile 163, and synclinal west to the Third fault near Harlech station at mile 166.

The beds are dipping steeply to the southwest at mile 136 just west of the Second fault. A prospect has been opened on the coal measures by J. Siminiotti in sections 14 and 23, township 40, range 11, and seams of coal of good quality occur at this point. The strike of the beds is north 45 degrees west to Jackfish lake where another exposure was observed in section 6, township 41, range 11. A section of the measures at this locality is given below. The measures are also exposed on Lawrence creek about the center of township 41, range 12, and here the stratigraphic succession is similar to that in the measures at Jackfish lake on the southeast. Between Lawrence creek and Nordegg river at the mouth of Colt creek no exposures of the coal formation were observed.

The west limb of this structure crosses the railway at Saunders creek where the coal mine is located and operated by the Bighorn and Saunders Creek Collieries Ltd. The measures strike north 50 to 60 degrees west and dip 5 to 10 degrees to the northeast. A mile west of Saunders creek at West Saunders, there is a coal mine operated by the Saunders Alberta Collieries Ltd., and a mile and a half to the northwest is another mine operated by Alexo Coal Company Ltd. The measures in all three mines are dipping to the northeast at low angles and the average trend of the strike is about north 42 degrees west. No exposures were observed to the northwest until Colt creek was reached. About two miles and also at three miles from the mouth of Colt creek in a straight line, the coal measures are well exposed with a northeasterly dip up to 40 degrees. At the mouth of Colt creek, the measures on both sides of the structure meet and form the bottom of the synclinal trough. It was therefore on structural and lithological evidence that the measures exposed on Lawrence creek and those near the Alexo

[1]Discovered by Mr. Stewart Kidd in 1911.

mine were connected with the coal seams and associated beds at the mouth of Colt creek.

West of Alexo mine the structure is anticlinal and has been referred to as the Stolberg anticline in another part of this report. The coal mine one mile east of Harlech station is located on the west limb of this anticline and is operated by the Harlech Coal Company. The coal measures strike about northwest and the dip varies from 15 to 30 degrees to the southwest into a narrow assymmetrical syncline less than a mile wide. On account of this dip it would seem that the coal seams should be reached by shaft some distance from the outcrops, rather than by drifting down the dip as is being done in the Harlech mine. The beds in the western limb of this syncline are overturned and dip at steep angles up to 90 degrees to the southwest. Structure section No. 1 shows the relation of the coal measures to the structure. On Saskatchewan river the coal measures are exposed in both limbs of the syncline about three miles in a straight line southwest from the mouth of Shunda creek. These beds were not observed on Nordegg river west of Colt creek. It is assumed that the Third fault has cut them off south of Nordegg river.

On Blackstone river the same coal measures are exposed at two places, at the mouth of Chungo creek and near the mouth of Brown creek. The structural relation between the coal measures exposed on the Blackstone, on the Nordegg and also those along the Saskatchewan valley cannot be worked out in detail without a topographic map.

There is one other locality in the area shown on the map where coal measures occur at the surface. In the northeast corner of the map on Nordegg river close to the First fault on the west side, a coal seam 16 feet thick outcrops on the river cut-bank and has a southwesterly dip. The nearest exposure of the Saunders coal measure is at the mouth of Colt creek about 17 miles in a straight line to the southwest, and much of the intervening section is covered with recent deposits and vegetation. In structure section No. 2 the coal at the First fault on Nordegg river has been correlated with the Saunders coal measures. There is, however, the possibility that this coal seam may be younger in which case it would correspond in age to the uppermost Montana beds that are included in the Edmonton formation. The field survey will have to be extended to the north and east before this correlation can be definitely determined.

Lithology of Saunders Coal Measures.—The sediments associated with the coal seams vary laterally within a short distance, so that it is difficult to correlate columnar sections of the coal measures that are widely separated. The coal seams are the most persistent members. No definite stratigraphic horizons can be taken as the top and the base of the Saunders coal measures as the beds change gradually upwards and downwards into the upper and lower Saunders formations respectively.

