PROVINCE OF ALBERTA

Scientific and Industrial Research Council. *Report No.* 19

University of Alberta, Edmonton, Alberta.

GEOLOGICAL SURVEY DIVISION

JOHN A. ALLAN, Director.

Geology of the Area

BETWEEN

North Saskatchewan and McLeod Rivers, Alberta

BY

RALPH L. RUTHERFORD

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY

EDMONTON:

PRINTED BY W. D. McLEAN, ACTING KING'S PRINTER

1928

ORGANIZATION

The Scientific and Industrial Research Council of Alberta, formed in January, 1921, carries on its work in co-operation with the University of Alberta.

The personnel of the Council at the present time is as follows:

Hon. J. E. Brownlee, Premier of Alberta, Chairman.

H. M. Tory, President, University of Alberta.

J. T. Stirling, Chief Inspector of Mines, Province of Alberta.

J. A. Allan, Geologist.

N. C. Pitcher, Mining Engineer.

R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta.

R. M. Young, Canmore, Alberta.

Edgar Stansfield, Honorary Secretary, Industrial Research Department, University of Aiberta.

Requests for information and reports should be addressed to the Honorary Secretary, Industrial Research Department, University of Alberta, Edmonton.

LETTER OF TRANSMITTAL

HONOURABLE J. E. BROWNLEE,

Premier of Alberta,

Chairman, Scientific & Industrial Research Council of Alberta,

Edmonton, Alberta.

SIR:—I have the honour to transmit herewith a report of the Alberta Geological Survey Division, entitled "*Geology of the Area between North Saskatchewan and McLeod Rivers, Alberta,*" prepared from field observations, by Dr. Ralph L. Rutherford in 1926 and 1927. This is Report No. 19 of the Scientific and Industrial Research Council of Alberta.

The area mapped geologically and discussed in the report is approximately 5,000 square miles, extending from the North Saskatchewan river north to the Athabaska and west to Edson. A geological map in three colours on a scale of one inch to three miles accompanies this report.

The object of this survey was to determine and map the areal boundaries of the Edmonton and Paskapoo formations which occur within this area and to obtain information on the thick coal seams which occur here also. Attention was also given to the occurrence of building stone, gravel and placer gold.

This report covers an area adjacent to the east to that already reported on by the Alberta Geological Survey Division.

All of which is respectfully submitted.

Yours truly,

JOHN A. ALLAN,
Geologist.

Department of Geology,
University of Alberta,
Edmonton, June 1, 1928.

TABLE OF CONTENTS

Geology of the Area
BETWEEN
North Saskatchewan and McLeod Rivers, Alberta

By
RALPH L. RUTHERFORD.

CHAPTER I.
INTRODUCTION.

General Statement.—The Geological Survey Division of the Scientific and Industrial Research Council of Alberta carried out geological investigations in the foothills south of the Athabaska river during the field seasons of 1922, 1923 and 1924. In 1925 this work was extended eastwards from the foothills as far as Edson.[1] During parts of the field seasons of 1926 and 1927 the writer extended these investigations from Edson north-east to Whitecourt; east across Pembina river and south-east along North Saskatchewan river.[2] The greater part of the area covered in 1926 and 1927 is shown on the accompanying map, No. 13, and the present report is based largely upon observations made within this area.

The chief purpose of this work was to investigate the coal that occurs along the Saskatchewan, Pembina, McLeod rivers and in the intervening areas and also to determine if possible its stratigraphical relation to the coal occurring west of this area in the outer foothills. A further purpose was to delimit and map the areal boundaries of the Edmonton and Paskapoo formations. These objectives have been accomplished to a degree of accuracy dependent to some extent on the development of the coal areas and the accessibility of the area as a whole. Information relative to these objectives will always be cumulative, thus geological boundaries and correlations will possibly be changed as new and more accurate data are obtained. Conclusions which are given below are based on data obtained by previous investigators and by the writer who has had the advantage of this previous work as a guide and the additional advantage of easier accessibility to the area, due to agricultural development and road construction within recent years.

Geographical Position and Accessibility.—The area discussed in this report and shown on the accompanying map (No. 13), is situated within the plains area of west central Alberta. It lies between 114°0′ and 116°30′ west longitude, and includes all or portions of townships 45 to 60, ranges 1 to 18, west of the 5th meridian. The greater part of it lies within the area covered by the St. Anne

[1]Geology of the Area Between Athabaska and Embarras Rivers, Alberta. Sci. & Ind. Res. Coun., Alta., Rept. No. 15, 1926.
[2]Hereafter referred to as the Saskatchewan river.

sectional sheet, No. 314. Parts of it extend into the bordering sectional sheets, namely, the Fort Assiniboine, No. 364, on the north, the Brule, No. 313, on the west, and the Brazeau, No. 264, on the south. Most of the area is accessible by means of railways and roads. The main line of the Canadian National railway crosses about the centre and a branch line extends to Whitecourt in the northern part. The Jasper highway crosses the area almost parallel to the railway and utilizes considerable portions of abandoned railway grade. During the summer of 1927 the abandoned grade between Evansburg and Edson was used from Styal to Carrot Creek. At present this grade is followed west as far as Horner and a new road has been constructed west to Edson. This change avoids a long detour north via McLeod valley. A notable feature of the position of this highway as shown on the map is that it follows an almost straight east to west direction, lying entirely within township 53 in this area. Some well-travelled trunk roads are shown on the map, especially those leading from the railway to rural centres. These can all be travelled by automobile during the dry seasons.

A large part of the area lying west of Saskatchewan and Pembina rivers and south of Chip lake and the Jasper highway is inaccessible to ordinary means of travel. Most of the territory is unsettled and covered with muskeg and forest growth and is accessible only in winter by roads used in lumbering operations.

Culture.—Farming constitutes the chief occupation of most of the settlers in this area. One may judge the thickness of settlement in different parts by the proximity and number of rural post offices, which are shown on the accompanying map.

Coal mining has been carried on for a number of years at Evansburg on Pembina river and near Wabamun station. Gainsford was also a coal mining centre for a few years. This industry is more fully discussed in the chapter on economic geology.

Considerable quantities of timber are cut annually in the area south of Chip lake. Most of this is used for railway ties. Timber is also taken from the Athabaska valley and manufactured into lumber at Whitecourt.

Some of the beaches along the shores of the larger lakes are utilized as summer resorts. Seba Beach at the west end of Lake Wabamun has the largest number of summer cottages and is the most extensively patronized resort in this area. Edson is the largest town within the area. Its size is due largely to the fact that it is a railway divisional point and also is transfer point for all traffic going up the Alberta Coal Branch of the Canadian National railway.

Field Work and Preparation of Map.—This report is based on information obtained during parts of the field seasons of 1926 and 1927. In 1927 traverses were made along McLeod river from Edson to Whitecourt; along Pembina river from a point ten miles south of Evansburg to a point twelve miles north-east of Sangudo; along the Saskatchewan river from the south-western limit of the surveyed country in township 47 to Rocky Rapids in township 49. In addition, observations were made at numerous points between these streams. Most of the McLeod river traverse was made by boat.

The Pembina was traversed on foot since during most of the summer it is low enough to wade. The Saskatchewan was traversed along the north side only, except in some places where outcrops occur on the south side near ferrys.

During 1927 the Saskatchewan traverse was continued to the mouth of the Brazeau and eastward from Rocky Rapids as far as Edmonton. Camp equipment was moved by automobile, and most of the stream traverses were made on foot. A wagon was used to move camp along the Saskatchewan from Rocky Rapids to Blue Rapids.

