**PROVINCE OF ALBERTA**

*Research Council of Alberta* — *Report No.* 30

*University of Alberta, Edmonton, Alta.*

**GEOLOGICAL SURVEY DIVISION**

JOHN A. ALLAN, Director

# Geology of Central Alberta

BY

**JOHN A. ALLAN**

AND

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DEPARTMENT OF GEOLOGY
UNIVERSITY OF ALBERTA
EDMONTON, ALTA.
1934

## LETTER OF TRANSMITTAL

DR. ROBERT C. WALLACE,
*Director of Research,*
*Research Council of Alberta,*
University of Alberta,
Edmonton, Alberta.

SIR:—

I beg to submit herewith a map and report entitled "The Geology of Central Alberta" prepared in co-operation with Dr. R. L. Rutherford.

The report, general rather than detailed, has been prepared to accompany the geological map of Central Albrta, which covers an area of approximately 100,000 square miles lying between north latitudes 52°30′ and 56°20′. This geological map is on a scale of one inch to ten miles and is printed in ten colours. The map is designated as No. 15 and the report as No. 30 in the series issued by the Research Council of Alberta.

Much new geological information not previously published is shown on this map which includes many of the areas studied by the Geological Survey Division of the Research Council during the past fifteen years.

All of which is respectfully submitted,

JOHN A. ALLAN,
*Geologist.*

Department of Geology,
University of Alberta,
Edmonton, Alberta,
March 14th, 1934.

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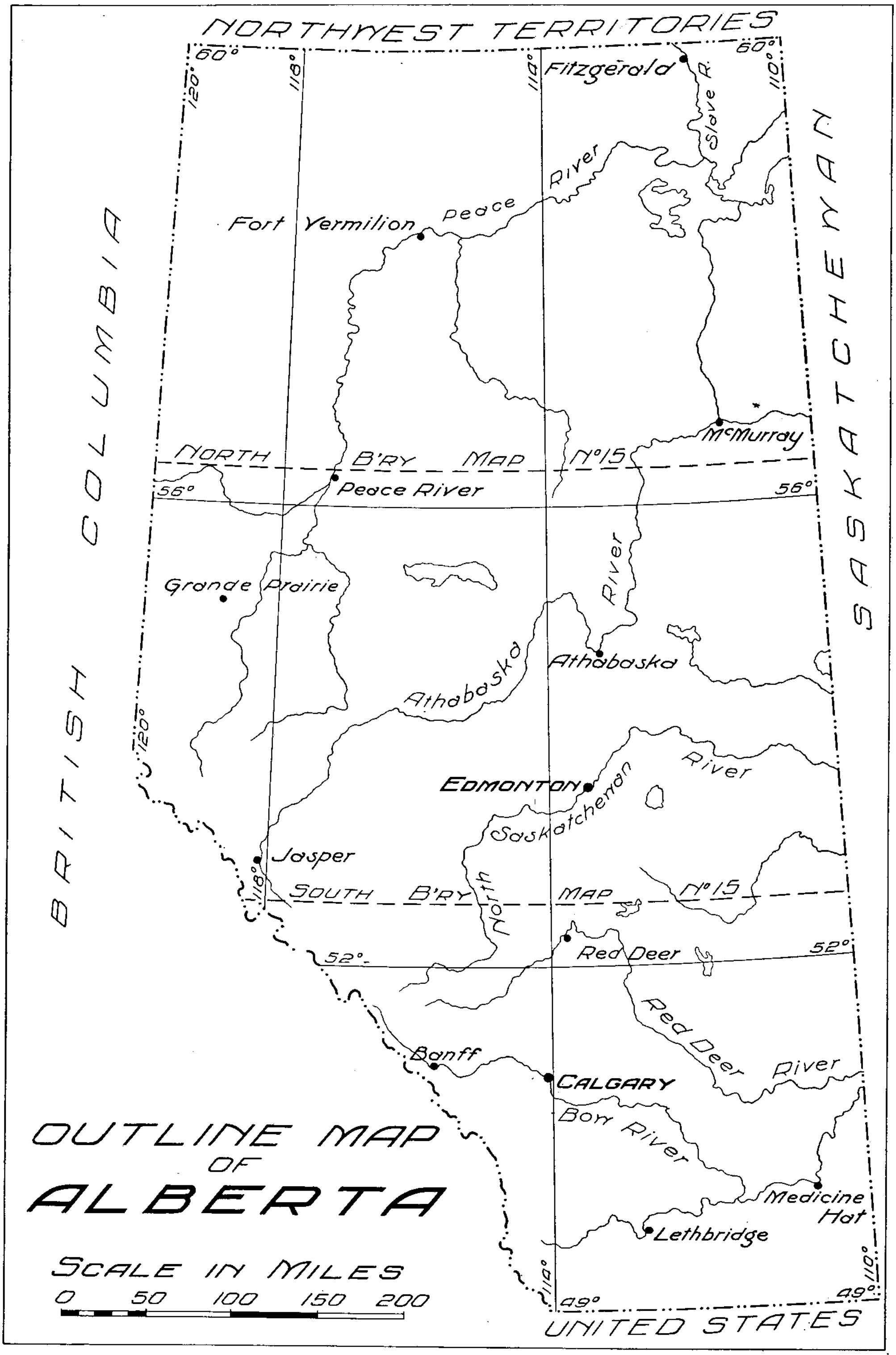


**Plate I.—Outline map of Alberta showing the north and south boundaries of geological map No. 15.**
**To accompany report No. 30, Research Council of Alberta.**

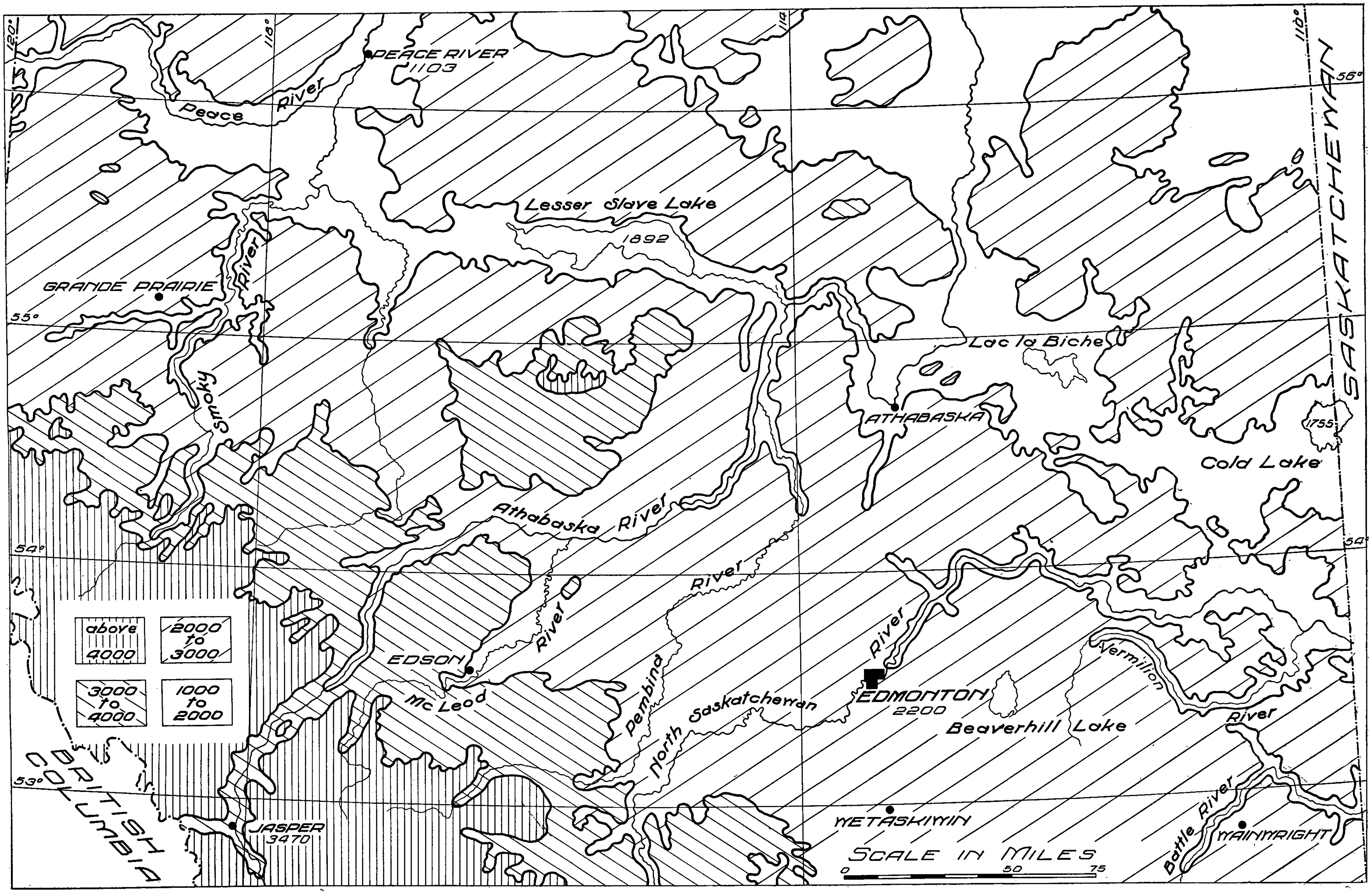


Plate II.—Relief map of central Alberta.

To accompany report No. 30, Research Council of Alberta.

# Geology of Central Alberta

BY

J. A. ALLAN AND R. L. RUTHERFORD.

## INTRODUCTION

During the past fifteen years the Geological Survey Division of the Research Council of Alberta has examined many parts of Alberta. Some of the investigations have been of a detailed nature on relatively small areas, others have been more general, and reconnaissance traverses have been made in areas reported on in detail by other organizations. One of the ultimate objects of this work has been to gradually assimilate the information in order that larger areas might be mapped in a general way. In 1925 the first geological map of Alberta was published. In preparing this map all available information was used and the positions of many of the geological boundaries were changed. This map is now out of print and a new edition will require several changes as a result of new information. The work done in the northern part of Alberta since 1925 has not added much information relative to the general distribution of the formations. Much new geological data on the central part of Alberta have been obtained since 1925, and although there are still relatively large districts that have not been examined in detail, the available data have been used in preparing the geological map of central Alberta which accompanies this report.

The writers have examined the greater part of the area with varying degrees of detail, and the geological information mapped and discussed is based largely on these observations. There are two general areas that have not been examined, namely, that along the Athabaska north of Calling river, and parts of the mountains and foothills along the headwaters of Smoky river. In addition there are some relatively inaccessible interstream areas that have not been studied, especially in the north central part and in some districts between Athabaska and Smoky rivers. It is believed, however, that an examination of these interstream areas on the plains would not add materially to our general knowledge of the distribution and character of the underlying formations, although such work might necessitate minor changes in the mapping.

In the following discussion use has been made of information contained in various reports dealing with areas where detailed work has been done. Many of these publications are cited, but no attempt has been made to compile a complete bibliography of the geology of central Alberta. Considerable geological data have been obtained within recent years in some parts on which very little has been published and in such cases the discussions have been made somewhat fuller than in dealing with districts on which there are detailed reports of relatively recent date.

Fossil material collected at various places has been determined and classified by P. S. Warren who, on occasions, has cooperated in the field examinations of some districts. We are indebted to B. F. Hake for information regarding the distribution of the Cretaceous formations in the foothills northwest of Smoky river.

## PREVIOUS MAPS

In 1925 the Geological Survey Division of the Research Council of Alberta published Map No. 10, a geological map of Alberta, compiled by J. A. Allan, on a scale of one inch to 25 miles. Previously, the geology of Alberta has been shown on general maps of the whole, or of the western parts of Canada prepared by the Geological Survey of Canada. The following are the latest editions of these maps:

Geological map of Canada. Scale 1 inch to 100 miles. Geological Survey of Canada, publication No. 1277, 1924.

Geological map of Alberta, Saskatchewan and Manitoba. Scale 1 inch to 35 miles. Geological Survey of Canada, Map 55A, 1913 and 1914.

The geology of the plains of central Alberta is shown on D. B. Dowling's map on the "Coal Areas of Alberta, Saskatchewan, and Manitoba." Scale 1 inch to 35 miles. Geological Survey of Canada, publication No. 1010, 1906.

The southeastern part of the plains of central Alberta is included on the geological map accompanying Tyrrell's report on northern Alberta, forming a part of the report of the Geological Survey of Canada for 1886.

The geological map (publication No. 1585) accompanying Memoir 108 (1919), Geological Survey of Canada on "The Mackenzie River Basin," shows the general distribution of the formations along the major stream valleys in the northern part of central Alberta.

In 1928 the Geological Survey of Canada issued a map covering the greater part of southern Alberta, designated as Map No. 204A, Calgary Sheet, scale 1 inch to 8 miles. This map shows the geological boundaries in more detail than previous maps of this part of Alberta.

## MAP NO. 15

This map is designated as No. 15 in the series issued by the Geological Survey division of the Research Council of Alberta. The area included on this map extends across the central part of Alberta lying between north latitudes 52 degrees 30 minutes, and 56 degrees 20 minutes approximately. The east boundary is longitude 110 degrees which is the interprovincial boundary between Alberta and Saskatchewan. The west boundary of Alberta follows the mountain watershed northwest to longiture 120 degrees which is the west boundary from this point north. Map No. 15 has been extended a short distance west of the 120 meridian to include a small part of British Columbia. The total length of Alberta lies between the 49th and 60th parallels of latitude and this map occupies about the central third of the province, or approximately 100,000 square miles. See Plate I.

The base for map No. 15 has been compiled from published geographical maps with the addition of information from recent surveys. About 75 per cent of the area included has been surveyed according to the system generally used in th prairie provinces; that is, into townships, ranges and sections, having east-west and north-south boundary lines. The base lines, meridians, range and township lines are shown as solid lines in surveyed areas, and as broken lines in unsurveyed areas on map No. 15. In some parts only the base lines and some meridians have been surveyed. Narrow belts have been surveyed along the valleys of the major streams or routes followed by railways. Some of the larger unsurveyed areas, especially in the plains, are inaccessible to ordinary means of travel. The mountains and foothills are, in general, traversed by means of a system of trails suitable for pack horses.