Several sections were measured of which three are as follows:

A. On Saunders creek in section 19, township 40, range 12.
B. Partial section near Jackfish lake in section 5, township 41, range 11.
C. On Colt creek in township 42, range 15.

A		feet
Soft buff sandstone and shale		13.0
Bentonitic clay		0.2
Coal (dirty)		1.0
Soft blue grey sandstone		4.0
Coaly shale		0.8
Hard, massive buff sandstone		5.0
Coal (dirty)	1.3	3.4
Bentonite	0.4	
Shale	0.3	
Coal	1.4	
Dark carbonaceous shale		1.2
Blue grey shaly sandstone		35.0
Black coaly shale		1.2
Bluish shaly sandstone		4.0
Dark ferruginous shale		1.5
Nodular ironstone band		0.8
Hard, bluish grey sandstone		4.5
Bluish shale		1.2
Soft sandstone		7.7
Black carbonaceous shale		3.2
Bentonite		0.3
Coaly shale		0.7
Blue black shale		9.0
Coal	6″	No. 2 seam 5.8
Bentonite	2″	
Coal	20″	
Clay shale	34″	
Coal	6″	
Hard clay shale		13.0
Soft bluish sandstone		16.0
Bluish shale		1.0
Ironstone nodule band		1.0
Soft sandy shale, soft shales and sandstones		27.0
Shale		1.0
Coal		0.3
Shale		0.4
Coal with several partings, No. 1 seam		4.5
Shale		3.0
Total		170.7

B		feet
Yellow weathering sandstone		5.0
Clay	3″	4.0
Coal	2″	
Bentonite	2″	
Clay	4″	
Coal	2″	
Clay shale	16″	
Coal	6″	
Shale	15″	
Coal (clean)		2.0
Shale, soft		1.5
Hard clay shale		4.9
Coaly shale		0.3
Coal		1.7
Shale and carbonaceous bands		3.0
Coal		2.0
Shale		3.0
(Bottom not exposed)		
Total		27.4

C		feet
Soft brown sandstone and shales		25.0
Coal	6′ 6″	Big Seam 11.0
Clay	1′ 9″	
Coal	2′ 9″	
Grey soft sandstone		25.0
Coal		3.0
Sandy shales and ribboned sandstone bands		40.0
Coal		3.0
Sandy shales and sandstone bands		20.0
Coal, clean		6.8
Soft grey sandstone and shaly sandstone		20.0
Coal		2.0
Total		155.8

The coal measures at Saunders creek have a thickness of about 170 feet, but the thickness varies in different localities. Field observations and data obtained from the mines seem to indicate that there are four principal coal horizons in these measures. These are numbered 1 to 4 in stratigraphic succession from the lowest to the highest. It is advisable to number the seams because the coal seams at Harlech are numbered in reverse order from those at Saunders creek, for example No. 2 seam in the mines near Saunders creek is

No. 4 at Harlech mine, while No. 2 at Harlech is No. 4 in the mines to the east. Numbers one and three are too thin and too dirty to mine where they have been prospected. No. 2 seam is worked at the Saunders Creek, Saunders Alberta and Alexo mines on the east side of the fold, and at Harlech mine on the west limb. No. 4 is being worked at Harlech and has been mined at Saunders Creek and Saunders Alberta, but was later abandoned. There is an apparent thickening of these two seams towards the west but there is no positive evidence that the seams contain less bone and fewer partings except locally. There are a few minor faults where the seams have been worked in the east band. Faulting is more pronounced to the west at Harlech. This would be expected because the beds have been subjected to greater deformation from forces which caused the overthrusting of Brazeau range. For the same reason the dip in the measures is greater in the Harlech syncline than to the east in the vicinity of Saunders creek.

Columnar section C of the coal measures on Colt creek shows the coal seams have thickened and the coal appears to be more blocky in character. At several places on Colt creek the coal seams are more resistent to erosion than the beds above and below. Plate X shows one of these coal seams at the mouth of Colt creek.

Prospecting on the Siminiotti coal seams north of Lamoral was not sufficiently advanced when the examination was made, to prove the thickness of the seams or the character of the coal on an unweathered surface.