During both seasons the writer was ably assisted by Mr. L. S. Russell. The duties of chauffeur and cook were executed by Geo. C. Haworth. Most of the geological data on which this report is based were obtained by stream traverses, since the most continuous exposures are found along the stream channels. In this connection it may be of interest to note that the minor streams, such as the McLeod and Pembina, show relatively much more continuous exposures than does the Saskatchewan river, where the strata are often concealed for long distances by recent deposits and vegetation.

The base for the accompanying map has been compiled from the sectional sheets and township plans issued by the Topographical Survey of Canada. These sectional sheets are now relatively old editions, and consequently do not show many desired details such as topography and culture, as are shown on recently revised editions of similar maps of other areas. The Topographical Survey of Canada is gradually revising these sectional maps, and it is likely that a revised map covering the eastern part of this area will be soon forthcoming. The western part is only sparsely settled and relatively inaccessible.

The accompanying map has been compiled from the geographical data available. Some changes in the position of the Saskatchewan river channel have been made as variations in position of the stream courses and larger islands have occurred since the area was surveyed. Aerial photographs of the Saskatchewan, obtained from the Topographical Survey of Canada were used in making the corrections. These photographs, taken by the Royal Canadian Air Board at the request of the Geological Survey Division of the Scientific and Industrial Research Council of Alberta, were of much assistance while traversing the Saskatchewan south-west of the surveyed country.

Sketch contours are shown on most of the sectional sheets covering this area, but these have not been included in the accompanying map since they are too inaccurate. They serve to show in a very general way the slope of the land, but do not indicate local relative elevations correctly. For example, the sectional sheets show a maximum difference of elevation of 500 feet in the area between McLeod and Pembina rivers south of Whitecourt, whereas the maximum is over 1,200 feet in Whitecourt Hill. The positions of rural post-offices are shown, these positions having been changed in several instances from those shown on earlier maps.

Previous Work.—The Saskatchewan river was a trade route through the west for many years preceding railway development;

consequently some early observations of the geology along this river were recorded by early river travellers. The most comprehensive early record is that of Tyrrell,[3] who traversed the Saskatchewan river within and beyond the limits of this area. Some geological observations were made and recorded previous to those of Tyrrell, but these are very general. A summary of these earlier observations is contained in Tyrrell's report.[4]

A part of Athabaska river is shown on the map accompanying this report. Dawson reported on the geology of this part of the stream in an early report[5] on a portion of northern Alberta.

The central part of the area was traversed by McEvoy in his general reconnaissance of the Yellowhead Pass route,[6] from Edmonton west through the mountains.

In addition to the work of these three investigators, several references to specific features, such as coal seams, building stone and glacial deposits, may be found within the geological literature as a result of special investigations by various geologists at different times. These references do not deal with an appreciable part of the area and are specifically referred to at other places in this report.

Acknowledgments.—The writer wishes to acknowledge assistance and courtesies given the party during both seasons by various persons met in the field. The officials of the Pembina mine at Evansburg and the Lakeside mine at Wabamun gave valuable information regarding the thickness and character of the coal seams at these mines.

Dr. J. A. Allan has also given considerable time to the revision of this report. The fossils collected in the field have been determined by Dr. P. S. Warren, who has prepared the lists of fossils included in this report.

[3]Tyrrell, J. B., Report on Part of Northern Alberta, etc., Geol. Surv., Can., Ann'l Rept., Vol. II, Part E, 1886.
[4]Idem, p. 7E.
[5]Dawson, G. M., Geol. Surv., Can., Rept. of Prog., 1879-80, p. 126B.
[6]McEvoy, J., Yellowhead Pass Route, etc., Geol. Surv., Can., Ann. Rept., 1898, Pt. D.

CHAPTER II.

GENERAL CHARACTER OF THE AREA.

Physiography.—The area shown on the accompanying map is in general of low relief, similar to the plains area of central and eastern Alberta, to which it belongs physiographically. There is a gradual rise from east to west as shown by the elevations of various stations along the railway, which indicate a rise of approximately 600 feet from the eastern to the western side. Parts of the area along McLeod river north of Mahaska ferry show the most marked relief. Here the upland elevation is over 1,200 feet above the stream level.

The interstream areas have a rolling surface composed of gently sloped uplands and valleys. The underlying strata are in general flat-lying and relatively high uplands such as those along the McLeod are erosion remnants.

The present surface is a composite resulting from erosion and deposition which may be referred to in three time divisions, namely, pre-glacial erosion, glacial deposition, and post-glacial erosion. The major relief is largely due to pre-glacial erosion. There is considerable evidence in central and eastern Alberta which indicates that a relatively long and active period of erosion preceded glaciation. This evidence is the presence of well-defined erosion remnants, such as the Cypress hills in south-eastern Alberta and the Swan Hills south of Lesser Slave lake. The thickness of beds removed during this erosion in this area is in places over 2,000 feet, assuming that there was no appreciable denudation of the higher points. There are places between these two uplands where the general level was reduced but which contain relatively high areas which are intermediate in elevation between the general level of the plains and that of the remnant high uplands. The area covered in this report contains some of these uplands of the intermediate type which are represented by the higher areas occurring along McLeod river. The Athabaska valley at Whitecourt is about 2,000 feet lower than the top of the Swan Hills. The uplands along the McLeod south of Whitecourt are about 1,400 feet higher than the Athabaska river. The proximity to the Swan Hills makes it fairly certain that about 1,000 feet have been eroded from the higher parts of this area and 1,500 to 2,000 feet from the lower parts. This erosion was pre-glacial and subsequent to deposition of the youngest Tertiary beds which were deposited here. The youngest beds forming the uppermost strata in the Swan hills and Cypress hills are Oligocene or younger in age. It is not possible to say whether later Tertiary time was represented here by the deposition, but if such has been the case, then a greater pre-glacial erosion occurred than has been indicated above.

The deposits resulting from glaciation are spread over the whole area but are thickest in the lower parts of the bigger valleys. This deposition temporarily dammed some of the streams and

diverted the drainage, but the larger streams in most places now occupy pre-glacial valleys. Erosion since glaciation has deepened the valleys to some extent, but the surface aspect is largely the same as it was in pre-glacial times following a prolonged erosion period.

Drainage.—The area is drained by streams tributary to two large systems. The northern and western parts are drained by the Athabaska, McLeod and Pembina rivers, which form a part of the Mackenzie river system that drains north to the Arctic. The Saskatchewan drains eastward to Hudson Bay. In addition to these major streams, there are a number of large tributary creeks which drain large sections of the country and some smaller rivers, such as Lobstick river, draining Chip lake, and Sturgeon river, draining Isle lake. The more important large creeks are those to which names are attached on the accompanying map.

The major streams occupy well-defined valleys which usually consist of two parts, namely, a comparatively recent valley which is steep-sided, rising 100 to 200 feet above the stream bed, and a gently sloped upper part, which extends to the watershed of the interstream areas. The deeper valleys are occupied by the larger streams.

The lower or comparatively recent part of the Athabaska valley is about two miles wide at Whitecourt. The stream occupies a shallow channel in the floor of the valley, in which there are numerous broad, low river terraces. The lower part of the valley is about 200 feet deep. The upper part rises gently north to the Swan Hills and south to the uplands along the McLeod in township 58.