The topography of central Alberta has been mapped with varying degrees of detail. The more accurate maps are those made in recent years of districts in the southeastern part of the surveyed area and in a few localities in the foothills and mountains. The general topography of the other parts is known from various lines of levels obtained during the surveying of base lines, meridians, railway routes and river courses.

In preparing map No. 15 some of the geological formations have been grouped together, while others are shown separately. In some places it has not been possible to map the formations separately and in others the formations cannot be readily designated on a map of this scale. It is difficult to show the same detail in mapping the formational boundaries over the whole area, since in the eastern part the beds are nearly flat-lying, while in the mountains they are folded and faulted. Some formations that occupy a broad belt on the plains occur as narrow bands in the mountains and foothills, and it would require maps of different scales to show the same relative detail in the mountains and foothills as in the plains. The topography over parts of the area is known only in a general way, and the position of some of the geological boundaries are therefore approximate, as in some cases these have been projected in accordance with the topography.

The formational names used in the various districts shown on this map are tabulated on subsequent pages. An attempt has been made to tabulate the various formations or divisions in a manner to show general correlation by placing them in parallel positions in the respective columns. Separate correlation tables are used for the plains and for the mountains and foothills, because the formational names used on the plains have not, as a rule, been the same as those used in the foothills and mountains and the correlation between them has not been well established.

Precambrian strata occur along the western side of the province, but the field work has not been sufficient to determine the distribution of the formations of this age. Some early Palaeozoic strata have been mapped with the Precambrian since they occupy approximately the same areas. The Triassic and Jurassic systems are each represented by thin formations in the foothills and mountains. Their representation on a map of this scale cannot be readily shown and since their distribution corresponds approximately to that of the Palaeozoic in the outer mountains and foothills, they have been mapped with the Palaeozoic. A finer division has been made of the Cretaceous, especially on the plains where it has been possible to show most of the upper formations separately.

## GENERAL CHARACTER OF THE AREA

### PHYSIOGRAPHY

The area shown on the accompanying map includes three general physiographical types; namely, plains, foothills, and mountains. The mountains and foothills occupy a relatively small area since the interprovincial boundary between Alberta and British Columbia, which follows the continental watershed from the southern boundary of the province, leaves the mountains at the 120th meridian and follows a north-south line across the foothills and plains. The general slope is to the north and east with the divide between the Saskatchewan and the Mackenzie drainages crossing the south-eastern part of the map. The general relief of central Alberta is illustrated on Plate II which has been prepared from the topographical map of Alberta issued by the Topographical Survey of Canada. Contour intervals of 1,000 feet have been used in the preparation of this illustration.

#### PLAINS

The plains are part of that area generally referred to as "The Great Plains" or "Interior Plains" of Canada. The transition from plains to foothills is gradual and almost imperceptible, a convenient dividing point being at places where the underlying formations show recognizable dips to the east.

The surface features of the plains are due to several factors. The underlying surface formations are Cretaceous and Tertiary beds that are relatively soft and flat-lying or gently inclined. A prolonged period of erosion following Tertiary deposition left an undulating surface with relatively broad valleys and occasional erosion remnants forming relatively high areas such as the Swan Hills. This period of erosion was followed by glaciation. The deposits from glaciation covered most of the plains to varying depths and filled in many of the valleys and depressions. A subsequent period of erosion and deposition established the present drainage system which in part occupies some of the preglacial valleys and river courses. Glacial action tended to block the earlier drainages, and with the retreat of the ice a temporary drainage system was established. The prevailing direction of this temporary system was to the southeast approximately parallel to the general direction of the ice front on the plains. Since the final retreat of the ice the tendency has been to establish a general north and east drainage direction, and in many places the deserted valleys of an earlier system are still present.

Three large rivers and their tributaries rise in the mountains and foothills and flow across the plains. These are the North Saskatchewan, the Athabaska and the Peace. The Saskatchewan drains to Hudson Bay and the other two form part of the Mackenzie river system. These streams and their major tributaries all occupy well defined valleys in the plains.

The Saskatchewan valley between Edmonton and the foothills consists of a broad open upper valley and a relatively narrow lower valley about 150 to 200 feet deep. East of Edmonton the lower valley broadens and merges with the upper, forming a wide open valley. The general elevation of the interstream areas south of the Saskatchewan is approximately 3,000 feet along the west side of the plains and 2,200 feet along the east side.

The Athabaska valley is similar to that of the Saskatchewan. From the foothills to Whitecourt at the mouth of McLeod river its valley is like that of the Saskatchewan above Edmonton, and from Whitecourt to Smith, at the mouth of Lesser Slave river, it is broad and open like the Saskatchewan valley east of Edmonton. East and north from Smith the lower part of the valley becomes increasingly deeper and narrower.

The general elevation of the area between the Athabaska and the Saskatchwan is somewhat higher and more irregular along the west side of the plains than the corresponding area to the south of Saskatchewan river. Elevations of 3,000 to 3,600 feet prevail along the west side of the plains. To the northeast the average elevation ranges from 2,000 to 2,200 feet.

Peace river crosses the northwest corner of this map area. The valley is narrow and deep averaging 800 to 1,000 feet below the general level of the immediate plains which have an average elevation of about 2,000 feet. Its main tributary, the Smoky, is much like the Athabaska in its upper parts, but along the lower 50 miles it occupies a deep valley which meets the Peace at grade.

The plains between the Peace and the Athabaska contain some relatively high areas, the most notable being the Swan Hills south of Lesser Slave lake. These rise in place to elevations of over 4,300 feet, or more than 2,000 feet above the level of the lake. The north slope of these hills is relatively steep especially in the upper part, whereas the slope to the south towards the Athabaska is more gradual.

Marten and Pelican mountains to the north and east of Lesser Slave lake are similar to the Swan Hills except that they do not rise as high and do not have such steep slopes towards the top. Near the west side of the province, south of the Peace, apparently there has been less folding and faulting, and the foothills are not as pronounced as along the Athabaska and other streams to the southeast. Thus the western edge of the plains appears to be marked more by erosional forms than by folding, and some flat-topped uplands occur along the headwaters of the Wapiti at the west side of the plains.

There are numerous lakes on the plains of central Alberta. The greater number of these occupy small depressions, especially in the eastern part to the north of Saskatchewan river. Lesser Slave is the largest lake, being about 60 miles long and averaging about 10 miles in width. This and some of the other large lakes furnish a considerable annual production of fish, most of which is exported.

The plains of central Alberta are mostly wooded, and although in many parts this growth has been removed by agricultural development, there are large areas covered to varying degrees of density with forest or parkland vegetation. In southern Alberta the prairies extend west into the foothills. North of latitude 53 degrees, the boundary of the prairies has a northeast trend and crosses the southeast corner of this map-area in the vicinity of Wainwright. A belt of parkland or semi-wooded country, which usually lies adjacent to the prairies marking the transition to the wooded areas, also crosses the southeastern part of this area. This parkland belt occurs chiefly south of the Saskatchewan river. Open areas of parkland and prairie occur within the larger wooded areas. The best examples are those along the Peace and its tributaries, such as the Grande Prairie district.

Most of the settlement of central Alberta is confined to the parkland and open areas. The surveyed districts and the distribution of rural post offices, as shown on Map No. 15, indicate in a general way the extent and position of the open areas. Some parts of the plains have not been settled to any extent because of the wooded character, the thick cover of coarse glacial material and the elevation. The most heavily wooded parts are along the western side of the plains and in some of the outlying uplands such as the Swan Hills. These heavily wooded areas often contain patches of open country suitable for settlement, but the elevation is such that unseasonable frosts mitigate against the successful growing of grain crops. The heavily glaciated districts are those north of the Saskatchewan and east of the Athabaska rivers where deposits of boulder clay, gravel and sand are frequently too extensive to permit successful agricultural development on a large scale.

### FOOTHILLS AND MOUNTAINS

The foothills include features grading from gently sloping uplands along the east side to mountainous ranges along the west. The boundary between the foothills and mountains is more definite than that between the foothills and plains. The most easterly range containing the Palaeozoic rocks is commonly referred to as the eastern edge of the mountains, although outliers of Palaeozoics commonly occur in the foothills. The foothills and mountains are composed entirely of sedimentary rocks and the physiographical features bear a close relation to the lithological character of the formations and to the structural features resulting from faulting and folding. The general structural trend is to the northwest and the ranges of hills and mountains are in general parallel to the structural trend.

The headwaters of the major streams rise within the mountains. These streams cross the eastern ranges and foothills in well defined valleys that are in part antecedent, although in many places the valleys have been considerably modified by glacial action. The Athabaska has the most pronounced valley of this type in the area. Many of the tributary streams have a subsequent trend. There are no large lakes within the mountains and foothills, although some of the rivers are expanded into long, narrow lakes within the mountain valleys.

The average elevation along the east side of the foothills is between 3,000 and 3,600 feet, while ridge and hills from 6,000 to 7,000 feet high are common along the west. Elevations of 6,000 to 9,000 feet prevail along the tops of the eastern ranges of the mountains whereas elevations between 10,000 and 11,000 feet are more common near the interprovincial boundary on the west. Yellowhead pass, at an elevation of about 3,729 feet (the precise elevation of this pass is not given in the publications of the Geodetic Survey of Canada), represents the lowest point in the Continental Divide. Mount Robson, elevation 12,972 feet, the highest peak in the Canadian Rockies, is situated about three miles west of the Continental Divide north west of Yellowhead pass.

A large part of the mountains of this area is included in the national park known as Jasper Park. The west boundary of this park is the Continental Divide. The north and eastern boundary, as shown on the map, is an irregular line. The park extends for some distance south of this map-area, and although it forms a part of the province of Alberta, it is administered by the federal government of Canada.

The mountains to the north of Jasper Park and most of the foothills are included in forest reserves administered by the provincial government. These are timber and game reserves, although commercial development of mines and timber berths is permitted within them.

Most of the foothills and mountains are wooded with conifers, except in the higher ranges where the upper parts extend above timber line. Spruce is by far the most common tree, although pine and larch and some poplar occur in the outer foothills.

## STRUCTURAL FEATURES

The structure in each of the three physiographical divisions of central Alberta is somewhat different. The beds are almost flat-lying on the plains, but are folded and faulted in the foothills and mountains.

General geological maps including Alberta indicate a broad synclinal structure in the plains. This feature is more evident on maps of southern Alberta where the correlation between the stratigraphy of the plains and foothills has been more easily determined because of the shorter distance across the structure. This structure on the plains has sometimes been referred to as the *Alberta syncline*, although such a designation has been applied with different meanings.[1] In some cases it has been used with reference to post-depositional structure, and in others it refers to the geosyncline of deposition existing throughout most of the western part of Alberta in Cretaceous and Tertiary time, during which time the axis of the structure migrated in an eastward direction with the deposition of the succeeding formations. In the following discussion the term is used with reference to a structural feature defined mainly after the deposition of the youngest strata which are included in structure.

(1) Link, T. A., Bull. Am. Assoc. Pet. Geol., Vol. 15, 1931, p. 491.

The position of the axis of the Alberta syncline is not sharply defined because of the low angles of dip prevailing. It has a general north-south direction in southern Alberta and previous geological maps indicate that this trend prevailed to the north into Central Alberta. The accompanying map indicates an appreciable bend to a northwesterly direction. The change in direction is gradual, but appears to be greatest between latitudes 52 and 53 degrees.

Throughout most of the plains, the strata dip to the south and west forming the eastern limb of the broad synclinal structure. The inclination of the strata is on the average less than 20 feet to the mile, although locally there are minor structures superimposed on this east limb. The location of these have been important in the search for oil and gas in the plains.

The west limb is represented by a belt of easterly dipping strata which extend east from the foothills. The dip increases in a westerly direction from the axis and the western edge of this structure is placed where the beds show changes in dips due to more pronounced folding and faulting. The west limb is broad in the southern part of this map and is narrow to the northwest where the structure crosses into British Columbia.

The structural features of the foothills and mountains are more pronounced than those of the plains. The Rocky Mountains and adjacent foothills are the result of a period of uplift, folding, faulting and overthrusting known as "Laramide" or "Rocky Mountain" revolution which occurred during Cretaceous and early Tertiary time. The maximum effect of this deformation probably occurred in late Cretaceous or early Tertiary time, and there is evidence of activity as early as the Lower Cretaceous and of uplift in post-Pleistocene time.

The deformation in the foothills and mountains increases from east to west. Open folds with minor faulting prevail along the eastern foothills, while to the west the faulting and folding increases in intensity, bringing to the surface lower strata. The structural units also increase in size to the west and faulting and overthrusting become more pronounced. The net result is a series of subparallel units in the form of folds and fault blocks with a northwest trend.

Relatively soft and incompetent Upper Cretaceous beds prevail in the folded areas along the eastern foothills. In the western foothills older Mesozoic strata are more common. Upper Palaeozoic strata predominate in the eastern ranges of the mountains whereas to the west the more competent and massive Palaeozoic and Precambrian formations prevail.

## GLACIAL AND RECENT DEPOSITS

Glaciation during Pleistocene time was the latest major geological event in central Alberta. This was preceded by a period of erosion and deposition which determined the general contour of much of the present surface. Erosion and deposition following glaciation have, to some extent, modified the surface left by glaciation. The result of these events is represented by a mantle of unconsolidated deposits over much of the plains and the lower parts within the foothills and mountains.

Glaciation of Alberta was caused by ice sheets moving from two main centers, namely, the mountains on the west and the present lowlands to the northeast on the Canadian Shield. That from the mountains is usually referred to as Cordilleran ice-sheet and that from the northeast as the Keewatin ice-sheet. The glacial history of Alberta has not been worked out in sufficient detail to determine whether the glaciation from these two centers occurred simultaneously or at slightly different times. Coleman, from studies in southern Alberta, believed that the Rocky Mountain glaciation preceded that from the northeast, although it did not advance very far east of the foothills.(2)

The deposits left by the Cordilleran ice-sheet have been subjected to post-glacial erosion, transportation and redeposition by active mountain streams and in most places they do not afford reliable data relative to this problem. It is difficult in most cases to determine whether the unconsolidated deposits in the mountains and foothills are of preglacial, glacial or post-glacial age. The deposits from the Keewatin center have not been subjected to such active post-glacial erosion as those from the mountains, and are more readily determined as distinct glacial deposits.