Much valuable information was received from the officials of the following mines that were operating on the Saunders coal measures when this field survey was being made:

Description of Mines.—BIGHORN AND SAUNDERS CREEK COLLIERIES LTD. (Began operation 1913).

N.E. ¼, section 24, township 40, range 13, west of the 5th meridian,
W. G. Pearson, manager; A. E. Williams, mine surveyor,
No. 2 seam, shale roof, coal 53 to 56 inches, dip 5° N.E.

No. 4 seam in the Saunders Creek abandoned mine is represented by:

Poor roof,
4 feet coal with partings,
1 foot bentonitic clay,
4 feet dirty coal.

SAUNDERS ALBERTA COLLIERIES LTD. (Began operation 1918).

L.S. 16, section 23, township 40, range 13,
J. Stevenson, manager,
No. 2 seam, shale roof, coal 55 to 56 inches, dip 3° to 15° N.E.

ALEXO COAL COMPANY LTD. (Began operation 1920).

Section 27, township 40, range 15,
Major E. F. Pullen, managing director; J. MacDonald, mine manager (Thomas Horne, manager when mine was examined).
No. 2 seam.

HARLECH COAL COMPANY LTD. (Reopened 1922).

Section 10, township 41, range 14, west of 5th meridian.
M. Nordegg, managing director; James McKelvie, mine manager, (J. McMillan was mine manager when examination was made); Stewart Kidd, secretary-treasurer;
Considerable development work has been done in this mine since the date of our visit early in July.
No. 2 seam consists of 5 feet 6 inches coal with 5 inches bentonite and bone in centre.
No. 4 seam (called No. 2 at the mine) is 8 feet 9 inches thick, but only the upper coal is extracted. It consists of:

Coal	4 to 5 feet
Clay	1 foot 6 inches
Coal	– 10 inches
Shale	– 5 inches
Coal	2 feet 0 inches

Analyses.—Samples from the various mines were collected by mine inspectors and analysed by J. A. Kelso at the University of Alberta. The official analyses of coal from the four mines in the Saunders Creek coal basin are as follows[1]:

	Saunders Creek	*Saunders Alberta*	*Alexo*	*Harlech*[2]
Loss on Air Drying	2.3	3.0	3.0	1.3
Moisture	4.9	5.4	6.6	5.3
Ash	6.7	8.8	10.2	9.7
Volatile Matter	32.7	31.4	33.4	32.6
Fixed Carbon	55.7	54.4	50.8	52.5
Sulphur	0.3	0.4	0.3	0.4
B.T.U. per lb.	11,730	11,300	11,180	11,390
Fuel Ratio	1.70	1.75	1.50	1.60

Conclusions.—This preliminary field survey has proven that the Saunders Creek coal basin is extensive and that the coal measures consist of a thin series of beds that are widely distributed. The measures are of upper Cretaceous age and correspond to the Belly River series in central and southern Alberta. At least two coal seams are of commercial importance and these can be expected wherever the measures are prospected. The coal appears to get thicker and freer from impurities towards the northwest. In many places the roof is not good and it has given considerable trouble in the mines in operation. There are four seams in the measures exposed on Colt creek. The approximate position of the outcrops of the coal measures has been mapped from the data available at the present time. The most eastern outcrop of the measures has only been prospected at one point. A sixteen foot seam of coal comes just to the surface on Nordegg river in township 41, range 12. The stratigraphic position has not yet been definitely determined but it is possibly younger than the Saunders coal measures.

This survey also proves that both the Saunders Creek and the Nordegg coal basins extend south of the Saskatchewan river, but

[1]Scientific and Industrial Research Council, Alberta, No. 5, 1921, p. 67.
[2]Average of three analyses: Scientific and Industrial Research Council, Alberta, Report No. 8, 1922 (in press).

the measures have not been prospected in this direction as the railway follows the north side of the valley.

It is intended to extend the field survey on these coal measures to the northwest at least as far as Athabaska river west of Edmonton.