The Saskatchewan occupies a valley similar to the Athabaska, the lower part being 150 to 200 feet deep, and averaging one to two miles in width. In the south-western part of the area, from the Brazeau to Berrymoor ferry, the lower valley is approximately coincident with the meanders of the river and is narrower than to the east. Some low river terraces exist along this part of the river valley, which is about a mile in width. The valley is relatively narrow in the southern part of township 47, and this part was at one time selected as a possible dam-site for an hydro-electric power project. It was the preliminary work on this project that stimulated the beginning of the farming settlement in the Rocky Rapids district.

Most of the maps of this district indicate the occurrence of two rapids on the Saskatchewan, namely, Rocky rapids and Blue rapids. There are no actual rapids at either of these places. The river channel is somewhat restricted at both places, but only at Blue rapids is there any indication of turbulent water. This is due to the presence of large blocks of sandstone which fall from the cliffs of exposed bedrock. These are soft rocks and soon become rounded by a stream action.

From Berrymoor ferry east, the lower part of the Saskatchewan valley is on the average wider than it is to the south-west. There are numerous large islands in the stream course, and broad river terraces are common along the bottom of the valley. The stream

channel frequently changes its course through these broad, low terraces. The meanders of the stream channel are more abrupt than those in the valley, which averages one to two miles in width.

The upper part of the Saskatchewan valley rises gently to the uplands forming the interstream areas similar to the corresponding portion of the Athabaska valley.

The McLeod and Pembina rivers have well-defined valleys. In some places these valleys are broad and have gentle slopes and at others they are steep-sided and narrow. These differences are largely due to the local lithological character of the strata in which the valley has been eroded. The deep, narrow, steep-sided valleys occur where the underlying beds are dominantly massive sandstones. (Plate 1A.) This feature is well-defined on Pembina river at Evansburg and on McLeod river in townships 57 and 58. Similar beds of approximately the same stratigraphical position occur along these streams at these localities. The McLeod at Peers ferry and the Pembina at Sangudo may be cited as examples where these streams occupy broad, gently-sloped valleys.

The lakes occupying considerable portions of the central part of the area are a noticeable feature of the drainage system. Chip lake, Isle lake, Wabamun lake, and Low-Water lake are the largest of these. Lake St. Anne, of similar magnitude, borders the area northeast of Isle lake. There is some evidence which indicates that these lakes are remnants of much larger water-bodies, which perhaps resulted from melting ice following glaciation.

The trend of Chip lake, Isle lake and Lake St. Anne, and their outlets, is suggestive of the possible occurrence at one time of a long, narrow, continuous body of water with an east-west trend. The in-flow and out-flow of Chip lake are dominantly in a west to east direction and Isle lake drains areas west almost to the Pembina near the mouth of Lobstick river. Wabamun and Low Water lakes may have been extensions of the same water-body. The low divide between Wabamun and Isle lakes, between Seba Beach and Gainford, suggests a possible connection of the two lakes when their water-level stood at higher elevations. Wabamun lake possibly extended much farther east at one time and covered the general area east and beyond Duffield. The numerous small lakes south of Duffield are possibly remnants of a greater Wabamun lake.

There undoubtedly have been several geologically recent changes in the size and extent of the lakes now occurring in this area as well as in the stream courses. Many of these changes were undoubtedly due to glacial damming and deposition. The larger streams, such as the Saskatchewan and Athabaska, may have suffered temporary diversion or damming due to glaciation, but at present they are flowing in pre-glacial valleys. The McLeod river appears to occupy a pre-glacial valley throughout most of its course, although it is possible that part of the McLeod valley north of Mahaska is of post-glacial development. The Pembina valley at Evansburg has the appearance of being post-glacial (Plate 1A). The possibility of Chip lake having been drained into or connected with Isle lake was mentioned above. At present the Pembina river course intersects such a possible drainage system almost at right

angles. It is, however, also possible that the Pembina is here following an old drainage course established in pre-glacial times to which it has returned again in post-glacial times.

A detailed examination of the physiography of this area would probably reveal evidence of numerous minor changes in drainage caused by glaciation. The drainage history of the area cannot be worked out in any appreciable detail until a contour map of the area is available.

Forests.—Most of the area is covered with trees or smaller growths of shrubs, except where they have been removed by agricultural development. Deciduous trees and shrubs are most common in the eastern part of the area where a slight intermingling of evergreens occur, represented by spruce and pine. Spruce is largely confined to valleys or low wet places. The pine, which is very scattered, occurs in sandy places and appears to be the remnant of an earlier, more extensive growth. In the western part, evergreens predominate and deciduous trees are found in abundance only locally, although small patches occur in almost all parts. Spruce and pine are especially abundant in the districts west of Pembina river and south of Chip lake, where muskeg growth is also prevalent.

CHAPTER III.

DESCRIPTIVE GEOLOGY.

Structure.—The strata underlying this area appear to be flat-lying. There are indications of low angle dips prevailing for appreciable distances locally, but it was not possible to determine whether these structures are regional in extent. The best example of local structure is that shown by the coal seam which is mined at Wabamun by the Lakeside Mine. Here the seam is about 90 feet above the level of the lake, whereas on the south side of the lake the same seam is at the water level. The seam is well exposed in section 15, township 53, range 6, west of the 5th meridian, where prospecting has exposed it at lake-level. Some further evidence of a south to south-west dip occurs along the Saskatchewan in township 50, but it is difficult here to be certain of dips on account of the prevalence of slumping along the valley sides.

A traverse up Saskatchewan river shows a gradual but regular rise in section from the Fifth Meridian to the Brazeau river, although locally there may be slight reverses due to small undulations. This rise in section is about equal to the stream gradient. Similarly along the Pembina there is a rise in section from Sangudo south beyond Evansburg, and this rise is also approximately equal to the stream gradient. On McLeod and Athabaska rivers conditions are somewhat different. There is a rise in section up the Athabaska from the east boundary of the map to Whitecourt and up the McLeod from Whitecourt to about the centre of township 58. From this point south to the centre of township 57 the beds exposed are highly cross-bedded showing local inclinations, but are believed to be flat-lying. Similar structural conditions prevail south to Peers ferry. From Peers ferry west to the boundary of the area the strata appear to have a slight dip to the east. This dip is about equal to the stream gradient, so that no appreciable change in stratigraphical position occurs between Peers ferry and the western boundary of the area. In a previous report covering the area adjoining to the west it was stated that the strata exposed on McLeod river south of Edson dip to the east about 2 degrees, or slightly greater than the gradient of the river.[7] This condition extends to the east side of range 17.

The lithological character of the underlying beds is such that the above structural conditions could be explained as due to unequal settling of the strata or the lenticular character of the beds. These broad, open and almost imperceptible structures, however, may have been caused by the same forces which formed the foothills to the west and may represent the most easterly influence of the mountain building forces.

It has been generally assumed by geologists that a broad open syncline occupies a large part of Alberta lying east of the foothills. The west limb of this syncline becomes a more pronounced struc-

[7]Sci. & Ind. Res. Coun., Alta. Report No. 15, p. 8, 1926.

tural feature as the eastern edge of the foothills is approached and forms the eastern boundary of the foothills. The east limb projects well out under the plains. If such a syncline is a general structural feature of this part of Alberta, this area should occupy an axial position. This broad syncline may represent the most easterly result of the mountain building movement to the west or may be interpreted as the remnant of a broad geosyncline which was gradually filled up during Cretaceous and early Tertiary time.