The boundary between the deposits from the two ice-sheets is not sharply defined, but its general position crosses this area along the western side of the plains. The trend of this boundary is northwest, but slightly less inclined to the west of north than the trend of the foothills and mountains.

The unconsolidated material on the plains is composed of three types and the deposits from the keewatin ice-sheet are the most pronounced of the three. Recent river and lake deposits of post-glacial deposition form the second type and the third is represented by some gravels and sands that appear to be possibly preglacial in age.

There is no definite evidence of more than one general advance and retreat of the ice over the plains at this part of Alberta, and the suggestion is that those advances and retreats recorded in the deposits from the southern extension of this ice-sheet were not represented by interglacial periods in central Alberta.

The deposits of probably preglacial time are represented by gravels and sands underlying glacial material. The period of erosion prior to glaciation was probably represented by some deposition and it is inferred that such deposits that might accumulate in the lower places would be more likely to be preserved from glacial and subsequent erosion. These should not contain material derived from the areas of Precambrian rock which underlie the Keewatin ice-center. Such deposits are found along the valleys of some of the major streams.

(2) Coleman, A. P., Trans. Roy. Soc. Canada, Vol. III, 1909, Sec. IV, p. 3.

Early workers noted the occurrence of gravel and sand, free from pieces of Precambrian rock, overlying the consolidated formations and beneath the glacial material, in various parts of the plains of western Canada.[3] Tyrrell first recorded these beds along North Saskatchewan river where they were later mentioned by Dawson[4] and Coleman.[5] D. A. Taylor, who has recently made a study of the geology in the vicinity of Edmonton, records a maximum thickness of 16 feet of sands and gravels in which he finds no trace of any Keewatin drift.[6] The writers have examined the Edmonton district and have verified the observations recorded by Taylor. Similar deposits occur in the valley of the Peace and its tributaries.[7] Aside from their stratigraphical interest they may have special bearing on the occurrence of the placer gold in river gravels. These beds, commonly known as "Saskatchewan gravels," were first described by McConnell, who named them the "South Saskatchewan gravels" and interpreted them to be derived from the Miocene beds occurring in the Cypress Hills of southern Alberta and Saskatchewan. Dawson and Coleman believed that these beds were derived from the glacial deposits of the Cordilleran ice-sheet which they thought had preceded the Keewatin ice-sheet glaciation.

Probably there are deposits of this type of more than one age, especially in the mountains and foothills. Some of the terraced gravels along the large valleys in the mountains are undoubtedly derived from material carried by the Cordilleran ice-sheet. The gravels referred to by Dowling as being Saskatchewan gravels in Athabaska valley in the eastern ranges of the mountains are not the same as those found beneath the glacial deposits on the plains.[8]

The glacial deposits from the Keewatin ice, consisting of boulder clay and some semi-stratified silts and clays, cover much of the plains areas of central Alberta. Boulder clays prevail in the interstream areas whereas the sorted material is more common along the valleys and depressions. The boulders are mostly Precambrian quartzites, gneisses and schists, with occasional blocks of Palaeozoic and Cretaceous rocks. The greater volume of the coarse material was derived from the general center of the ice-sheet and during movement to the south some of the surface material from the plains was incorporated. The larger boulders are from 5 to 6 feet in greatest dimension, but smaller sizes are more common.

The thickness of the drift varies considerably and is seldom more than 100 feet in the interstream areas and more often between 25 and 50 feet. Some parts are free from glacial material and others have a few miscellaneous boulders scattered over the surface. Some observations indicate that the deposits are usually thin where they are coarse or contain large sized boulders.

In some districts the deposits are quite extensive and have influenced the surface features to a marked degree. The area north

(3) McConnell, R. G., Geol. Surv. Canada, Ann. Rept. Vol. I, 1885, pt. C, p. 70.
Dawson, G. M., and McConnell, R. G., Bull. Geol. Soc. Can., Vol. 7, 1896, p. 31.
Tyrrell, J. B., Geol. Surv. Canada, Ann. Rept. Vol. II, 1886, Pt. E, p. 139.
(4) Dawson, G. M., Geol. Surv. Canada, Ann. Rept. Vol. XI, 1898, Pt. A, p. 14.
(5) Coleman, A. P., Trans. Roy. Soc. Canada, Vol. III, Sec. IV, 1909, p. 7.
(6) Thesis, M. Sc., 1934, Library, University of Alberta, Edmonton, Alta.
(7) Rutherford, R. L., Res. Coun. Alberta, Rept. No. 21, 1930, p. 34.
(8) Dowling, D. B., Geol. Surv. Canada, Sum. Rept. 1911, p. 203.

of Saskatchewan river and to the east of Edmonton is of this type. Here there are myriads of small lakes as shown on the map in the surveyed districts. These lakes are small, poorly drained and rest in small depressions in the impervious boulder clay. Similar conditions are common along the Athabaska, especially to the north of the mouth of Pembina river.

The prevalence of boulder clays over some large districts has been a factor preventing agricultural development. The proximity and number of rural post offices in districts within reach of transportation in the surveyed areas are indications of the settlement within such parts. Likewise the paucity of such rural centers indicates the general lack of settlement which is also, to some extent, an indication of the distribution of the coarser glacial material.

The deposits usually referred to as recent, consist of river-terrace gravels, sands, silts, and some poorly stratified lacustrine beds. There is evidence of considerable impounding of the waters during the ice retreat and many depressions are filled with lake deposits. Some of the existing lakes are remnants of larger post-glacial water bodies that have been reduced in size through alluviation, drainage or decrease in water supply.

The recent deposits have been derived chiefly from glacial material and bedrock. The soil conditions in many parts are directly related to the character and extent of the recent deposits, especially those of the lacustrine type which are more extensively developed in the vicinity of large streams that occupy preglacial valleys and depressions.

The deposits from the Cordilleran ice-sheet within the mountains and foothills, have been subjected to active stream erosion since glaciation and have been modified considerably since deposition. At present they are represented chiefly by extensive terraces along the valleys of streams which have eroded their channels through these deposits to the underlying bedrock. Thus a large amount of the glacial material has been reworked to form recent deposits. Extensive broad terraces indicating the impounding of water following glaciation are well developed along the major valleys at their exits from the mountains and foothills. The terrace deposits in places have become partly indurated to form a conglomerate through cementation by carbonate from circulating ground waters. Some of this glacial material has been transported to the plains and mixed with other material forming the recent river terraces and flood plains.

Since this glacial material is confined largely to valleys into which it has been concentrated to some extent by post glacial erosion, it does not affect the general surface aspect of the foothills and mountains to the same extent as does the Keewatin drift on the plains. The more pronounced physiographical effect of the Cordilleran glaciation is the shape, size, and in some instances, the direction of the larger valleys along which the ice travelled. For example the contour of Athabaska valley within the eastern mountain ranges bears distinct evidence of intense glacial erosion.

## CORRELATION TABLE FOR PLAINS OF CENTRAL ALBERTA

| MAP LEGEND | TIME DIVISION | Vermilion—Wainwright | Viking District | N. Saskatchewan River | Athabaska River | Swan Hills—Lesser Slave Lake | Peace River |
|---|---|---|---|---|---|---|---|
| | Quaternary | | | | | | |
| LATER TERTIARY | | | | | | | |
| PASKAPOO | Tertiary | | | | | PASKAPOO* | |
| EDMONTON | | | | Edmonton | | Edmonton | |
| BEARPAW | | | Pierre shale<br>Bulwark ss.<br>Pierre shale | Bearpaw<br>(not observed) | | Bearpaw<br>(not observed) | |
| BELLY RIVER | Upper<br>Cretaceous | Pale beds<br>Variegated beds<br>Birch lake<br>Grizzly bear<br>Ribstone creek | Pale beds<br>Variegated beds<br>Birch lake<br>Grizzly bear<br>Ribstone creek | Myrtle creek<br>Pakan<br>Victoria<br>Shandro<br>Brosseau | | SAWRIDGE | WAPITI |
| LOWER UPPER CRETACEOUS | | Lea Park | Lea Park | Lea Park | La Biche<br>Pelican ss. | Upper La Biche | Upper Smoky R.<br>Bad Heart<br>Lower Smoky R.<br>Dunvegan |
| LOWER CRETACEOUS | Lower<br>Cretaceous | | | | Pelican sh.<br>Grand Rapids<br>Clearwater<br>McMurray | | St. John<br>Peace River<br>Loon river |
| Not exposed on plains included on Map No. 15 | Palaeozoic | | | | DEVONIAN | | DEVONIAN |
| | | Hume, G. S., Geol. Surv. Can., Sum. Rept. 1924, pt. B., p. 3. | Slipper, S. E., Geol. Surv. Can., Sum. Rept. 1917, pt. C., p. 8. | Allan, J. A., Geol. Surv. Can., Sum. Rept. 1917, pt. C., p. 11. | McLearn, F. H., Geol. Surv. Can., Sum. Rept. 1916, p. 146. | Allan, J. A., Geol. Surv. Can., Sum. Rept. 1918, pt. C., p. 10. | McLearn, F. H., Geol. Surv. Can., Sum. Rept. 1918, pt. C., p. 2. |

*Names shown in capitals indicate that all the formations represented in the corresponding map legend divisions are included.

# DESCRIPTION AND DISTRIBUTION OF THE FORMATIONS

## PLAINS AREA

Upper Cretaceous and early Tertiary beds underlie most of the surface of the plains. The upper formations of the Lower Cretaceous occur along the major river valleys in the north, although to the north of this map-area the lower members are present. Some late Tertiary beds occur in the upper parts of the Swan Hills. The formational names that have been used in different districts are tabulated above and an attempt has been made in this tabulation to indicate our present knowledge of the correlation of these formations. The younger formations are mapped separately whereas several of the older ones have been grouped together. The mapping divisions used in the plains include fewer formations in most instances than those in the foothills and mountains. The formations mapped as lower Upper Cretaceous in the plains correspond in general to those included under the same name in the foothills.

In the following discussion the formations are described in ascending order from the southeastern districts across the map to the north and west. Summaries and references to the reports dealing with the description and distribution of the formations are given for each formation or group shown on the accompanying map.

### LOWER CRETACEOUS

SOUTHEASTERN DISTRICTS.

Hume, G. S., Oil and Gas in Western Canada, Second Edition, Geol. Surv. Canada, Economic Geol. Series, No. 5, 1933, p. 188.

*Sandstone and shale*—not exposed at the surface but recorded from well drilling. Approximate thickness 150 to 570 feet. Age uncertain.

ATHABASKA RIVER DISTRICTS.

McLearn, F. H., Geol. Surv. Canada, Sum. Rept. 1916, p. 146.

*Pelican shale*—black marine shale, arenaceous towards the top. Thickness 90 feet.

*Grand Rapids formation*—mostly sandstone—lower part marine and concretionary—upper part subaerial and contains some thin coal seams. Thickness 280 feet.

*Clearwater formation*—soft grey and black shales, grey and green sandstone with concretionary layers—marine. Thickness 275 feet. Only the upper part exposed in this map area.

*McMurray formation*—mostly sandstone and some shale layers and conglomerates. Parts impregnated with bitumen. Subaerial. Thickness 110 to 180 feet. Not exposed in this area but encountered in well drilling.

PEACE RIVER DISTRICTS.

McLearn, F. H., Geol. Surv. Canada, Sum. Rept. 1917, pt. C., p. 14, and 1918, pt. C., p. 1.

Rutherford, R. L., Research Council, Alta., Rept. No. 21, 1930.

*St. John formation*—dark grey to black shales with some clay ironstone bands and concretions—marine. Thickness 550 to 600 feet at Peace River—thickens to the west.

*Peace River formation*—

Upper sandstone—massive, crossbedded, marine and freshwater. 130 feet thick but thins to the north.

Middle shale—dark colored, probably marine—30 feet thick—exposed north of this area.

Lower sandstone—massive and crossbedded at the top—interbedded with shale at the bottom—in part marine. Exposed to the north of this area where it is 160 feet thick.

*Loon River formation*—dark colored marine shale. Exposed to north of this area. 1,100 feet thick and somewhat arenaceous in drill records at Peace River.

Formations with appreciable thicknesses have a wide distribution on the plains, due to physiography and structure. The Lower Cretaceous formations occur along the major stream valleys in the northern part of this map-area and further north they underlie relatively large interstream areas. Lower Cretaceous strata overlie the Palaeozoic limestones along the Peace and Athabaska north of the area, and drilling records indicate a similar relationship along North Saskatchewan river and adjacent districts. The age of the limestones on the Athabaska and North Saskatchewan rivers has been determined as lower Upper Devonian by Warren,[9] although Hume records 155 feet of Mississippian strata in the log of the Duvernay well on Saskatchewan river.[10]

The Lower Cretaceous consists of shale and arenaceous formations of marine deposition although some of the arenaceous members grade laterally into subaerial types. There is considerable lateral variation in the lithological character and thickness of the formations as revealed by exposures in the stream valleys and from drill records in the intervening parts. The correlation between widely separated sections has been made largely on palaeontological evidence and lithological sequence.

Data from exposures and drilling records indicate a general thickening of the Lower Cretaceous in a northwesterly direction. Drilling data from areas along Saskatchewan river indicate a thickness of 150 to 570 feet of strata that may be of Lower Cretaceous age. The section along the Athabaska totals about 800 feet, but this is a composite section made from widely separated outcrops. Recent drilling near the town of Athabaska shows less than 700 feet of beds of Lower Cretaceous age. Similar records near the east end of Lesser Slave lake show about 800 feet, whereas drilling near Peace River indicates about 2,000 feet. The records of drilling in the Pouce Coupe district near the west side of Alberta are not readily interpreted, but it appears that the Lower Cretaceous is here over 2,500 feet thick. Further west in British Columbia the Lower Cretaceous is known to be much thicker.[11]

There are several well defined formations in the Lower Cretaceous succession on Peace river. These are represented by thinner formations on the Athabaska, and in the southeastern part of the area, drilling records indicate a still thinner arenaceous series as the possible equivalent of the Lower Cretaceous formations occurring on the Peace and Athabaska.