PETROLEUM

In 1914 during the "boom" which followed the discovery of oil near Okotoks, a drilling site was located at mile 136, just east of the Second fault between the railway and Saskatchewan river. Drilling was commenced but the well was never completed as the well was located on a large slump block which caused the drill to go crooked. Since that date several claims have been staked for petroleum in the vicinity of the Stolberg anticline. No drilling has been started, and no surface indications were observed that would encourage drilling operations in these areas. This structure is suitable for petroleum accumulation and there are several members in the underlying formation that are porous and suitable containers for oil or gas, but the presence of these conditions does not necessarily indicate that there are petroleum accumulations at depth.

There are many sandstone members in the Colorado formations, but there are no indications of petroleum in sections of these beds exposed in the Blackstone, Nordegg or Saskatchewan rivers. The Kootenay formation contains many sandstone members but none of these are petroliferous where they are well exposed between Brazeau mine and Saskatchewan river. Gas seepages have been reported from the Nordegg, Blackstone, and Brazeau rivers but only one seepage was observed. This gas seepage which keeps burning when lighted, occurs on the Nordegg river about a mile below Sunbeam cabin. Dried bitumen occurs in certain cavernous limestones of Devonian age in Shunda gap. The bitumen has been derived from bituminous limestones which have been effected by dynamic forces during the period of mountain building when Brazeau range was formed.

PHOSPHATE

The formation immediately below the Jurassic beds at Nordegg consists largely of thin-bedded dark bluish to black limestones interbedded with calcareous shale. Some of the beds contain cherty masses. The age of these beds is still in doubt but in another part of this report it has been suggested that they are possibly of Triassic age. The best exposure that was observed occurs in Martin creek at the railway a few yards east of Brazeau station in Nordegg. Plate IX. shows the character of this exposure.

Some of the darkest layers and especially the cherty lenticular shales give chemical reactions for phosphate. Several samples have been tested but the quantity of phosphoric acid is very small, less than one per cent. The phosphate content is too small to be of commercial value, but the trace of phosphate in these rocks is important as it indicates the continuation of phosphatic beds from the south.

Phosphate-bearing beds at a similar horizon occur from Utah as far north as Banff[1]. In the United States the phosphate content is sufficiently high to mine the deposit at a profit[2]. In the vicinity of Banff a phosphate bed has been determined that has an average thickness of 12 inches which is too thin to be worked profitably[3].

The importance of deposits of phosphate rock in Alberta, which could be utilized in the manufacture of superphosphate for fertilizers, would warrant close observation on the beds between the Carboniferous and Jurassic along the eastern part of the Rocky Mountains in Alberta.

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[1]Adams, F. S., and Dick, W. J.—Report, Conservation Commission, 1915.
[2]Weeks, F. B., and Ferrier, W.F.—Bull. No. 315, U.S. Geol. Surv., 1907, p. 449.
[3]Spence (deSchmid) H. S.—Bull. No. 12, Mines Branch, Ottawa, 1916.