The lenticular nature of the beds and the small angle of dip make it difficult to determine even the approximate position of the axis of this basin or syncline. From observations made, both within this area and in others adjacent, it appears that the beds on McLeod river in townships 57 and 58 are about on the axis. Farther south on Saskatchewan river the position of the axis is probably somewhere near the mouth of Brazeau river. Traverses were not extended up Brazeau river from its mouth, but previous work to the south and west on Nordegg and Saskatchewan rivers seems to warrant this conclusion. From observations made on Nordegg river in 1922[8] it was found that the most easterly foothills structure occurred in township 44, range 12. This is about 21 miles south-west of the mouth of the Brazeau. At this locality the beds are faulted, the west limb dipping 40° to the south-west, whereas the east limb dips gently to the east. The strata have not been examined over a large part of the intervening 21 miles, but observations made farther south, near Rocky Mountain House, indicate that there are not likely to be any appreciable structures in this 21 miles. At Rocky Mountain House the Saskatchewan turns abruptly from an easterly to a northerly direction. This is about 40 miles south of the Brazeau, but west of here the Saskatchewan crosses approximately the same strata as does the Brazeau in its lower part.

West from Rocky Mountain House the beds are nearly flat-lying for over 10 miles, as exposed intermittently along Saskatchewan river. These strata are lenticular, and it is impossible to differentiate between initial and deformational dips, but there appears to be a small regional dip to the east. From Rocky Mountain House north to the Brazeau the Saskatchewan flows about north 10° west or approximately parallel to the structural trends in the outer foothills to the west. Consequently the position of the river is believed here to be almost coincident with the axes of the broad syncline in this general area. From the Brazeau north, the Saskatchewan assumes a more easterly trend as it crosses the eastern limb of this structure.

Thus from a consideration of the slight structure revealed in this area and others adjacent, it seems likely that a broad open syncline occurs within this area. The approximate position of the axis of this syncline may be defined as a line drawn from the mouth of the Brazeau river to a point on McLeod river at the north end of township 57.

---

[8]Sci. & Ind. Res. Coun., Alta., Rept. No. 6, p. 19.

Stratigraphy—General Statement.

The rocks underlying this area consist principally of sandstones and shales of fresh-water deposition of late Cretaceous and early Tertiary ages. The uppermost Cretaceous beds belong to the *Edmonton* formation, while those of the Tertiary age are assigned to the *Paskapoo* formation. Coal seams occur commonly within the *Edmonton* formation and some are in the *Paskapoo* formation. The approximate distribution of these formations is shown on the accompanying map.

In the foothills to the west the writer was unable to separate into formations the thick series of fresh-water deposits of upper Cretaceous and early Tertiary ages which were designated as the *Saunders* formation, that included all beds above the marine Colorado shales. In the districts lying between this area and the foothills it was not possible to determine any formational boundaries, and the beds were assigned to the inclusive Saunders formation,[9] although some of the beds were believed to be younger than the uppermost Saunders beds occurring in the foothills.

In eastern central Alberta the upper Cretaceous and lower Tertiary can be separated on a lithological basis, and furthermore the upper Cretaceous can be divided into several formations or members of different lithological character. This is due to the fact that there is a considerable interfingering of marine and fresh or brackish-water deposits.[10]

The area covered by this report lies about midway between the eastern districts, where divisions are readily made, and the foothills, where it is difficult to determine formational boundaries, and may thus appear as a favorable area in which to obtain data that could be used in correlating the formations of eastern Alberta with their stratigraphical equivalents in the foothills.

The marine interfingering did not extend west to the foothills where deposition of fresh-water beds appears to have continued throughout late Cretaceous and early Tertiary time. Correlation is difficult because long distances have to be traversed in order to examine relatively small thicknesses of vertical section due to the almost flat-lying attitude of the strata. Further difficulty arises from the fact that the thicknesses of the formations and the lithological character change considerably from east to west.

The Edmonton formation.—The Edmonton formation in its eastern development is characterized both vertically and laterally by the presence of light-colored bentonitic clays. The greater part of the formation is composed of clays or shales, while sandstones constitute only a minor part, and these also are in most cases bentonitic. Thus any exposed section of the Edmonton formation is usually very light grey in color, due principally to the bentonitic clay material so universally distributed throughout the whole formation. Where the beds are dominantly clays they are often characterized by the presence of clay-ironstone nodules which weather to a reddish brown color. These nodules vary from an

9Sci. & Ind. Res. Coun., Alta., Rept. No. 15, 1926, p. 10.
10Allan, 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.

inch to about ten inches in diameter, and frequently occur in rows or bands. In addition, the Edmonton formation is characterized by coal seams varying in thickness from a few inches up to as much as 25 feet. The thickest seams occur in the upper part of the formation and are present in this area. These are discussed in more detail below. There are also seams of commercial thickness occurring in the lower part of the formation in the vicinity of Edmonton east of this area. On the whole, the Edmonton formation is remarkably free from beds of coarse, clastic material. The above description of the Edmonton applies to its development in the eastern part of the area and in general to the Edmonton formation throughout its distribution in Alberta along the eastern side of the general synclinal basin. These beds apparently were deposited as near-shore deposits in shallow water. This deposition followed the retreat of the Bearpaw sea from eastern Alberta and practically the same type of beds was laid down all through Edmonton time.

On the western side of the geosyncline within this area and other parts of Alberta, it is difficult to recognize beds of Edmonton age. In these districts, deposits made during Edmonton time are similar to those preceding and following. No definite lithological characters have been detected that may be used to determine or distinguish the Edmonton beds from those older or younger.

Only the upper part of the Edmonton formation in its eastern development is exposed in this area, but from observations made to the east the thickness of this formation is believed to be over 1,000 feet. Allan[11] records a thickness of 1,124 feet of Edmonton beds in the Red Deer river valley. Tyrrell reported a maximum thickness of 700 feet for the Edmonton formation in this and adjacent areas.

The Paskapoo formation.—The *Edmonton* and *Paskapoo* formations have usually been differentiated on the basis of lithology. The name *Paskapoo* was first used by Tyrrell[12] for the beds occurring on Blindman river near its confluence with the Red Deer. Dawson[13] earlier described beds of the same age in southern Alberta and Tyrrell included part of these in the Paskapoo, but did not define the upper and lower limits of the formation. This formation is composed of shales and sandstones of fresh-water deposition. The thicknesses of the beds vary and in most places the strata are lenticular. The shales are poorly laminated and usually arenaceous. Some coal seams and carbonaceous beds occur in the lower part of the formation.

The basal Paskapoo in its eastern development is usually characterized by massive sandstones, which are readily differentiated from the Edmonton formation that is largely clays and shales. These sandstone beds are often over 50 feet thick and usually highly cross-bedded (Plate 1, A and B). Lenses of clay shale frequently occur within the sandstones. These massive sandstones are well exposed in several places, for example on the Saskatchewan at Berrymoor ferry (township 50, range 5); around the west end of Lake Wabamun at

11Allan, J. A., Geology of Alberta Coal. Bull. Can. Inst. Min. & Met. No. 156, p. 387—1925.
12Tyrrell, J. B., Geol. Surv. Can., Sum. Rept., New Series, Vol. 2, 1887, p. 135E.
13Dawson, G. M., Geol. Surv. Can., Rept. of Prog. for 1882-83-84, p. 113C, 1885.