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(9) Warren, P. S., Can. Field Naturalist, Vol. XLVII, 1933, p. 148.
(10) Hume, G. S., Geol. Surv. Canada, Ec. Geol. Series, No. 5, 1933, p. 228.
(11) McLearn, F. H., Geol. Surv. Can., Sum. Rept. 1922, Pt. B, p. 3.

The exact stratigraphical position of the top of the Lower Cretaceous has not been definitely determined, but palaeontological evidence thus far obtained indicates that it occurs approximately at the top of the St. John shale on the Peace and the Pelican shale on the Athabaska. Since these stratigraphical positions occur at recognizable lithological boundaries, they have been used in the mapping as the division between the Lower and Upper Cretaceous.

The St. John shale and the upper Peace River beds are exposed in the general vicinity of Peace River, whereas only the upper part of the St. John is exposed along the Peace towards the western side of Alberta and in the eastern part of British Columbia.

The Pelican shale, the Grand Rapids sandstone and part of the Clearwater formation are exposed along the Athabaska. A small area has been shown as Lower Cretaceous along Christina river in the northeast corner of the map. There are no recorded exposures on this part of the Christina, but from data obtained on this stream a short distance to the north of the map boundary it is probable that the Lower Cretaceous extends up this valley to the approximate position as mapped.

## LOWER UPPER CRETACEOUS

SOUTHEASTERN DISTRICTS.

Allan, J. A., Geol. Surv., Can., Sum. Rept. 1917, pt. C., p. 9.

Slipper, S. E., Geol. Surv., Can., Sum. Rept. 1917, pt. C., p. 6.

Hume, G. S., Geol. Surv., Can., Sum. Rept. 1924, pt. B., p. 1.

*Lea Park formation*—dark to black colored shales with some nodular bands. Thickness up to 700 feet. Underlain by black marine shales of Upper Cretaceous age.

ATHABASKA RIVER.

McLearn, F. H., Geol. Surv. Can., Sum. Rept. 1916, p. 145.

*La Biche formation*—dark colored shale with some concretions at various horizons. Thickness over 1,100 feet.

*Pelican sandstone*—crossbedded sandstone, conglomeratic at the top—marine to freshwater. Thickness 35 feet.

PEACE RIVER.

McLearn, F. H., Geol. Surv. Can., Sum. Rept. 1918, pt. C., p. 1.

McLearn, F. H., Geol. Surv. Can., Sum Rept. 1917, pt. C., p. 14.

Rutherford, R. L., Research Council, Alberta, Rept. 21, 1930.

*Smoky River formation.*

Upper shale—dark colored marine shales with numerous ironstone concretions. Thickness about 300 feet—thins to the west.

Bad Heart sandstone—red weathering—marine. Thickness 10 to 25 feet.

Lower shale—dark colored marine shale. Thickness 600 feet.

*Dunvegan formation*—massive crossbedded sandstone with some interbedded shale. Some thin coal seams—subaerial to brackish. Thickness 450 to 550 feet.

The strata here assigned to the lower Upper Cretaceous are mostly marine shales which have a wide distribution in the northern and eastern part of the map-area. Arenaceous formations, mostly of marine or brackish water deposition, such as the Dunvegan and the Pelican sandstone, are included.

Marine shales underlie the greater part of the area here mapped as lower Upper Cretaceous. The thickness of these shales averages 1,200 to 1,500 feet in the eastern part and about 900 feet in the Peace river districts. The arenaceous Upper Cretaceous formations underlying these marine shales occupy narrow areas along the Peace and Athabaska rivers and their tributaries.

The base of the Upper Cretaceous has been placed at the base of the Dunvegan formation on the Peace and the Pelican sandstone on the Athabaska. Palaeontological data thus far obtained have not been sufficient to determine the exact stratigraphical position of the boundary between the Upper and Lower Cretaceous, but such data as known indicate the approximate position to be at the lithological boundary here used.

The most persistent lithological feature of the lower part of the Upper Cretaceous is the relatively thick marine shale formation known as the *La Biche* on the Athabaska and the *Smoky River* on the Peace. The greater part of this formation is of Colorado age, but the upper part is of Montana age (Lower Pierre). There is no readily recognizable lithological difference between the upper and the lower parts of the marine shale formation, and it is not possible to use the palaeontological division as a mapping basis.

Somewhat similar conditions occur in the foothills to the west and in southern Alberta. The Colorado sea had a wide distribution extending across the plains into the foothills and mountains. Similarly in Lower Pierre (Montana) time the sea covered the plains and extended into the foothills on the west, but is represented by a thinner series of marine shales than those representing the Colorado sea.

In 1929 Hume(12) proposed the name *Alberta shale* as a series name for the lower Upper Cretaceous marine shales occurring in the Turner Valley and adjacent districts of southern Alberta. The Alberta shale includes the thick series of marine shales of Colorado age and the overlying similar beds of Lower Pierre age. These had been commonly referred to as the "Benton," which in the original locality in western United States did not include beds of Montana age, nor the Niobrara strata which are of upper Colorado age.

In the eastern plains of this map-area, the Lower Pierre is represented by marine shales known as the *Lea Park* formation, which overlie the thicker series of marine shales of Colorado age. The upper Smoky River shale on the Peace, and the upper part of the La Biche on the Athabaska are considered to be the equivalent of the Lea Park formation. The Lea Park shale, or its equivalent, thins in a westerly direction, and the upper limit of these marine beds may occupy somewhat different stratigraphical positions in the plains and in the foothills, the general conclusion being that the top of the Lea Park occurs at a higher stratigraphical position than does the top of the marine shales in the foothills. For this reason it does not seem advisable at the present time to use the term "Alberta shale" on the plains. Hume, who defined the term, does not include all of the Lea Park formation in the Alberta shale.(13)

(12) Hume, G. S., Geol. Surv. Canada, Sum. Rept. 1929, Pt. B, p. 6.
(13) Hume, G. S., Geol. Surv. Canada, Ec. Geol. Series, No. 5, 1933, p. 188.

The top of the lower Upper Cretaceous shale beds is marked by a lithological change to the Belly River series of sandstone and shale of freshwater deposition. This lithological change is one of the most persistent features of the succession in the plains. It has been used as a mapping boundary and is discussed in some detail.

The boundary between the marine shales and the overlying Belly River strata is exposed at several points along the Saskatchewan and its tributaries. Allan(14) recorded it in township 55, range 8, on the Saskatchewan river, and Hume mapped it on the Vermilion river a short distance above its mouth.(15) It is exposed on a small creek in township 57, range 7, west of Elk Point, where the railway levels establish the elevation of the boundary as 1,980 feet. Using the data from these three separated points the geological boundary has been projected to the east side of Alberta.

Three small areas along the north side of Saskatchewan river east of Elk Point are shown as underlain by Belly River beds. This district is heavily covered with glacial drift, but from the topography and the known approximate elevation of the base of the Belly River beds near here, the Belly River beds must occur in the areas as shown unless the glacial deposits are 400 to 500 feet thick.

A hill rising about 400 feet above the general level of the surrounding district in the north central part of township 59, range 8, northeast of St. Paul, is believed to be capped by Belly River sandstones. Since the general slope of the surface is to the north it does not seem likely that outliers capped by Belly River beds could occur to the north of the boundary as mapped. From this hill to Cold lake there is a heavy overburden of glacial drift and the only exposure of bedrock is the La Biche shales that outcrop on the south shore of Cold lake in township 63, range 1, near Cold Lake village.

The position of the boundary along the south side of the Saskatchewan river is approximate. There are numerous old river channels here and these are covered with glacial and recent deposits.

Northwest from Saskatchewan river and St. Paul districts the best sections are exposed near the town of Athabaska. The transition from the Upper Cretaceous marine shales to the Belly River is well exposed on a small tributary known as Muskeg creek in the southeast corner of township 66, range 23. There are no exposures in the Tawatinaw valley in townships 63 and 64, range 23, but the contact should cross approximately as shown, based on physiography and general elevations. There are several exposures of basal Belly River beds in the district between Colinton and Boyle and the boundary as mapped in townships 64 and 65, ranges 19 to 22 inclusive, is fairly accurate.

From Boyle east to the St. Paul district the position of the boundary is assumed, and based on the general physiography of the district. Glacial and recent deposits conceal the bedrock along

(14) Allan, J. A., Geol. Surv. Canada, Sum. Rept. 1917, Pt. C, p. 12.
(15) Hume, G. S., Geol. Surv. Canada, Sum. Rept. 1924, Pt. B, Map. 2058.

Beaver river between ranges 1 and 13, and are prevalent throughout the district between Boyle and St. Paul, especially in the vicinity of Ashmont. The average slope to the north is such that it is not likely that there are isolated areas underlain by Belly River beds north of the position of the boundary as shown.

West of the town of Athabaska the approximate position of the boundary can be traced through range 23, but there are no exposures from this point west to the Athabaska valley, nor along Athabaska river, between Smith and the mouth of Pembina river. Highway excavations have exposed La Biche shales on the river bank at Smith, and Belly River beds outcrop on the Pembina in townships 65 and 66, but there are no exposures between these two places. Consequently, the position of the boundary on the Athabaska is somewhat indefinite and has been determined largely from physiography and elevations.

A small area in the central part of township 68, range 24, is shown as capped by Belly River beds because of the elevation at this point. A somewhat larger area is shown on the north side of the river southwest of Calling lake. The mapping of this outlier is based on elevations shown on topographical sheets, and if these elevations are approximately correct the marine shales should be capped by Belly River beds, unless the glacial deposits are unusually thick.

The boundary is shown as assumed from Athabaska river west to the vicinity of Lesser Slave lake. Traverses have not been made in this district, which is heavily wooded and swampy. The marine shales are exposed in excavations along the highway, following the north side of Lesser Slave river between Smith and Lesser Slave lake, and lower Belly River beds are exposed on Sawridge river in the north part of township 72, range 6. The contact of the Belly River with the marine shales is here interpreted to be near Lesser Slave lake and at an elevation above that of the lake. There are some eroded exposures on the Northern Alberta Railway grade along the shore of the lake in ranges 7 and 8 where the boundary has been mapped close to the south shore of the lake. These appear to be the transition beds between the marine shales and the Belly River.

A comparatively large area east of Lesser Slave lake, occupied by Marten and Pelican mountains, is shown to be underlain by Belly River. The position of the boundary at the top of the marine shale is assumed and mapped almost entirely on the general physiography of the district.

The boundary is shown to swing south along the central part of the lake, due to the deltaic deposits built up by the Swan and Driftpile rivers. A few small exposures occur along the railway and highway in range 13.

The district between the west end of Lesser Slave lake and Smoky river is heavily wooded and the boundary is shown as assumed, except on the Little Smoky where the exposures are sufficient to indicate its approximate position. The contact is well exposed on Smoky river.

The boundary as shown from the 6th meridian west to range 8 is taken from the map accompanying a report on this district.(16) From range 8 west to the Rolla and Pouce Coupe districts the position has been determined in relation to the general physiography, but in the eastern districts of British Columbia and along the west side of Alberta sufficient data have been obtained to show the approximate boundary.

In summary it may be said that although the exposures of the contact between the marine shales and the overlying Belly River beds are on the whole few, they are spaced in such a manner as to warrant a reasonably accurate projection of the boundary across the entire width of this map which represents a distance of about 450 miles. This geological boundary is here discussed in detail because it represents one of the most determinable lithological breaks in the succession in the plains and has a wide lateral continuity. This break extends into the foothills and mountains where it occurs at approximately the same stratigraphical horizon, and may be used as one of the main geological boundaries. This contact occurs at about the same elevation, namely, 1,800 to 2,000 feet, where it crosses pronounced valleys or rivers in the plains of this area.

## BELLY RIVER SERIES

SOUTHEASTERN DISTRICTS.

Allan, J. A., Geol. Surv. Can., Sum. Rept. 1917, pt. C., p. 9.
Slipper, S. E., Geol. Surv. Can., Sum. Rept. 1917, pt. C., p. 6.
Hume, G. S., Geol. Surv. Can., Sum. Rept. 1924, pt. B., p. 1.
Rutherford, R. L., Res. Counc. Alberta, Rept. No. 24, 1928, p. 37.

Slipper and Allan working simultaneously in adjacent districts assigned different names to the formations comprising the Belly River series. Hume at a later date restudied the area examined by Slipper.

| North Saskatchewan river. | Viking district. | Wainwright-Vermilion. |
|---|---|---|
| 1. *Myrtle creek*.....425 ft. | *Pale beds* ..............500 ft. | *Pale beds*....................500 ft. |
| 2. *Pakan* ....................225 ft. | *Variegated* ..........200 ft. | *Variegated* ..........200 ft. |
| 3. *Victoria ss.* ... 95 ft. | *Birch L. ss.*......60-100 ft. | *Birch L.* ...........60-100 ft. |
| 4. *Shandro sh.*......... 70 ft. | *Grizzly Bear*...40-100 ft. | *Grizzly Bear*.. 40-100 ft. |
| 5. *Brosseau* ..............325 ft. | *Ribstone Cr.*........225 ft. | *Ribstone Cr.*...........325 ft. |

1. Pale colored sandstones, arenaceous shales and clays—thin coal seams—freshwater.
2. Interbedded sandstones and shales of various volors—thin coal seams—fresh to brackish water.
3. Massive buff-colored sandstones with layers of hard phases—fresh to brackish water.
4. Dark grey shales with calcareous and sandstone nodules—marine.
5. Massive soft sandstones and carbonaceous shales—thin coal seams near the top—grey sandstones near the base—fresh to brackish water.

(16) Research Council of Alberta, Rept. No. 21, 1930.

PEACE RIVER AND ATHABASKA DISTRICTS.

Allan, J. A., Geol. Surv. Can., Sum Rept. 1918, pt. C., p. 7.

McLearn, F. H., Geol. Surv. Can., Sum. Rept. 1918, pt. C., p. 1.

Rutherford, R. L., Res. Coun. Alta., Rept. No. 21, 1930, p. 30.

*Sawridge formation*—name suggested by Allan for the Belly River series in the Swan Hills district. Only part of the series is exposed.

*Wapiti formation*—This name has been used for the Belly River and possibly some younger beds in the Peace River districts. It is composed of a series of sandstones, shales and clays of freshwater deposition and is about 1,100 feet thick.