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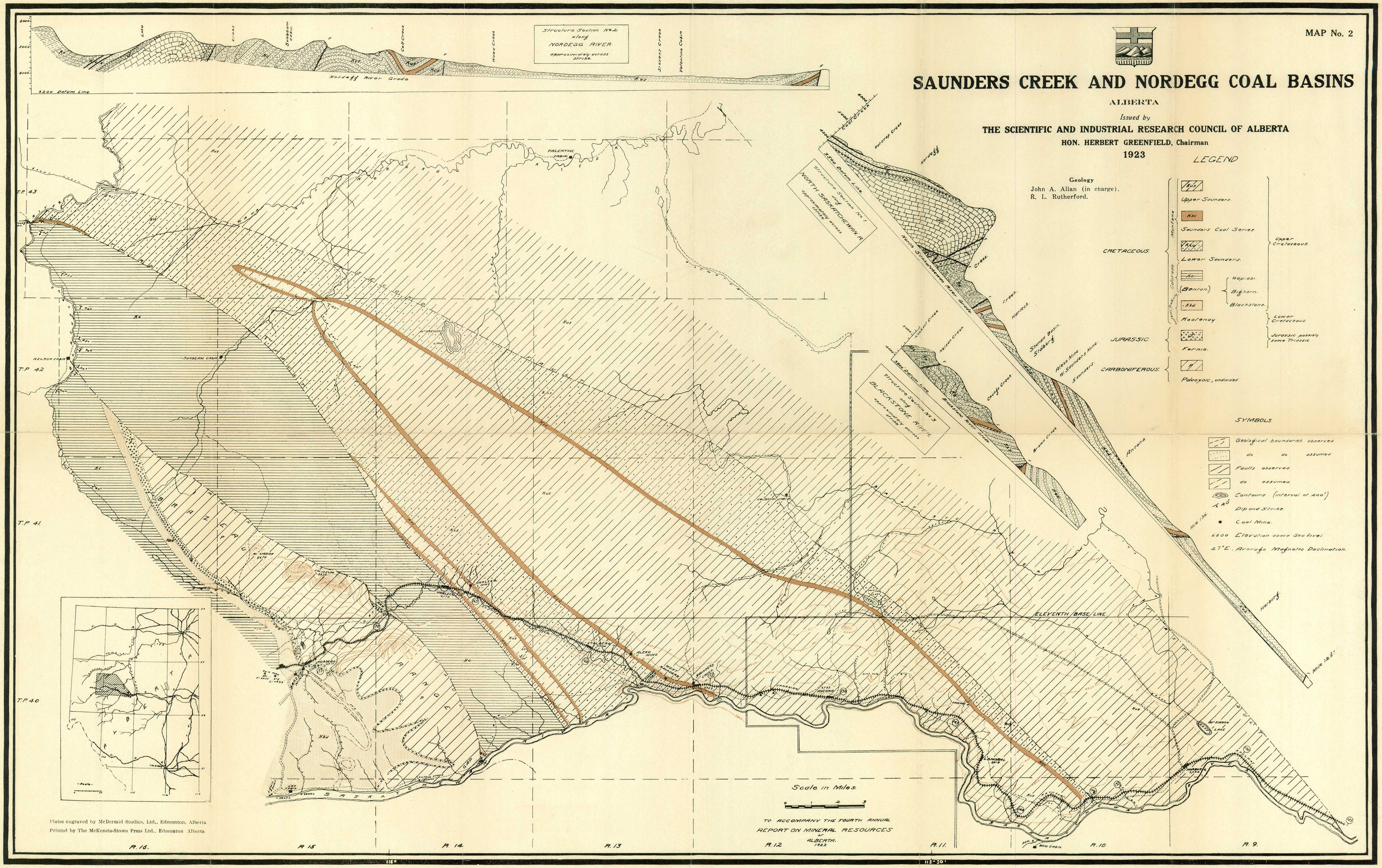
MAP No. 2
SAUNDERS CREEK AND NORDEGG COAL BASINS
ALBERTA
Issued by
THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA
HON. HERBERT GREENFIELD, Chairman
1923
Geology
John A. Allan (in charge).
R. L. Rutherford.
LEGEND
CRETACEOUS.
Upper Saunders.
Saunders Coal Series.
Lower Saunders.
Wapiabi.
Bighorn.
Blackstone.
Kootenay
Upper Cretaceous.
Lower Cretaceous.
JURASSIC.
Fernie.
Jurassic possibly some Triassic
CARBONIFEROUS.
Paleozoic, undivided.
SYMBOLS.
Geological boundaries observed
do do assumed
Faults observed
do assumed
Contours (interval of 200')
Dip and Strike.
Coal Mine.
6600 Elevation above Sea level.
27°E. Average Magnetic Declination.
Structure Section No. 2 along NORDEGG RIVER. approximately across strike.
Structure Section No. 3 along BLACKSTONE RIVER. approximately across strike
ELEVENTH BASE LINE.
Scale in Miles.
TO ACCOMPANY THE FOURTH ANNUAL REPORT ON MINERAL RESOURCES of ALBERTA. 1922
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