Fallis and north of Seba Beach; along the Pembina at Evansburg and on the McLeod in townships 57 and 58. The first appearance of these sandstones above the typical Edmonton beds has been taken to represent the base of the Paskapoo by most investigators. Tyrrell placed the base of the Paskapoo on the Saskatchewan at the first appearance of these massive sandstones. McEvoy[14] assigned a Paskapoo age to similar beds near Evansburg, although he grouped the Edmonton and Paskapoo together under the *Laramie*.

Similar basal Paskapoo massive sandstones occur on McLeod river in the northern part of township 58. These exposures along the McLeod and those in the uplands along the river afford the best data relative to the thickness of Paskapoo still remaining in this area. The McLeod valley here rises to relatively high hills on both sides of the stream. On the east side the highest point is represented by an upland designated as Whitecourt Hill.[15] This hill, which is shown by hachures on the map, slopes off gently in all directions, but is steeper in the upper 500 feet. The highest part occurs in section 21, township 58, range 12, 4 miles east of McLeod river at its nearest point. The top of the south end is scarped and exposes about 150 feet of Paskapoo beds consisting of sandstones interbedded with shales. This escarpment can be seen from open places many miles to the south. The top of this hill is about 1,200 feet above the level of McLeod river at the nearest point, and since Paskapoo beds occur near this point on the river the formation is at least 1,200 feet thick here. In most of the area erosion has reduced the total remaining Paskapoo to much less thickness.

There is a corresponding upland of greater extent occurring on the west side of the McLeod opposite Whitehourt hill. This is known as Shiningbank ridge, the east end of which occupies the northern part of townships 57 and 58, range 14. This ridge extends west beyond this area, and is believed to be represented in the gently-sloped uplands which occur about twenty-five miles north of Edson. Strata are exposed near the top of this ridge in a south-facing scarp which occurs in township 57, range 15, about six miles west of Shiningbank lake. This exposure is near the west boundary of the area and is situated similarly to that occurring on the south face of Whitecourt hill.

Some relatively high parts occurring south of Shiningbank lake are shown to be underlain by Paskapoo beds. These have approximately the same stratigraphical position as those occurring on the McLeod in the northern part of township 57.

The first appearance of Paskapoo sandstones occurring above the Edmonton is easily recognized on the major streams in this area when one traverses upstream and upsection from the places where Edmonton beds of the eastern development occur, but in traversing from west to east and rising in section stratigraphically from beds definitely older than Edmonton it is not possible with data thus far obtained, to recognize the top or bottom of the Edmonton because of the lithological similarity of the Edmonton and Paskapoo formations in their western development. Similarly, by starting on the

[14]McEvoy, J., Geol. Surv. Can., Sum. Rept., 1898, Pt. D, p. 24.
[15]This is known locally as "House Mountain," but this name has already been adopted by the Geographic Board for an upland in the Swan Hills north of the Athabaska.

Paskapoo and traversing west it is not possible to definitely recognize the base of the Paskapoo. Previous investigators found this same difficulty. McEvoy recognized the east Paskapoo-Edmonton boundary near where Evansburg is now located, but farther west the boundary between these formations is not in evidence, although on his map[16] he places its approximate position at a point a few miles east of the mouth of Wolf creek. The writer has changed the position of the western boundary of Paskapoo in this part of the area, but it should be noted that the local evidence of the contact is entirely lacking and its position is approximate, based on information obtained to the north and south of this general position.

Tyrrell[17] assigned a Paskapoo age to beds exposed on the Saskatchewan near the mouth of the Clearwater river (Rocky Mountain House; see key map). His map accompanying this report shows Paskapoo beds extending 12 miles up the Saskatchewan river west of Rocky Mountain House. The west boundary of his map is at this point. A north-west projection of the west boundary of the Paskapoo shown a few miles south of Rocky Mountain House indicates that Paskapoo beds extend west up the Saskatchewan for at least twenty miles from Rocky Mountain House. This information is relative to an area outside that covered in this report, but is close enough to be of value in determining boundaries within it.

In the discussion on the structure it was noted that the first indication of eastward dipping beds on Nordegg river occurred in township 44, range 12, where faulted relations exist. From data obtained to date the writer believes that this fault marks the western boundary of the large area to the east underlain by Paskapoo beds, and a projection of the fault position to the north-west parallel to the foothill structure has been taken as the approximate western boundary of the Paskapoo. It should be noted that this does not necessarily represent the absolute western extent of Paskapoo beds, since it is possible that strata of equivalent age occur as the upper beds in local synclinal basins in the outer foothills.

All the comparatively recent editions of the geological maps of Canada or parts of Western Canada show the approximate position of the west boundary of the Paskapoo crossing the Saskatchewan about twelve miles north of Rocky Mountain House and extending south-east from here, excluding the massive beds of sandstone which occur on the Saskatchewan at Rocky Mountain House. These were included in the Paskapoo by Tyrrell, and the writer has been unable to find any report giving reasons for this change in the mapping.

In determining the western boundary of Paskapoo, it should be emphasized that it is very difficult to differentiate Edmonton and Paskapoo beds on the west side of the general geosyncline and projections of assumed boundaries are thus tentative pending further investigations. The writer believes that Tyrrell's mapping of the Paskapoo boundary west of Rocky Mountain House was approximately correct, but judging from the text of his reports it is evident that he did not recognize this Edmonton-Paskapoo contact on the west side.

[16]Geol. Surv. Can., Map No. 676, 1898.
[17]Geol. Surv. Can., Ann. Rept., 1886, p. 103E.

The following quotation[18] relative to this is significant.

> "To the west this series (*Edmonton*) gradually disappears under the overlying beds of the Paskapoo series and in the foothills no sign of its presence could be detected, although in many places, the junction of the Pierre and the Laramie (*Edmonton and Paskapoo*) was clearly seen, the sandstones of the Paskapoo series appearing to rest conformably on the shales of Pierre, so that the Edmonton series seems to thin out and disappear between its western outcrop and the eastern edge of the foothills."

The Pierre shales are marine, and it is now known that the upper marine Pierre (Bearpaw) did not extend to the foothills of central Alberta. The marine lower Pierre shales, underlying the Belly River freshwater beds, do occur, although as a thin member, within the foothills. Consequently it seems obvious that Tyrrell, in working down section from the Paskapoo, passed all the way through the Edmonton and Belly River (lower Saunders) and did not recognize any geological boundary. Such an interpretation of the section as made by Tyrrell, while obviously incorrect in the light of present day information, is readily understood by the writer, who has worked in an opposite direction; that is, from the base of the Saunders formation up into the Paskapoo, and has been unable to recognize any boundaries between beds of Belly River, Edmonton or Paskapoo ages.

From the above discussion it is readily seen that the mapping and differentiation of the boundaries of the formations of Upper Cretaceous and Tertiary age is a problem that awaits further investigation. The relative inaccessibility of parts of the area which might afford important data adds further delay to the solution of the problem.

There is only one instance in this area and in others traversed by the writer where there is apparently a recognizable transition from Paskapoo to Edmonton beds on the west side of the general syncline. This is on McLeod river in the centre of township 57, range 13, where the Paskapoo type of sandstone is met with in traversing northward down this stream (Plate 1B).

The most noticeable change made in the mapping of the formational boundaries is the position of the east boundary of the Paskapoo in the northern part of this area and the west boundary in the southern part. Previous maps show these boundaries considerably to the east of those shown on the accompanying map.