A belt extending from east to west across the map is shown as underlain by beds designated as Belly River. In the southeast and along Battle river south of the boundary of this map, the top of the Belly River series is placed at the transition to marine shales known as the Bearpaw formation. This transition forms a convenient dividing line for mapping purposes, but the Bearpaw does not have a wide distribution in this map-area.

The term Belly River as a series or a formational name has been used with different meanings in various districts. Recently, the Geological Survey of Canada have restricted the use of the term *Belly River* in the plains of southern Alberta to include only certain formations, and have excluded some formations of Upper Cretaceous age which are younger than the uppermost beds included in the Alberta shale in the southern foothills.[17] To the writers this is considered to be an unfortunate decision.

Allan and Slipper and Hume have used the term Belly River for the series of formations above the Lea Park and below the Bearpaw. The lower formations of this series are older than the lowest beds included in the Belly River in the restricted sense in southern Alberta. It does not seem advisable at this time to introduce a new series name in central Alberta until a more definite correlation is established.

In 1917, Allan on the North Saskatchewan river, and Slipper in the Viking gas field, assigned to the Belly River a series of formations of fresh, brackish and marine deposition. They gave the names and thicknesses to these formations as tabulated above. Hume, at a later date, used the same divisions in the Vermilion-Wainwright area.

Allan and Slipper did not map the areal distributions of these formations except along the larger stream valleys. It might be possible to map the areal distribution of these formations separately in the interstream districts in the southeastern part of the area, which Hume has done to some extent in parts of the Wainwright district where the glacial covering is relatively thin. From Saskatchewan river northwest this would not be possible on account of the covering of recent and glacial material.

(17) Williams, M. Y. and Dyer, W. S., Geology of Southern Alberta and Southwestern Saskatchewan. Geol. Surv. Canada, Memoir 163, 1930, p. 17. See also Geological Map 204A, Calgary Sheet, 1928.

A broad, deep, poorly drained valley extends south from a point near Bondiss in township 65, range 18, to township 59 near Smoky Lake. A few outcrops occur in this valley, but they are not of sufficient extent or continuity to correlate readily with any particular formation exposed on the Saskatchewan. Some disconnected outcrops occur in the valley of the Tawatinaw between Nestor in township 60 and Perryvale in township 63, ranges 23 and 24, west of the 4th meridian, but it has not been possible to correlate these with any particular formation of the Belly River except in a general way with respect to their approximate stratigraphical position. The Pembina valley is practically free of exposures from Barrhead in township 59 north to Fawcett in township 64. There are some Belly River beds exposed on this stream in the vicinity of Flatbush. The outcrops are too few and scattered to determine the lateral continuity of the various Belly River formations between the Saskatchewan and Pembina rivers. Similar conditions prevail west of the Pembina and in the vicinity of Lesser Slave lake. There are some exposures of Belly River beds on the streams entering this lake from the south. Outcrops have been examined on Driftpile and Sawridge rivers. Allan used the name *Sawridge* formation for the Belly River on the north slopes of Swan Hills, but did not describe the series in detail since only a small part of it was exposed.[18]

It is assumed that the Belly River has approximately the same thickness south of Lesser Slave lake as it has along the Saskatchewan to the east and the Smoky to the west. The distribution of the Belly River shown on the accompanying map is here considerably different from that on previous maps which show the Edmonton formation extending almost to the south shore of the lake. Some incorrect correlation of the Edmonton formation has, in part, been responsible for what now appears to be errors on the earlier maps. The base of the Belly River is mapped as being close to the south shore of the lake, and there must be room for at least 1,000 to 1,200 feet of Belly River beds south of this boundary. The strata here have a small dip to the south in which direction the slope of the surface rises. Thus the width of the belt of Belly River here has been determined largely by considering the dip of the strata, the slope of the surface and the thickness of the beds.

Marten and Pelican mountains, northeast of Lesser Slave lake, are shown as underlain by Belly River. This has been done by projecting the geological boundaries in conformity with the surface features in so far as they have been mapped.

The Belly River beds are well exposed on Smoky river in ranges 2 and 3, west of the 6th meridian, where they have usually been referred to as the *Wapiti* formation. This name has been used to include strata younger than the Belly River series, but on the accompanying map the upper part has been shown as *Edmonton.* That portion of the Wapiti mapped as Belly River has not been divided into formations. Conditions of deposition appear to have been more uniform in Belly River time in the Smoky river district and a series of freshwater deposits were formed without inter-

(18) Allan, J. A., Geol. Surv. Canada, Sum. Rept. 1918, Pt. C, p. 11.

calations of marine or brackish water members. In the Peace River districts of Alberta and eastern British Columbia, the top of the Belly River has been placed at an horizon within the upper part of the Wapiti formation where a lithological change occurs. This horizon is discussed in more detail in the section on the Edmonton formation.

In Pouce Coupe district the massive sandstones capping the higher hills have been included in the Belly River. The beds here dip gently to the south and the top of the series is eroded. The base of the Belly River (Wapiti) may be at a somewhat lower stratigraphical horizon in the Pouce Coupe and Rolla districts than along Smoky river to the east. There is some evidence that the upper Smoky River shale thins out to the west, and is replaced by sandstone. The sandstones that cap the hills around Pouce Coupe may be equivalent in age to the upper beds included in the lower Upper Cretaceous marine shales to the east on the Smoky river, where the Smoky River formation is divisible into three members. It is our present interpretation that the upper Smoky River shale has disappeared to the west and the Bad Heart sandstone appears to grade lithologically continuously into overlying strata.

### BEARPAW FORMATION

In the plains of southern Alberta the Belly River beds are overlain by a marine shale formation of Upper Pierre (Montana) age, known as the *Bearpaw* shale. This formation thins to the north, but is represented by marine shales on Battle river in township 40 near the southern boundary of this map-area. Massive marine sandstones in the upper part of the Bearpaw in township 38, range 12, near Bulwark, were named the *Bulwark sandstone* by Slipper.(19) The exposure of Bearpaw beds on the Battle are the most northerly recorded, although they must occur as the surface formation beneath the mantle of recent and glacial deposits for some distance north of this river. In the well of the Hudson's Bay Oil and Gas Company, in township 39, range 14, the thickness of the Bearpaw is about 200 feet and approximately the same thickness is present on the Battle.

Allan considered the Bearpaw to be represented by shales and thin sandstones of brackish water deposition on the Saskatchewan near Fort Saskatchewan, but stated that no marine beds were observed.(20) The writers have re-examined the section on the Saskatchewan and on several tributary streams in this district, but have not found any definite evidence of marine shales. The districts north of the Saskatchewan are covered with glacial and recent deposits in places where the Bearpaw might be the underlying formation. In the Vimy district along the upper part of Redwater river in township 58, north of Edmonton, the glacial deposits are relatively thin and the nature of the soil suggests the possible derivation from shales or carbonaceous beds.

(19) Geol. Surv. Canada, Sum. Rept. 1917, Pt. C, p. 8.
(20) Allan, J. A., Geol. Surv. Canada, Sum. Rept. 1917, Pt. C, p. 12.

Until more definite field evidence is obtained the northern limit of the Bearpaw has been placed south of the Saskatchewan river. This indicates a thinning out of 200 feet of beds in a northwest direction in about 100 miles, or about 2 feet to the mile. If the thinning is more rapid the Bearpaw will not extend as far north as indicated on the map. Soil characteristics at Bruce and Holden, in townships 48 and 49, seem to indicate the presence of underlying marine beds, but in the vicinity of Beaverhills lake the glacial and post-glacial deposits have changed the general conditions so that there is no surface evidence of the nature of the underlying formations.

Records of wells drilled or bored might give data bearing on the distribution of the Bearpaw in districts where its presence is doubtful. No data of a reliable nature from this source are available and the interpretation of well logs in these places would require very careful examination to determine the Bearpaw, especially if the formation has become very thin or is represented by shore phases. It is very difficult to interpret the records of the deeper wells drilled some years ago in the Tofield and Edmontotn districts.[21] The lithological sequence recorded in these have not been made sufficiently definite to permit the detection of marine beds, although Dowling and others interpreted these logs as showing the probable presence of Bearpaw in the Edmonton district. At present there is no definite evidence of the occurrence of marine Bearpaw beds as far north and west as Edmonton.

## EDMONTON FORMATION

Tyrrell, J. B., Geol. Surv. Canada, Annual Rept. 1886, Vol. II, pt. E.
Dowling, D. B., Geol. Surv. Canada, Memoir 9-E, 1910.
Allan, J. A., Geol. Surv. Canada, Sum. Rept. 1917, pt. C., p. 12, and 1918, pt. C., p. 11.
Allan, J. A., Res. Coun. Alberta, Rept. 12, 1924, p. 37.
Rutherford, R. L., Res. Coun. Alberta, Rept. 19, 1928.

Brackish to freshwater deposits consisting of clays, shales and arenaceous beds—light colours prevail due to bentonitic content—carbonaceous and clay-ironstone bands common. Most of the coal seams of commercial thickness occur in the lower and upper parts. Thickness 1,000 to 1,200 feet.

The term *Edmonton* was first used by Selwyn in referring to the strata containing coal seams in the general vicinity of the present site of the city of Edmonton.[22] Later workers extended the use of this name into districts to the north and south. Tyrrell was the first to describe in some detail the strata now referred to as the Edmonton formation, and he mapped the areal distribution of these beds in parts of central Alberta.

The thickness of the Edmonton formation is difficult to determine because of the width of outcrop over a relatively flat area. An approximate thickness of 1,000 to 1,200 feet has been determined by using the slope of the surface, width of outcrop and average dip

(21) Geol. Surv. Canada, Memoir 116, 1919, p. 75.
(22) Geol. Surv. Canada, Rept. of Progress for 1873–74, p. 49.

of the beds. The most accurately measured section in areas adjacent is that on the Red Deer river where 1,224 feet of Edmonton beds are present.[23]

In the southeastern part of this map-area, the Edmonton overlies the Bearpaw, but elsewhere the Edmonton overlies the Belly River and the contact is not well defined. Further south on the Calgary Sheet, Map 204A, published by the Geological Survey of Canada, some beds overlying the Bearpaw are mapped as *Fox Hills*. There is no definite evidence of the presence of the Fox Hills type of beds in central Alberta and perhaps they occur only where the Bearpaw is well developed as a marine shale.

The Edmonton formation is composed of light to dark coloured shales, bentonitic clays and sandstones, coal seams and carbonaceous bands, and frequent layers of clay-ironstone nodules. A well defined volcanic ash bed occurs in the Edmonton on Red Deer river, but definite beds of this material have not been observed in the Edmonton formation in this area. The high content of bentonite is suggestive of volcanic dust in the original sediments. Similar lithological features characterize the upper part of the Belly River series, consequently in the absence of Bearpaw shale, it is difficult to determine the approximate position of the boundary between the Edmonton and the Belly River. Coal seams of commercial thickness in the lower part of the Edmonton formation in the Edmonton and Tofield districts, have been used in placing this boundary. From a general knowledge of the thickness of the formations and attitude of the strata, the Edmonton-Belly River, or Edmonton-Bearpaw boundary is shown as approximate as far northwest as the fifth meridian. In the vicinity of Athabaska river and the Swan Hills the Edmonton formation has been mapped in accordance with the physiography as known, assuming a regularity of dip and a thickness of 1,000 to 1,200 feet. Unless there are irregularities in the dip and thinning of the Belly River series it does not seem likely that Edmonton beds would occur on the upper slopes of Marten and Pelican mountains.

The Edmonton is extended west across the Smoky through the Grande Prairie district where the upper part of the Wapiti is correlated with the Edmonton on a lithological basis. This is a considerable change from that shown on previous maps. In the districts southeast of Edmonton the upper part of the Belly River (Pale Beds) and the Edmonton formation are almost identical in lithological appearance. The beds in the Grande Prairie district mapped as Edmonton are also of the same type. Exposures showing these lithological characteristics occur along Wapiti and Red Willow rivers south and west of Grande Prairie, and especially in the badland type of erosional forms in the eastern part of the Kleskun hills in township 72, range 4, west of the 6th meridian.

In southern Alberta and in parts of central Alberta, it is known that the bentonitic beds common to the Edmonton and Belly River, give place to coarser and more arenaceous strata in a westerly direction. Thus the Edmonton formation, which is highly ben-

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(23) Allan, J. A., Res. Coun. Alberta, Rept. No. 12, 1924, p. 38.

tonitic in the Drumheller district, becomes arenaceous with only occasional bentonitic zones in the foothills to the west. The Belly River beds which are rich in bentonitic material on the Red Deer river in the Steveville district are represented by coarser arenaceous beds in the foothills. These bentonitic beds represent near-shore shallow water conditions preceding and following the marine Bearpaw sea. The area of development of bentonite-rich beds in Belly River time appears to have been in general further to the east than in Edmonton time. The Edmonton beds are bentonitic along the Saskatchewan and McLeod rivers west to where they extend beneath the Paskapoo. Thus the deposition of such beds as far west as the Grande Prairie district is more likely to have occurred in Edmonton time than in the late Belly River, and these beds are correlated and mapped as Edmonton, although some of them may be of Bearpaw age.

### PASKAPOO FORMATION

Tyrrell, J. B., Geol. Surv. Canada, Ann. Rept. 1886, Vol. II, pt. E.
Allan, J. A., Geol. Surv. Canada, Sum. Rept. 1918, pt. C., p. 10.
Allan J. A., Res. Coun. Alberta, Rept. No. 12, 1924, p. 39.
Rutherford, R. L., Res. Coun. Alberta, Rept. No. 19, 1928.
Rutherford, R. L., Res. Coun. Alberta, Rept. No. 24, 1928, p. 32.
Russell, L. S., Trans. Roy. Soc. Canada, Vol. XXVI, sec. IV, 1932, p. 135.

The Paskapoo consists of sandstones, arenaceous and clay shales—massive crossbedded sandstones common in the lower part—fresh-water deposits. Lies disconformably on the Edmonton formation. Thickness not determinable as upper part has been removed by erosion, over 1,000 feet in the Swan Hills section.