The Character of the Edmonton-Paskapoo Contact.—The above discussion has indicated that Edmonton and Paskapoo beds are in general separable on a lithological basis in places along the east side of the general synclinal basin of central Alberta, but such a separation cannot be made readily along the west side. Allan and Sanderson[19] have reported that the Paskapoo rests disconformably on the Edmonton in the Red Deer valley. This relationship was found to exist over an area of 3,000 square miles, and in places as much as 450 feet of Edmonton beds had been eroded prior to the deposition of the overlying Paskapoo. This area along Red Deer

[18]Tyrrell, J. B., Opp. Cit., p. 133E.
[19]Allan, J. A., and Sanderson, J. O. G. An Upper Cretaceous Disconformity in Alberta (Abstract). Bull. Geol. Soc. Am. Vol. 36, 1925, p. 161, and Bull. Can. Inst. Min. & Met., April, 1925, p. 396.

river is about 150 miles south of the area discussed in this report, and the intervening districts have not been studied in detail.

The disconformity reported by Allan and Sanderson is the only record of such relations between the Edmonton and Paskapoo formations in Alberta made from field observations. Simpson,[20] discussing the correlation of the Paskapoo formation in Alberta, states that "The Paskapoo is everywhere found to be unconformably on the Edmonton beds . . . " It is difficult to understand how one who has never done any work in Alberta can make such an unqualified statement regarding formations which have not even been separated in many parts of the province by those who have done most work on them.

In making broad correlations of the Paskapoo and the Edmonton it has been customary to use the upper coal seam in the Edmonton formation as the key horizon. This horizon was first used by Tyrrell and subsequently by Dowling[21] and others. In the Red Deer valley it has been designated as the Ardley Seam, No. 14, by Allan.[22] On Saskatchewan river the thick upper seam has generally been known as the "Big seam" or as the "Pembina seam" on Pembina river. This seam has not been definitely traced through the area between the Saskatchewan and the Red Deer rivers, but a thick seam has been found near the top of the Edmonton at some intervening points.

On the Saskatchewan the most easterly exposure of this thick seam occurse on the south bank of the river at water-level in legal subdivision 1, section 32, township 50, range 3, where it is about 25 feet thick. It outcrops in the form of a small arch and has been known for many years as the "Coal Arch," or "The Arch" (see map), which is illustrated in one of the earliest reports on the geology along the Saskatchewan.[23]

The "Big seam" which outcrops at "The Arch" has been burned out along the banks of the valley in most of the eastern part of township 50, range 4, but outcrops near water-level on the south side of the river in section 15 or 16, township 50, range 4. This outcrop is illustrated in the frontispiece of Tyrrell's report, and this locality was known in early days as "Goose Encampment."

There are no rock or coal outcrops along the river in the west half of range 4 or the eastern half of range 5, township 50, and the horizon of the Big seam is below river-level. Massive sandstones occur in the upper parts of the river banks, through the western half of ranges 5 and 6.

In sections 13 and 14, range 6, massive sandstones occur along the river banks. These are typically Paskapoo in appearance, and at Berrymoor ferry they form a vertical cliff about 100 feet high. The lower 80 feet is dominantly sandstone, while the upper beds carry considerable shale. These massive sandstones extend up the river and are represented by several river-bank outcrops, especially along the north side of the stream in sections 21 and 22, township

[20]Simpson, G. G., American Museum Novitates, No. 268, April 30, 1927.
[21]Dowling, D. B. The Edmonton Coal Field, Geol. Surv. Can. Mem. 8E, 1910.
[22]Allan, J. A. Geology of Alberta Coals. Bull. Can. Inst. Min. & Met., April, 1925, p. 394.
[23]Selwyn, R. C. Geol. Surv. Can. Rept. for 1873-74. Plate opp. p. 61.

50, range 6. In section 21 a weathered coal seam occurs about 80 feet above the river-level and massive sandstones of Paskapoo character occur below the seam. The rise in section to the south brings the seam nearer to river-level, farther upstream in sections 15 and 16. In legal subdivision 6 or 11, section 8, township 50, range 6, the seam is exposed about 15 feet above river-level. It is 15 feet thick, and is mined in winter by local inhabitants. The seam and associated strata are in place here, and a noteworthy feature is that 1,500 feet upstream the seam is less than one foot in thickness. Part of the section between these two points is concealed, but it does not seem likely that the 15-foot seam would lense out to less than one foot in this short distance. From field observations the writer is of the opinion that the 15-foot seam or the material which originally formed it, was almost entirely eroded previous to the deposition of the beds now exposed 1,500 feet upstream. The 15-foot seam in legal subdivision 11, section 8, is represented in slumped and eroded exposures in the upper part of the banks east as far as section 21, and is at an horizon definitely above the massive sandstones considered to be Paskapoo, which occur at river-level at Berrymoor ferry in section 14, township 50, range 6. These are at an horizon above the "Big seam" which outcrops still farther to the east.

About 8 feet of the upper seam is exposed again farther up the Saskatchewan about the centre of section 6, township 50, range 6. The upper part of the seam is eroded, and it outcrops about 40 feet above the river-level. Farther west another exposure in legal subdivision 9, section 23, township 49, range 7, shows about 12 feet of coal, occurring about 20 feet above river-level (Plate 1C). The lower 6 feet are clean, while the upper part has several clay partings. This locality at this point is known as Rocky Rapids. The seam is exposed for about 300 feet along the bank and appears to dip slightly to the east. This dip may be local, as slumping of the banks is prevalent here. This is the most westerly exposure of the upper seam on the Saskatchewan, although some thin seams, usually less than 1 foot thick, occur above this horizon farther upstream.

Tyrrell observed this upper seam and commented on its stratigraphical relations to the "Big seam" below.[24] He thought that it occurred at an horizon about 400 feet above the "Big seam." It is difficult to obtain an accurate measurement of the thickness of beds between the two seams because of lack of exposure in much of the area between the outcrops of the seams and because of local undulations of the beds and lensing of the strata. Our observations indicate that 400 feet is a maximum thickness, and perhaps 300 to 350 feet of beds are all that occur between the two seams.

The above discussion includes a statement of the conditions that exist along the Saskatchewan river, where the transition of Edmonton to Paskapoo is thought to be represented. Tyrrell placed the upper seam in the Paskapoo and the lower or "Big seam" in the upper Edmonton.

Edmonton time was a coal-forming period of considerable extent in the eastern parts of Alberta, and numerous seams in several

[24]Tyrrell, J. B., opp. cit., p. 107E.

widely separated areas occur in the Edmonton formation. The seams are thicker and more prevalent in the lower and upper parts of the formation. The Paskapoo formation is in general free from thick coal seams, although thin lenses of coal are common in several districts underlain by beds of this age. At Rocky Rapids on Saskatchewan river a seam which is 12 to 15 feet thick occurs at an horizon above massive, cross-bedded sandstones of Paskapoo character which overlie typical Edmonton beds. This seam has been eroded in places previous to deposition of some later beds, and might possibly be interpreted as late Edmonton in age. Such an interpretation would mean that the Paskapoo lies disconformably on the Edmonton and that erosion in early Paskapoo times or just preceding it had removed a greater thickness of Edmonton beds at some points east of Rocky Rapids. This interpretation, however, is discounted by the fact that the massive sandstones at Berrymoor ferry extend west beneath the upper seam.

On Pembina river conditions are similar to those on the Saskatchewan, except that no thick upper seam has been observed. Typical Edmonton beds carrying coal seams at various horizons occur all the way from Sangudo to the mouth of the Lobstick river near Evansburg. The "Big seam" which outcrops at river-level in sections 3 and 10, township 54, range 7, extends south beneath the river and is reached by a shaft at the Pembina mine. At the Canadian National railway crossing at Evansburg the valley is steep-sided and about 200 feet deep. Massive cross-bedded sandstone, 50 to 75 feet thick, occur at the top of the valley (Plate 1A). These extend up the Pembina, almost flat-lying, as one continuous bed as far as legal subdivision 12, section 5, township 53, range 7. Here the massive sandstone lenses out rapidly to the south into alternating beds of shales and argillaceous sandstones. This exposure along the Pembina gives some quantitative data regarding the lateral extent of these massive arenaceous members. In this particular case the sandstone bed is at least 5 miles across from south to north. The bottom of this sandstone at Evansburg has usually been taken as the base of the Paskapoo, yet the beds immediately underlying it, which are largely clay shales and argillaceuos sandstones with occasional beds of carbonaceous shale or thin coal seams, are more like the Paskapoo than the Edmonton. At this locality there are about 100 feet of such beds beneath the massive sandstone and above the first appearance of the typical light-colored Edmonton beds which prevail along the Pembina to the north.

Alternating shales and sandstones outcrop along the Pembina in township 52. These are at the horizon which would be occupied by the massive sandstones were it continuous to the south. In the northern part of township 51 massive lensed sandstones occur in the river section. These are similar to those at Evansburg, but usually less than 40 feet thick. The stream gradient of the Pembina is relatively steep, so that further traverses to the south reveal only stratigraphically higher beds which are well above the top of the Edmonton.

Conditions on McLeod river are similar to those on the Pembina. Typical Edmonton beds are exposed intermittently along the river-banks from Whitecourt to the south boundary of township 59. Exposures are discontinuous and small through the northern part of township 58, but in section 15, massive, cross-bedded sandstones occur. These are similar in thickness and lithology to those occurring on the Pembina at Evansburg and on the Saskatchewan at Berrymoor ferry. There is no outcrop of coal of sufficient thickness between this point and Whitecourt that may be taken to indicate the presence of the "Big seam." The paucity and discontinuity of exposures along this part of the stream makes it impossible to state whether such a seam is present or not. It is known, however, that seams of appreciable thickness occur in the Athabaska valley a few miles from Whitecourt. One seam 10 feet thick is reported[25] to occur here. The stratigraphical horizon of these seams crosses the lower part of the McLeod river, but it is possible that they have been eroded out previous to the deposition of the massive sandstones now occurring as far north on McLeod river as section 15, township 57. These massive sandstones apparently lense out to the south in section 21, township 57 (Plate 1B). To the south of this point the succession consists of alternating sandstones and shales. Sandstone beds 10 to 20 feet thick are common, but none of them are as thick as those occurring to the north.

The above discussion of the Paskapoo relates particularly to its development at the present position of the eastern boundary of the formation along the major drainage channels in the area. From this discussion it is seen that the basal Paskapoo along the present eastern boundary is characterized by the presence of massive, cross-bedded sandstones which average 75 to 100 feet in thickness. They are in no place found in contact with typical Edmonton beds, but on Pembina river they overlie shales and argillaceous beds which are more like the Paskapoo than the Edmonton. On Saskatchewan and McLeod rivers the beds immediately below these sandstones are concealed.

It is perhaps incorrect to compare data obtained on streams separated by considerable distances and to make conclusions regarding the Edmonton-Paskapoo contact from such data, since it is known that the Paskapoo beds in the past must have extended much farther to the east. Erosion has removed them from areas to the east, and the shore trends in early Paskapoo time may not have been parallel to the line shown on the map as indicating the present boundary. The eastern boundary, however, is approximately parallel to the axis of the broad syncline outlined above in the discussion on structure. The trend of the axis may have been determined in post-Paskapoo time, although there is no evidence indicating that such is the case. It does appear, however, that similar conditions of deposition prevailed in early Paskapoo time at the respective points along the three major streams where lower Paskapoo beds are now exposed.

The upper and in fact the whole of the Edmonton formation in its eastern development indicates conditions of slow deposition in

[25]Dawson, G. M. Geol. Surv. Can., Rept. of Progress for 1879-80, p. 126B.

shallow quiet waters. The transportation and sorting of basal Paskapoo beds in their eastern development required much stronger transporting agents than those necessary for the movement of the material which made up the underlying Edmonton beds. Such increased strength of transporting agencies would very likely cause some erosion on the surface of deposition. Consequently, it is very likely that the present eastern Paskapoo beds rest on an eroded Edmonton surface. It is difficult to decide whether this erosion of the Edmonton surface was subaqueous or subaerial or both. In any case, it would lead to disconformable or unconformable or even conformable relations between the two formations.

There is no field evidence indicating a subaerial erosion surface on the Edmonton beds prior to the deposition of the Paskapoo. There is, however, considerable deductive evidence which indicates subaqueous erosion of the Edmonton beds during or immediately prior to the deposition of the lower Paskapoo beds now occurring along the eastern boundary of the formation. Such erosion at the beginning of Paskapoo time would likely produce a disconformity between the Edmonton and Paskapoo formations, and the present relationships existing along the three major streams and also at some intervening points seem to substantiate this conclusion.

Conditions of deposition during all of the Paskapoo time were much less stable than in Edmonton time. The whole formation consists of alternating shales and sandstones which are lensed. In some parts of the formation shales dominate for considerable thicknesses, and in others sandstones are prevalent. Sandstone deposition prevailed in early Paskapoo time along the present site of the eastern boundary; yet here the first beds of Paskapoo age were shales. Quieter conditions followed and coal seams were formed at least locally, as on Saskatchewan river near Rocky Rapids.

Most of the above discussion regarding the Paskapoo-Edmonton contact applies to the relations now existing near the eastern boundary of the Paskapoo. It has been stated that it is difficult to divide the Edmonton and the Paskapoo at the western boundary in this and other areas of Alberta. From data obtained along the McLeod it is believed that the west side of the Paskapoo is represented by beds exposed at river-level in section 21, township 57. These are believed to be basal Paskapoo, and since they are nearly flat-lying the Paskapoo should extend somewhat further to the west in the higher areas along the stream valleys as has been indicated on the map.

Traverses were not made up Pembina river far enough to cross the Paskapoo to its west side. On Saskatchewan river our traverse ended at the mouth of the Brazeau, but from previous observations in areas to the west it is believed that the Paskapoo continues southwest up Nordegg river as far as the first fault of the foothills structure, which occurs in township 44, range 12. Paskapoo beds high in the formation occur east of this fault and Edmonton or lower beds occur on the west side.

Farther south on Saskatchewan river, Paskapoo beds extend beyond Rocky Mountain House to a point about four miles west of Horburg. It was not possible to determine Paskapoo-Edmonton

boundary here since the beds are faulted, the Paskapoo occurring on the east side of the fault and dipping very gently to the east, whereas on the west side, beds older than Edmonton are brought to the surface. This fault crosses the Saskatchewan about the centre of township 40, range 10. There is some disturbance of the beds east of this in the western part of range 8. This was indicated as the "first fault" in the report on the Saunders creek and Nordegg areas.[26]

Massive Paskapoo sandstones, nearly flat-lying, occur in all the outcrops from Rocky Mountain House west to the fault in range 10, except at the fault in range 8, where 800 to 1,000 feet of beds below the massive sandstones are brought to the surface. These dip to the east, and possibly a greater thickness has been raised to the surface since bedrock is concealed for some distance west of the lowest outcrop of this easterly dipping succession. It is also possible that some Edmonton beds are brought to the surface at this point. The strata occurring along the Saskatchewan near Rocky Mountain House are much higher in the Paskapoo than those occurring near the eastern boundary of the formation along the major stream valleys in this area.