The Paskapoo formation was originally described by Tyrrell from exposures along Blindman river and as only the lower part of the formation is exposed he did not define its upper limit. The lower beds of this formation are in many places coarse sandstones and form a marked contrast to the underlying bentonitic beds of the Edmonton formation. Thin coal seams occur in the lower part of the formation. The thickest observed are those exposed along the Saskatchewan, although the lateral continuity of these has been interrupted by post-depositional erosion. Beds of volcanic dust have been observed in the Paskapoo and in some parts the massive coarse sandstone contains appreciable amounts of volcanic glass. The Paskapoo lies disconformably on the Edmonton along Red Deer river,(24) and similar conditions have been found to exist to the north and west across the Saskatchewan to McLeod river.(25) The position of the eastern boundary of the Paskapoo as far as the McLeod has been determined largely by the presence of massive basal Paskapoo sandstones that overlie the bentonitic Edmonton beds.

Russell,(26) from a study of the invertebrate and especially the vertebrate remains from the Paskapoo collected from a number of places near its eastern boundary in central and southern Alberta, has concluded that the Paskapoo is of Upper Paleocene age and that the older Paleocene is missing. It is possible that some of the Lower Paleocene beds may be represented in the sections to the west.

(24) Research Council Alberta, Rept. 12, 1924, p. 39.
(25) Rutherford, R. L., Res. Coun. Alberta, Rept. No. 19, 1928, p. 20.
(26) Russell, L. S., "The Cretaceous-Tertiary Transition of Alberta." Trans. Roy. Soc. Canada, Vol. XXVI, Sec. IV, 1932, p. 121.

The position of the eastern boundary of the Paskapoo is fairly accurately shown from the southern edge of the map, northwest to McLeod river. On the Athabaska its position is based on reconnaissance traverses and it has been projected north to the 6th meridian in general agreement with the physiography. One large outlier of Paskapoo is shown underlying the upper part of the Swan Hills. The boundary is more accurately shown along the north slopes of these hills, whereas the southern boundary of Paskapoo has been mapped at an assumed position in conformity with the topography.

Beds of the Paskapoo type cap a small but prominent flat topped hill known as Saskatoon Mountain in the Grande Prairie district. This hill occurs in township 72, range 9, west of the 6th meridian near Beaverlodge, and rises about 600 feet above the general level of the surrounding district. Similar strata underlie flat topped uplands situated south of the Wapiti river between the 16th and 17th base lines near the western side of Alberta.[27] It is possible that these sandstone beds capping these relatively higher parts are Paskapoo or later Tertiary in age.

The most marked changes made in mapping the Paskapoo are those in the vicinity of Wetaskiwin south of Edmonton and along McLeod river south of Whitecourt. Earlier maps extended the Paskapoo much further to the east in the Wetaskiwin district. No attempt has been made to designate the position of the western boundary of the Paskapoo since it has not been possible to make any accurate division of the beds of Belly River, Edmonton, Paskapoo and later ages, which have been mapped as the Foothills series on the west side of the general synclinal basin.

In traversing up the Saskatchewan, McLeod, Athabaska and their tributaries from places where the eastern boundary of the Paskapoo crosses, one rises in section through the lower beds of the Paskapoo until points are reached where the dip changes to the east, beyond which the section is reversed. In decending through the strata by continuing up these streams it has not been possible to determine the position of the base of the Paskapoo or earlier Tertiary formations. Thus the Paskapoo has been mapped from its eastern boundary west to where the dip changes although it occupies a greater area than has been shown on Map No. 15.

There appear to be beds of Tertiary age, older than the Paskapoo in its eastern development, occurring along the west side of the general synclinal basin. The lithological character of these is similar to lower strata which may be of Edmonton age. Detailed palaeontological and stratigraphical work may offer a possible solution to this question.[28]

## LATER TERTIARY

Allan, in 1918, reported the occurrence of unconsolidated boulder gravels on the top of the Swan Hills. He suggested a correlation with similar beds occurring on Hand Hills and on the Cypress

(27) Evans, S. C. and Caley, J. F., Geol. Surv. Canada, Sum. Rept. 1929, Pt. B, p. 38.
(28) Rutherford, R. L., Res. Coun. Alberta, Rept. No. 19, 1928, p. 24.
Russell, L. S., Trans. Roy. Soc. Canada, Vol. XXVI, Sec. IV, 1932, p. 146.

Hills in southeastern Alberta and southwestern Saskatchewan.[29] They were shown on the 1925 edition of the Geological map of Alberta as the uppermost Tertiary beds in Alberta and the Geological Survey of Canada has mapped them as Oligocene on the Cypress Hills. Russell and Wickenden[30] have recognized the presence of boulder gravels of more than one age in the Cypress Hills region based on vertebrate palaeontological studies. No fossils have been collected from the Swan Hills gravels and no definite correlation has been established further than that the latest deposits in the Swan Hills district remaining prior to glaciation are similar to deposits of approximately the same age in the Cypress Hills.

The thick series of beds mapped as the *Foothills* series and discussed in a later section, may include beds younger than those represented by the Paskapoo in the eastern part of the general synclinal basin. It is not likely, however, that any of this series is as young as the boulder gravels on Swan Hills since they, if transported from the west, should be represented by still coarser phases in the foothills.

Beds of volcanic dust have been observed almost on the top of Marten mountain near the east end of Lesser Slave lake.[31] It would require considerable excavating and prospecting to determine whether these are associated with the consolidated formations or the recent deposits which cover this district.

Some unconsolidated gravels and sands associated with the glacial and recent deposits appear to have been deposited prior to glaciation. These are discussed in more detail in the previous section on recent deposits.

## FOOTHILLS AND MOUNTAINS

Strata from Precambrian to Upper Cretaceous are exposed in the mountains and foothills of central Alberta. Upper Cretaceous predominates in the eastern foothills whereas Lower Cretaceous and some earlier Mesozoic beds are more common in the western foothills. Upper Palaeozoic with some early Mesozoic form the eastern ranges of the mountains whereas Lower Palaeozoic and Precambrian form the western ranges.

Most of the periods of the Palaeozoic are represented with the exception of the Silurian and possibly the Permian. There is some uncertainty as to the exact age of the youngest Palaeozoic beds, namely the Rocky Mountain Quartzite.

The various formations have been grouped into several divisions on Map No. 15. The formational names used in the various districts where some studies have been made are shown on the correlation table below. The divisions mapped are discussed in ascending order with summaries and references to the more important reports dealing with districts in the foothills and mountains of central Alberta.

(29) Allan, J. A., Geol. Surv. Canada, Sum. Rept. 1918, Pt. C, p. 12.
(30) Russell, L. S. and Wickenden, R. T. D., "An Upper Eocene Vertebrate Fauna from Saskatchewan." Trans. Roy. Soc. Can., Vol. XXVII, Sec. IV, 1933, p. 53.
(31) Rutherford, R. L., Res. Coun. Alberta, Rept. No. 26, 1930, p. 32.

## CORRELATION TABLE FOR FOOTHILLS AND MOUNTAINS OF CENTRAL ALBERTA

| MAP LEGEND | TIME DIVISION | Bighorn Coal Basin | Saunders Creek–Nordegg | Foothills Brazeau | Mountain Park–Cadomin | Athabaska–Smoky | Jasper Park |
|---|---|---|---|---|---|---|---|
| FOOTHILLS SERIES | Tertiary ? | Brazeau | SAUNDERS* | SAUNDERS | BRAZEAU | Upper Sandstone and shale | |
| LOWER UPPER CRETACEOUS (Alberta Shale) | Upper Cretaceous | Wapiabi Bighorn Blackstone | Wapiabi Bighorn Blackstone | Wapiabi Bighorn Blackstone | Wapiabi Bighorn Blackstone | Berland | |
| LOWER CRETACEOUS | Lower Cretaceous | Dakota Kootanie | KOOTENAY GROUP | McLeod Kootenay | Mountain Park Luscar Cadomin Nikanassin | Sunset Kootenay | |
| JURASSIC | Jurassic | Fernie | Fernie | Fernie | Fernie | | Fernie |
| | Triassic | U. Banff shale | U. Banff shale | | Spray river | | Spray river |
| TRIASSIC | Pennsylvanian | R. Mt. Quartzite | R. Mt. Quartzite | | R. Mt. Quartzite | | R. Mt. Quartzite |
| | | U. Banff lis. | U. Banff lis. | | Rundle | | Rundle lis. |
| and | Mississippian | L. Banff shale | L. Banff shale | | Banff | | Banff shale |
| PALAEOZOIC | Devonian | L. Banff lis. Intermediate | L. Banff lis. Intermediate lis. | | Devonian | | Minnewanka |
| | Ordovician | | | | | | Sarceen series. |
| EARLY PALAEOZOIC and PRECAMBRIAN | Cambrian | | | | | | Cambrian |
| | Precambrian | | | | | | JASPER SERIES |
| | | Malloch, G. S., Geol. Surv. Can., Memoir 9E, 1911, p. 21. | Allan, J. A., and Rutherford, R. L., Res. Counc. Alta., Rept. No. 6, 1923, p. 31. | Allan, J. A., and Rutherford, R. L., Res. Coun. Alta., Rept. No. 9, 1924, p. 7. | MacKay, B. R., Geol. Surv. Can., Maps Nos. 208A, and 209A. | MacVicar, J., Geol. Surv. Can., Sum. Rept. 1923, pt. B., p. 28. | Allan, J. A., Warren, P. S., and Rutherford, R. L., Trans. Roy. Soc. Can., Vol. XXVI, Sec. IV, 1932, p. 230. |

*Names shown in capitals indicate that all the formations represented in the corresponding map legend divisions are included.

### PRECAMBRIAN AND EARLY PALAEOZOIC

Walcott, C. D., Smithsonian Misc. Coll., Vol. 75, No. 12, 1913, p. 340.

Allan, J. A., Geol. Map of Alberta, Res. Council Alta., Map No. 10, 1925.

Allan, J. A., Res. Council Alta., Rept. No. 24, 1928, p. 23.

Allan, J. A., Warren, P. S. and Rutherford, R. L., Trans. Roy. Soc. Can., Vol. XXVI, Sec. IV, 1932, p. 231.

Collet, L. W., Extrait de la Revue du Club Alpine Suisse, Nos. 9 et 10, 1932.

Collet, L. W., and Paréjas, Ed., Extrait du Compte Rendu des Séances de la Société de Physique et d'Histoire Naturelle de Genève, Vol. 49, 1932, p. 40 and p. 60.

*Precambrian*—A series of argillites, quartzites, sedimentary breccias, arkoses, slates and conglomerates at Jasper and along the Athabaska. Thickness not determined. Massive grey sandstones and shales over 2,000 feet thick in the Yellowhead pass district.

*Early Palaeozoic*—A series of formations composed of limestones, dolomites, shales and arenaceous beds. Mostly Cambrian and Ordovician. Estimated thickness in the Mt. Robson district, 12,200 feet.

An area along the railway near the west side of Alberta was shown as underlain by Precambrian on the 1925 edition of the geological map of Alberta. On Map No. 15 the Precambrian and some early Palaeozoics have been mapped together since both occupy the same general area. Most of the structural units west of Jasper include Precambrian and some later beds, but the detailed distribution of the various formations has not been determined.

Walcott proposed the name *Miette formation* or *Miette sandstones* for the Precambrian in the vicinity of Yellowhead pass and in the Mt. Robson district, where these beds underlie a thick series of early Palaeozoic formations.[32] He also considered these strata to belong to the *Belt series*. At a later date the name *Jasper series* was proposed for the Precambrian along the Athabaska in the vicinity of Jasper.[33] Although Walcott's description of the Miette beds is different in some respects from that of the Jasper series, it is probable that they both include the same general group of strata.

The lithological types at Jasper and in the Yellowhead pass district are similar to those in the mountains of southern Alberta and eastern British Columbia, where they have been referred to as the northern extension of the *Beltian* or *Belt Series* occurring in the state of Montana.

The Precambrian occurs in Athabaska valley at Jasper and to the south up the Athabaska and tributary valleys. The eastern boundary crosses Athabaska valley east of Jasper where the Precambrian is in fault contact with the Palaeozoics. The Precambrian and early Palaeozoics extend north and south from Jasper, and the indications are that these strata extend throughout the length of the mountains along the west side of Alberta in the general vicinity of the interprovincial boundary.

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(32) Smithsonian Mic. Coll., Vol. 57, No. 12, 1913, p. 340.
(33) Trans. Roy. Soc. Canada, Vol. XXVI, Sec. IV, 1932, p. 231.

Lower Palaeozoic strata are well represented in the vicinity of Mt. Robson where Walcott records a section of over 9,000 feet of Cambrian, 3,000 feet of Ordovician and over 2,000 feet of Precambrian. These strata, especially the thick Cambrian section, are likely to have considerable areal distribution in districts along the interprovincial boundary.

## PALAEOZOIC, TRIASSIC AND JURASSIC

McEvoy, James, Geol. Surv. Canada, Annual Rept. 1898, Vol. XI, pt. D.
Dowling, D. B., Geol. Surv. Can., Sum. Rept. 1910, p. 150 and 1911, p 201.
Kindle, E. M., Am. Jour. Sci., Vol. 18, 1929, p. 177.
Kindle, E. M., Dept. of Interior, Ottawa, Can., 1930.
McKay, B. R., Trans. Can. Inst. Min. & Met., Vol. XXXIII, 1930, p. 473.
Raymond, P. E., Am. Jour. Sci., Vol. 20, 1930, p. 289.
Collet, L. W. et Paréjas, E., Extrait du Compte Rendu des Séances de la Société de Physique et d'Histoire Naturelle de Genève, Vol. 47, 1930, p. 80; Vol. 48, 1931, p. 14, p. 60; Vol. 49, 1932, p. 44.
Allan, J. A., Warren, P. S., and Rutherford, R. L., Trans. Roy. Soc. Canada, Vol. XXVI, Sec. IV, 1932, p. 225.
Allan, J. A., Trans. Can Inst. Min. & Met., Vol. XXXVI, 1933, p. 619.

A series of formations consisting of limestones, shales, dolomites, calcareous and arenaceous shales, and intergradational types of fine grained sediments. Considerable lateral variation in lithological character and thicknesses of the formations. Approximate aggregate thickness, 10,000 feet. Mostly of Devonian, Carboniferous and Mesozoic ages.

The greater part of the eastern ranges of the mountains is composed of rocks of Palaeozoic, Triassic and Jurassic ages. The major thrust fault east of Jasper is the west boundary of these strata in Athabaska valley and vicinity. The Palaeozoics to the east of this fault are mostly Devonian and Carboniferous. Some of the fault blocks include Cambrian and Ordovician, but thick sections of these strata occur to the west of Jasper where they have been mapped with the Precambrian. The Triassic and Jurassic occur most abundantly in the eastern ranges or with outliers of Palaeozoics occurring in the foothills.

The formations have not been mapped in detail except in a relatively small area in the vicinity of the Mountain Park and Cadomin coal basins.(34) The general distribution of these beds is known largely from traverses in areas to the north and south of the Athabaska valley in Jasper park. The position of the eastern boundary has been determined, in most cases, with reference to coal basins adjoining or within the outer ranges of the mountains where more detailed study has been made.

The Triassic and the Jurassic are each represented by relatively thin formations and since they occur in the folded and faulted mountains and foothills they do not occupy large areas. The Jurassic has been studied chiefly in areas adjacent to coal basins where fossil collections have been made. Warren's recent paper on the Fernie shale (Jurassic) includes a discussion of the Jurassic in this area in its relation to beds of the same age in other parts of Alberta.(35)

(34) Geol. Surv. Canada, Maps 208A and 209A, 1929.
(35) Warren, P. S., Am. Jour. Sc., Vol. XXVII, 1934, p. 56.

Some structural and stratigraphical data on the ranges along Athabaska valley are contained in the earlier reports referred to, and in the more recent work new formational names have been suggested and attempts have been made to correlate the Athabaska section with that along the Bow river in the Banff district. Kindle, who first reported in some detail on the Palaeozoic formations in Jasper park, used most of the formational names as applied to the section at Banff, Alberta, and suggested new names for some strata not represented in the Banff area. Raymond proposed new names for these formations with the exception of Rocky Mountain quartzite. These names cannot be accepted because the sequence of formations as determined by him was incorrect.[36]

The following is a summary of the general character of the formations occupying the greater part of the mountain ranges adjacent to the Athabaska east of Jasper, and shown under a common legend symbol on the accompanying map:[37]

| | |
|---|---|
| JURASSIC | *Fernie Shale.* Dark marine shale with some sandstone and limestone beds. Thickness 600 to 1,300 feet. |
| TRIASSIC | *Spray River.* Fine grained, thin bedded, arenaceous and calcareous shales and other carbonate rocks, frequently brown on weathered surfaces. Thickness 400 to 700 feet. |
| CARBONIFEROUS | *Rocky Mountain Quartzite.* Hard fine grained, buff-colored calcareous or dolomitic sandstones, some quartzitic and cherty beds. Thickness 0 to over 500 feet. *Rundle Limestone* (Mississippian). Dark to light-colored fine grained limestones and calcareous shales. Approximate thickness 500 to 1,000 feet. *Banff Shale* (Mississippian). Lower 100 to 200 feet—fine grained black fissile shale—grades upward into thin bedded argillaceous limestones and calcareous shales. Thickness, approximately 600 feet. |
| DEVONIAN | *Minnewanka Limestone.* Massive and bedded dark grey to black limestones, dolomites and magnesian limestones prevalent in the upper part. The lower part contains more calcareous shales and some black shale members. Considerable lateral variation in thickness and character especially in the lower part. Thickness up to 5,000 feet. |
| ORDOVICIAN | *Sarceen Series.* Thin bedded limestones with some shale. Thickness 700 to 800 feet. |
| CAMBRIAN | Massive to thin bedded light-colored limestones, shales and dolomites. Thickness over 900 feet in Miette range. |

(36) Am. Jour. Sci., Vol. 20, 1930, p. 300.
(37) Allan, J. A., Warren, P. S., and Rutherford, R. L., Trans. Roy. Soc. Can., Vol. XXVI, Sec. IV, 1932, p. 230.

## LOWER CRETACEOUS

Malloch, G. S., Geol. Surv. Can., Memoir 9E, 1911.
Dowling, D. B., Geol. Surv. Can., Sum. Rept. 1910, p. 150 and 1911, p. 201.
MacVicar, J., Geol. Surv. Can., Sum. Rept. 1923, pt. B., p. 21.
Allan, J. A., and Rutherford, R. L., Res. Council Alta., Rept. No. 6, 1923.
Allan, J. A., and Rutherford, R. L., Res. Council Alta., Rept. No. 9, 1924.
Rutherford, R. L., Res. Council Alta., Rept. No. 11, 1925.
McEvoy, J., Dominion Fuel Board, No. 7, Dept. of Mines, Ottawa, 1925.
MacKay, B. R., Geol. Surv. Can., Sum. Rept. 1928, pt. B, p. 1.
MacKay, B. R., Trans. Can. Inst. Min. & Met., Vol. XXXIII, 1930, p. 473.

A series of sandstone sand arenaceous shales with some conglomerates and coal horizons. Mostly fresh water deposits. Thickness 2,500 to 3,000 feet. Subdivided into formations or members based on lithology. Upper and lower limits of divisions not well defined.

A belt along the foothills from the southern boundary of the map, north across Athabaska and Smoky rivers, is underlain in part by Lower Cretaceous strata. The mapping of these beds has been done in greater detail south of the Athabaska in the more developed coal districts. The writers are indebted to B. F. Hake for information relative to the distribution of the Lower Cretaceous in the districts northwest of Smoky river where no geological mapping has been done by government surveys.

The Lower Cretaceous is composed of freshwater deposits consisting of sandstones and shales, with coal seams and some well defined conglomerate beds. In some districts occasional marine beds occur near the base.

In the foothills of southern Alberta the Lower Cretaceous is usually divided into two formations, namely, the Kootenay and the Blairmore, although the upper part of the Blairmore is Upper Cretaceous in age according to palaeobotanical evidence. In some of the earlier work in the southern foothills, the Blairmore was correlated with the Dakota formation in the United States, and a similar correlation was attempted in districts along the south boundary of this map.[38] In recent work the term Dakota has been dropped, and in reports on areas in the foothills of central Alberta the term Blairmore has not been used since the correlation with southern Alberta has not been definitely established.

The Lower Cretaceous has been divided into formations or members with varying degrees of detail in the different districts studied. In some reports the writers used the term *Kootenay group* for the Lower Cretaceous, and suggested the use of local names for members, although a definite division was difficult to make. In the districts north of Athabaska river, MacVicar divided the Lower Cretaceous into the Kootenay Coal measures and the Sunset sandstone.

MacKay divided the series into four formations in the Mountain Park, Cadomin, Brule and adjacent coal basins and the names he assigned to these formations are given in the correlation table. The only member of this group that can be readily recognized in the field is the Cadomin conglomerate, although with detailed

(38) Bighorn Coal Basin, Malloch, G. S., Geol. Surv. Canada, Mem. 9E, 1911, p. 23.

mapping he has found it possible to show the distribution of the other divisions. For general mapping purposes over relatively large areas it would be difficult to show these divisions accurately. The Luscar formation occurring above the Cadomin conglomerate carries most of the important coal seams, and in this respect the coal bearing beds appear to occupy a stratigraphically higher position than those in southwestern Alberta, where the coal bearing beds are the lowest in the Cretaceous series and are commonly referred to as the Kootenay. The term Kootenay has a definite stratigraphical significance in the southern Alberta foothills and mountains and refers to a relatively thin coal bearing series beneath a well defined conglomerate horizon similar to the Cadomin conglomerate. When used in the districts of central Alberta, the term Kootenay has been more inclusive.

### LOWER UPPER CRETACEOUS (*Alberta Shale*)

Malloch, G. S., Geol. Surv. Can., Memoir 9E, 1911.
MacVicar, J., Geol. Surv. Can., Sum. Rept. 1923, pt. B., p. 21.
Allan, J. A., and Rutherford, R. L., Res. Council Alta., Rept. No. 6, 1923.
Allan, J. A., and Rutherford, R. L., Res. Council Alta., Rept. No. 9, 1924.
Rutherford, R. L., Res. Council Alta., Rept. No. 11, 1925.
MacKay, B. R., Geol. Surv. Can., Sum. Rept. 1928, pt. B., p. 1.
MacKay, B. R., Trans. Can. Inst. Min. & Met., Vol. XXXIII, 1930, p. 473.

Three formations or members—two marine shale formations separated by a series of sandstones and shales of fresh to brackish water deposition.

Upper shale (*Wapiabi formation*)—dark colored, thin bedded shales, frequently arenaceous, bands of clay-ironstone nodules near the top. Thickness 1,500 to 2,000 feet.

Middle member (*Bighorn sandstone*)—fine grained sandstones, arenaceous and carbonaceous shales. Thickness 250 to 350 feet.

Lower shale (*Blackstone formation*)—black fissile shale. Thickness 1,200 to 1,700 feet.

The strata here included underlie long narrow belts and some isolated areas within the foothills. Their general distribution corresponds approximately with that of the Lower Cretaceous. They are readily recognized because of their lithological character and can usually be mapped separately from the Lower Cretaceous and from the younger formations that overlie them. The boundary between these beds and the overlying formation is one of the most commonly exposed geological boundaries in the foothills and has been used frequently in mapping. It is possible to map the three divisions of this series separately as has already been done in many of the coal areas.

The names, Blackstone, Bighorn and Wapiabi have been used for these divisions by all except MacVicar, who used the name Berland. According to the interpretation of the writers, MacVicar used Berland only for the lower member or Blackstone formation, although MacKay interprets it as the equivalent to the three members.

The lower Upper Cretaceous is composed mostly of marine shales, the greater thickness of which belongs to the Colorado group, although the upper 200 to 300 feet are of Montana (Lower Pierre) age. These are the youngest marine deposits in the foothills of central Alberta, since the Upper Pierre (Bearpaw) is not represented here by marine beds as in some of the foothills of southern Alberta. Hume, since 1929, has used the term *Alberta shale* for the lower Upper Cretaceous marine shales in the foothills of southern Alberta.[39] The thickness, lithological character, and stratigraphical horizon of these marine shales are similar throughout most of the foothills except that in central Alberta the middle sandstone member is a more pronounced lithological feature.

Thus a name, such as Alberta shale, can be applied to these beds in most parts of the foothills with the same general significance with respect to lithology, thickness, stratigraphical boundaries and relationship to overlying and underlying formations. Hume proposed the term Alberta shale to include the continuous series of marine beds of Colorado age, but which included some beds of Montana age at the top. The name "Benton" has been commonly used for these beds in southern Alberta, but the Benton in its present usage in the United States does not include the uppermost Colorado nor any Montana strata.

## Foothills Series

Malloch, G. S., Geol. Surv. Canada, Memoir 9E, 1911.
MacVicar, J., Geol. Surv. Canada, Sum. Rept. 1923, pt. B., p. 21.
Allan, J. A., and Rutherford, R. L., Res. Council Alta., Rept. No. 6, 1923.
Allan J. A., and Rutherford, R. L., Res. Council Alta., Rept. No. 9, 1924.
Rutherford, R. L., Res. Council Alta., Rept. No. 11, 1925.
MacKay, B. R., Trans. Can. Inst. Min. & Met., Vol. XXXIII, 1930, p. 473.

A series of freshwater deposits of sandstones, arenaceous shales and clays. Some conglomerates and coal seams at different horizons. Thickness variable but aggregates over 11,000 feet. Thickest sections along the east side of the foothills.

The name *Foothills series*, is here proposed to include all strata above the Upper Cretaceous marine beds in the foothills. In the central and western parts of the foothills only the lower portion of the series is present, the upper beds having been removed by erosion. It was to the lower beds that Malloch assigned the name *Brazeau formation* in the Bighorn coal basin. In reports by the writers the name *Saunders formation* was used for all the strata overlying the Upper Cretaceous marine shale. The Saunders is a much thicker series than Malloch's Brazeau formation, and contained important coal horizons. MacKay has extended the name *Brazeau* in the Cadomin and adjacent districts and included beds to which the name *Saunders* had been previously applied. Malloch's original usage of the term Brazeau did not include more than the equivalent of the Belly River on the plains, whereas the Saunders included the equivalent of the Belly River, Bearpaw, Edmonton and perhaps some Paskapoo and earlier Tertiary. Thus on maps that cover parts of the same areas, but prepared by different organizations, the same strata have been designated by different names.

(39) Geol. Surv. Canada, Sum. Rept. 1929, Pt. B, p. 6.

In the foothills between Athabaska and Smoky rivers, MacVicar used the general designation, *Upper sandstone and shale* for the beds above the Berland shale. It appears that he included the Bighorn sandstone and Wapiabi shale in this division.

In southern Alberta the marine Bearpaw extends west into the outer foothills and the Belly River can be mapped separately, but in the western foothills the marine beds are missing and a division between the Belly River and younger formations has not been made. In these districts the name *Allison* is applied to the series overlying the Alberta shale. In proposing the usage of the term *Foothills series* in central Alberta, it is believed that such a series can be mapped as a unit throughout most of the foothills of Alberta. This general grouping does not prevent the mapping of separate divisions that may be made in some districts.

It has not been possible to divide the Foothills series into formations that can be readily recognized. Conditions similar to those that prevailed in Lower Cretaceous time recurred in the Upper Cretaceous and a thick series of freshwater beds were deposited. These are essentially sandstones, arenaceous shales and clays. Some beds of conglomerate and coal seams occur at several horizons. The coal horizons are best developed in the middle part of the series. In some districts it is possible to determine lithological differences for parts of the section, but these differences have not been proven to have a regional significance. Special types of sedimentary beds, such as those composed almost entirely of volcanic dust, form local horizon markers, but these have not been found to have a wide areal distribution.[40]

The lower part of the series is the approximate equivalent of the Belly River on the plains, and the basal beds of both occupy approximately the same stratigraphical position. In the general absence of stratigraphical breaks or marked changes, it has not been possible to determine the stratigraphical position of the top of the Belly River or the base of the Edmonton formation. A similar problem arises in attempting to determine the position of the base of the Paskapoo or earlier Tertiary. Because of these difficulties, the general term *Foothills series* is used for these beds. The use of such a general term is similar to the application of the term Alberta shale, except that in the case of the Foothills series the upper limit has not been determined.

Further study of the lithology, invertebrate, vertebrate and plant remains, may furnish a means of dividing this series into formations. The most promising results to date are those from the study of the vertebrate remains which may ultimately be used to determine the position of the Cretaceous-Tertiary boundary. If such a boundary is also marked by some definite lithological change, it would be possible to map the Tertiary separately from the upper Cretaceous. The collection and study of this fossil material has not been sufficient to furnish data that can be used in the mapping, although some general idea of the position of the Cretaceous-Tertiary boundary has been determined in some parts of the central foothills by Russell.[41]

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(40) Sanderson, J. O. G., Trans. Roy. Soc. Canada, Vol. XXV, Sec. IV, 1931, p. 64.
(41) Russell, L. S., The Cretaceous-Tertiary Transition of Alberta. Trans. Roy. Soc. Canada, Vol. XXVI, Sec. IV, 1932, p. 121.

The Foothills series is not exposed in any one section and the thicker sections have been measured or estimated from exposures along the eastern side of the foothills where the strata are gently inclined. Thicknesses of 11,000 to 13,000 feet have been determined by measuring a series of gently dipping beds over a considerable horizontal distance. Because of the lenticular nature of the beds it is possible in some cases that such measurements are greater than would be obtained from vertical sections.

The Foothills series occupies a relatively large continuous belt across the southwestern part of this map-area. The western boundaries of areas underlain by these beds are more accurately mapped south of the Athabaska than to the north.

In the discussion on the general distribution of the Paskapoo it was pointed out that only the eastern occurrences as far northwest as the 6th meridian were mapped. If the whole area underlain by Paskapoo and earlier Tertiary were mapped it would occupy a considerable portion of that shown as *Foothills series* on the accompanying map. Since the position of the Cretaceous-Tertiary boundary has not been determined, the boundary line between the Paskapoo and the Foothills series has been left indefinite on the map. No detailed mapping has been done on this series west of the 6th meridian, and the boundaries as shown are approximate. Evans and Caley have done some reconnaissance work on the headwaters of the Wapiti and recorded the occurrence of beds similar to those in the *Foothills series*.[42] Information as to the boundaries along the upper part of Porcupine river and its tributaries was obtained from B. F. Hake.

## ECONOMIC GEOLOGY

Coal, natural gas and oil are the chief mineral products of central Alberta. In addition there has been production of materials used in the building trades, chiefly clay products and cement. Gold has been recovered from stream placers and there are possibilities of production of salt and gypsum within this area. In the following discussion some of the major features of these economic products are indicated and the references cited contain further detail on these materials.

### COAL

Coal is produced from several districts in the plains and foothills of central Alberta. The coal produced in Alberta comes from one of three general horizons within the Cretaceous. In the foothills the producing horizons are in the Lower and Upper Cretaceous, whereas in the plains there are two horizons in the Upper Cretaceous. In central Alberta almost all of the coal production from the plains has been from one horizon, namely the Edmonton formation. The distribution of the coal producing areas and a discussion of the coal reserves in Alberta have been dealt with in some detail by Allan.[43] The quality and grade of the coal is set forth

(42) Evans, C. S. and Caley, J. F., Geol. Surv. Canada, Sum. Rept. 1929, Pt. B, p. 38.
(43) Allan, J. A., Geol. of Alberta Coal, Trans. Can. Inst. Min. & Met., Vol. XXVIII, 1925, p. 231.
Allan, J. A., Coal Areas of Alberta, Res. Coun. Alta., Rept. 10, 1923, p. 55, and Map No. 6.

in a general report on the analyses of Alberta coals.[44] The annual reports of the fuels division of the Research Council of Alberta contain further data on the quality, composition and physical character of Alberta coal.

Most of the production of coal in the plains of this area is from seams in the lower part of the Edmonton formation. These are most extensively mined in the immediate district of Edmonton. Seams at approximately the same general horizon are mined at Tofield and in the Camrose and Battle river districts to the south. In the lake Wabamun and Evansburg districts west of Edmonton, coal is mined from seams near the top of the Edmonton formation.

This coal is used for domestic purposes and for stationary power and electrical plants. Most of this coal is consumed within this map-area by markets adjacent to the mining centers.

In the foothills and mountains, coal of two different grades is produced from two widely separated stratigraphical horizons. In the outer foothills, southwest of Edson, high grade domestic and some steam coal is obtained from horizons within the *Foothills series*. This coal is sometimes considered as the stratigraphical equivalent of that mined from the Belly River beds in southern Alberta. The seams of commercial thickness occur over a wide stratigraphical range within the Foothills series and some of them may be in strata equivalent in age to the Bearpaw and Edmonton formations on the plains. Their proximity to the mountains, however, is such that the metamorphism caused by the deformation of the strata has changed their quality to such an extent that they are of much higher grade than seams of possibly the same age on the plains.

In the western foothills and in some basins within the mountains, coal of Lower Cretaceous age is mined. At present the production is almost entirely from districts south of the Athabaska valley including the mines at Mountain Park, Cadomin and Luscar. Several large mines have been developed along the Athabaska valley near the eastern edge of the mountains, but these have been abandoned. Large reserves of Lower Cretaceous coal have been prospected and examined in the foothills along the Hay, Berland and Smoky rivers. These have not been developed because of the distance from transportation and for some time a large block of leases in this district was withheld by the dominion government as a national coal reserve.[45]

Other areas have been prospected and reserves determined in districts south of Mountain Park, but have not been developed as this would require railway extensions. The Brazeau Collieries at Nordegg are in a district about twelve miles south of the boundary of this map.

Although the coal is from the Lower Cretaceous it apparently does not come from the lower part of this division and is thus not quite as old as that mined in the mountains and foothills of southern Alberta. The discussion of the stratigraphical relationship of these beds has been given on previous pages.

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(44) Stansfield, E. et. al., Res. Coun. Alta., Rept. 14, 1925.
(45) McEvoy, J., Smoky River Coal Field, Dominion Fuel Board, Rept. No. 7, 1925.

The coal mined in the Lower Cretaceous is usually of high grade but of small sizes, unsuitable for domestic purposes. It is used almost entirely for steam generation, particularly by railroads. Statistics on the annual production of coal from the coal areas in central Alberta are given in the Annual Report of Alberta Mines Branch.

## PETROLEUM AND NATURAL GAS

Prospecting and drilling for oil and gas have been carried on intermittently for over 35 years in several districts in central Alberta. The occurrence of oil and gas in western Canada has been made the subject of a detailed report by Hume.[46]

The history of the search for gas and oil in central Alberta dates back to the late nineties when three test wells were drilled by the Geological Survey of Canada. In 1895 the first test well was drilled by the federal government at Athabaska to a depth of 1,770 feet. This was followed by a test well on Athabaska river close to the mouth of the Pelican. In 1899 a third drilling test was made on the south bank of the north Saskatchewan river at the mouth of Limestone creek opposite Pakan. The tests made along the Athabaska were to a certain extent stimulated by the fact that large areas of bituminous sand occur at the surface in the McMurray district to the north, and it was considered that at depth these sands might carry lighter oils than those present in the exposed portions. Private interests later continued similar tests at Pelican rapids, House river and in the vicinity of McMurray north of this map-area, and other tests were made at widely separated points throughout central Alberta. These are recorded by D. B. Dowling.[47]

Between 1916 and 1929, nineteen wells were drilled along the valley of the Peace north of the town of Peace River. These tests penetrated the Lower Cretaceous and in some wells the underlying Palaeozoic limestone. The results obtained were not considered satisfactory and the wells were abandoned.

Viking gas field was discovered in 1914 and since that date over twenty-five gas wells have been drilled. Gas from this field is piped to Edmonton. In the Wainwright district more than fifty wells have been drilled since 1922 and productive horizons have been encountered in the Lower Cretaceous. The production from this district is not large, but two or three wells have contributed annually to the oil production in Alberta, and this is the only oil producing district at the present time in central Alberta. The conditions encounered in this oil field have been discussed by the Director, Petroleum and Natural Gas Division, Department of Lands and Mines, Edmonton.[48]

(46) Hume, G. S., Geol. Surv. Can., Ec. Geol. Series No. 5, 2nd Edition, 1933.
(47) Geol. Surv. Can., Memoir No. 116, 1919, p. 34.
(48) Calder, Wm., Bull., Can. Inst. Min. & Met., Nov. 1932, p. 639.

Gas obtained from the Wainwright district is used mainly in the town of Wainwright. Reserves of gas, apparently of large volume, have been proven by drilling operations in the vicinity of Kinsella. Some of the gas reserves have been discovered incidental to the search for oil. The horizons are in the Cretaceous, the productive zones being arenaceous strata either at the base of the lower Upper Cretaceous marine shales or within the Lower Cretaceous. Small quantities of gas have been encountered in the Belly River and younger strata, but no large amounts have been obtained from these horizons.

No gas is produced from any of the foothills districts of this area, although some gas bearing horizons have been noted in the drilling tests made near Coalspur.

Other districts have been tested within recent years by one or more wells. Three wells have been drilled in the district between Athabaska and Smith, two near the east end of Lesser Slave lake and one near High Prairie and others in the Rolla district along the west side of Alberta. No satisfactory results have been obtained from any of these tests. Wells have been drilled near Pigeon lake and Nakamun, but these have not been drilled deep enough to be considered satisfactory tests. The foothills have only been tested at one point, namely near Coalspur, and drilling projects for other parts were not carried out.

There are still many districts in which no tests have been made. The lithology and general structure of the plains are suitable for the migration and accumulation of oil. The foothills structures are in many cases ideal, but oil has not been found in large quantities in areas tested. In the plains where most of the drilling has been done, it is difficult to select favorable structures from a study of the surface, due to the general scarcity of exposures over large distances. Furthermore, because of the lithological character of the formations, many of the local surface structures are not indicative of coincident or similar structure at depth. Shallow test drilling has been used in attempting to locate structure and geophysical methods have also been used for the same purpose.

## GOLD

Gold is obtained in small quantities from the gravels and sands of some of the stream courses in the plains. The recovery has been made almost entirely by individual "washers." The greater amount of gold has been taken from the river bed of the North Saskatchewan in the vicinity of Edmonton. Ever since the occurrence of gold in the Saskatchewan was noted by the early explorers, the question of its origin or source has been of interest, as it is known that the upper reaches of this river do not traverse mineralized districts. Furthermore, the occurrence in recoverable amounts that will pay individual workers for their efforts is confined to a distance of about 50 miles on this stream, although similar geological conditions prevail over a much wider distance.

There are several possible sources for the gold. It may be of glacial origin, either from the mountains and brought in by the Cordilleran ice-sheet, or from the drift of the Keewatin ice-sheet from the northeast. It may be derived from the erosion of the Cretaceous and early Tertiary formations at the present surface, or from the erosion of coarses phases of the later Tertiary strata that have been removed from the greater part of the area. All of these origins have been suggested at different times by various authors, but evidence at present seems to exclude the Keewatin drift. A definite knowledge of the source might be of value in determining the best method and places to work most intensely.

## MISCELLANEOUS MINERAL PRODUCTS

Materials used in the building trades have to a certain extent added to the mineral production of central Alberta. Clays, chiefly from recent deposits such as the river flood plains, have been used for the manufacture of brick. Sand and gravel are used extensively for road surfacing and in construction work. Palaeozoic limestones in the mountains have been used in making cement at Marlboro, where also Upper Cretaceous marine shale from the foothills is used in the same industry.

At the present time practically none of the consolidated rocks are used in the building trades. Paskapoo sandstone from Evansburg has been used in buildings in Edmonton and a small amount of glacial boulders of Precambrian rocks are used in decorative masonry.

Potential reserves of salt are known to occur at McMurray on the Athabaska twenty miles north of this map-area.[49] Production was obtained from these deposits for a time, but of late they have not been worked. Gypsum is known to occur in considerable quantity in the mountains in Jasper Park,[50] but investigation to date indicates that these deposits are too impure to warrant commercial development. Furthermore, they are distant from present transportation routes and, since they are within the national park, they cannot be developed under existing governmental regulations.

The occurrence of phosphatic rocks associated with marine strata in the front ranges of the Rocky Mountains has been known for over twenty years.[51] In recent years there has been a study of these phosphatic beds with a view to their possible utilization in the manufacture of fertilizers.[52]

The study of the occurrence of ground water supply is economic geology since the development of such reserves is directly related to the geological conditions. The writers have given considerable attention to this matter during the past ten years in several districts,

(49) Allan, J. A., Res. Coun. Alta., Rept. No. 1, 1919, p. 87; No. 2, 1920, p. 102, and No. 10, 1923, p. 48.
Allan, J. A., Trans. Can. Inst. Min. & Met., Vol. XXXII, 1929, p. 232.
(50) Allan, J. A., Res. Coun. Alta., Rept. No. 27, 1931, p. 27.
Allan, J. A., Trans. Can. Inst. Min. & Met., Vol. XXXVI, 1933, p. 619.
(51) Allan, J. A., Res. Council, Alta., Rept. No. 1, 1920, p. 82, and Rept. No. 16, 1929, p. 34.
Allan, J. A., and Rutherford, R. L., Rec. Coun. Alta., Rept. No. 6, 1923, p. 33.
(52) Telfer, L., Phosphate in Canadian Rockies. Trans. Can. Inst. Min. & Met., Vol. XXXVI, 1933, p. 566.

because of the diminishing supply from present sources. Edmonton, and some of the larger towns, derive their water from surface supplies, such as rivers or lakes, but many of the towns, villages and rural populace depend on small local supplies of surface waters or shallow wells. With increased agricultural development, drainage and road construction, the supply of surface water has diminished and new supplies are sought at deeper levels. The problem of obtaining a satisfactory supply from deeper wells is most difficult in those districts underlain by marine Cretaceous shales, and it is anticipated that in such areas the problem will become more acute as development and settlement continues. Areas underlain by the arenaceous formations are more favorably situated in this respect and usually a good supply is obtainable from drilled wells.

In summary it may be said that at the present time the coal industry is the most productive mineral industry in central Alberta. Oil has possibilities beyond the present production which is small, while large gas reserves have been proven in several districts.[(53)] Other mineral material produced adds to the general total, but as yet the demand for these materials has not been sufficient to maintain a large industry.

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(53) Allan, J. A., Res. Council, Alta., Rept. No. 20, 1926, p. 34.

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