There has been an impression that the massive sandstones occurring on Saskatchewan river at Rocky Mountain House are basal Paskapoo and that they are the approximate stratigraphical equivalent of those occurring on the Saskatchewan as Berrymoor ferry and on the Pembina at Evansburg. The beds at Rocky Mountain House overlie carbonaceous shales and a thin coal seam outcrops near the river-level. Some have taken this seam to be of Edmonton age, representing the upper Edmonton horizon. Dowling[27] includes this seam in the "Edmonton coals" without making any particular statement for so doing.

Geological maps of western Canada indicate a somewhat similar correlation by excluding from the Paskapoo all beds west of Rocky Mountain House, but differ in further excluding from the Paskapoo the massive sandstones occurring here on Saskatchewan river. The writer has been unable to find in published reports the reasons for this correlation, or for the position of the Paskapoo boundary north of Rocky Mountain House. This apparently was not Tyrrell's interpretation, and it appears that some unreported change has been made in the compiling of data for the later editions of geological maps covering this area.

The above discussion regarding the relation of the Edmonton to the Paskapoo has included a consideration of conditions existing in districts outside the area shown on the accompanying map, but these districts are close to the area in question; consequently much of the data obtained in these adjacent districts are believed to be applicable to this area.

In summary it may be said that the Paskapoo and Edmonton formations appear to be the result of continuous sedimentation in those parts now occurring along the present position of the approximate western boundary of the Paskapoo and that conditions of

[26]Sci. & Ind. Res. Coun., Alta., Rept. No. 6, 1923.
[27]Dowling, D. B. Geol. Surv. Can., Mem. 53, p. 57, 1914.

sedimentation during both ages were very similar. At points situated along the present eastern boundary of the Paskapoo, conditions of sedimentation in Edmonton time were somewhat different from those in Paskapoo time, and the basal Paskapoo was apparently deposited on an eroded Edmonton surface. From data available this erosion appears to have been caused by the same agencies which transported the lower Paskapoo sediments.

Palaeontology.—Fossil animal remains are not abundant in the Edmonton and Paskapoo beds in this area. Plant remains occur at a few localities, and some have been collected for the Department of Geology, University of Alberta, on occasions previous to our general survey of the area. Both the animal and plant remains occur in pockets or lenses which do not have a wide lateral distribution. Dr. P. S. Warren has determined the following from the collections made by the writer.

INVERTEBRATES AND PLANTS.

FIELD NUMBER		LOCALITY.
50-26	*Sphaerium formosum* M. & H. *Physa canadensis* Whiteaves *Vivipara leai* M. & H. *Valvata bicincta* Whiteaves *Valvata subumbilicata* M. & H. *Planorbus* sp. nov.	McLeod river, L.S.D. 12, Sec. 28-54-15 W. 5th.
52-26	*Typha* sp. Penhallow	McLeod river, L.S.D. 4, Sec. 25-54-15 W. 5th.
53-26	*Typha* sp. Penhallow *Viburnum asperum* Newberry? *Taxodium dubium* (Sternb.) Heer *Taxodium occidentalis* Newberry	McLeod river, L.S.D., 6, Sec. 5-55-14 W. 5th.
54-26	*Glyptostrobus europaeus* (Brong.) Heer *Taxodium dubium* (Sternb.) Heer	McLeod river, L.S.D. 7, Sec. 17-55-13 W. 5th.
56-26	*Sphaerium ellipticum* M. & H. *Vivipara leai* M. & H. *Vivipara* sp. undet. *Valvata subumbilicata* M. & H. *Valvata bicincta* Whiteaves *Physa canadensis* Whiteaves *Micropyrgus minutulus* M. & H. *Taxodium dubium* (Sternb.) Heer	McLeod river, L.S.D. 13, Sec. 28-56-13 W. 5th.
59-26	*Unio danae* M. & H. *Unio minimus* Warren *Sphaerium formosum* M. & H. *Sphaerium subellipticum* M. & H.	Pembina river, L.S.D. 7, Sec. 29-53-7 W. 5th.
60-26	*Unio priscus* M. & H. *Goniobasis tenuicarinata* M. & H. *Vivipara retusa* M. & H. *Vivipara leai* M. & H. *Campeloma producta* White? *Valvata bicincta* Whiteaves *Valvata subumbilicata* M. & H. *Ficus?* fruit	Pembina river, L.S.D. 12, Sec. 5-53-7 W. 5th.

Professor E. W. Berry[28] has determined a number of fossil plants collected from various parts of Alberta, which are in collec-

[28]Trans. Roy. Soc. Can., Vol. 20, Sec. IV, p. 189, 1926.

tions at the University of Alberta. These include the following from the Pembina river at Evansburg:

Glyptostrobus europaeus (Brong.) Heer.
Typha sp. Penhallow.
Musophyllum sp.
Palmacarpon truncatum Lesq.
Platanus aceroides Lesq.
Platanus aceroides latifolia Knowlton.
Populus arctica Heer.
Populus speciosa Ward.
Aralia notata Lesq.
Viburnum nordenskioldi Ward.
Viburnum newberryanum Ward.
Viburnum elongatum Ward.

These occur below the massive sandstone at Evansburg, which has generally been considered as basal Paskapoo.

Some of the invertebrate and plant remains listed above were collected from beds just below the massive Paskapoo sandstones near the eastern boundary of the formation. Others are from districts to the west, but none from horizons high in the Paskapoo. The invertebrates do not contain any species not previously listed from areas to the west[29] and are also much less abundant in this area.

A few vertebrate bones were collected from the Edmonton beds exposed on the north side of Athabaska river near Whitecourt (section 1, township 60, range 12). A bone was also observed in sandstones outcropping near the river-level in section 34, township 59, range 10, on the south side of the Athabaska. These remains are too fragmentary to permit determination, but are probably dinosaurian. They are of interest since this is the most northerly reported occurrence of vertebrate remains in the Edmonton, or earlier formations, in Alberta. McLearn, however, reports[30] footprints "suggesting a carnivorous dinosaur" from the Gething formation (Kootenay) in the upper Peace River district. Dislodged, fragmentary vertebrate remains were collected on Saskatchewan river just east of the boundary of this area and they have also been collected on the Saskatchewan a few miles above Edmonton.

In the area to the west covered by Report No. 15, approximately 5,300 feet of beds were estimated to be present. Fossils were collected from horizons down to within 1,700 feet of the base of this section, and nearly all of them were forms which occur in beds of Paskapoo or Fort Union age. Consequently there are approximately 3,600 feet of beds which are believed to occur below the Paskapoo as represented in this area and which at the same time carry typical Paskapoo fossils. It should be noted, however, that most of these invertebrates have a long vertical range, and while they probably occur most abundantly in beds of Paskapoo age at some localities, their vertical distribution has not yet been definitely determined.

Invertebrate remains are fairly abundant in the lower Paskapoo beds on Red Deer river, near the eastern boundary of the Paskapoo. The same forms are abundant in much lower horizons on Saskatchewan river west of Rocky Mountain House. In the area covered

---

29Sci. & Ind. Res. Coun., Alta., Rept. No. 15, 1926.
30McLearn, F. H. Geol. Surv. Can., Sum. Rept., 1922, Pt. B, p. 5.

in this report invertebrate remains are not very abundant in lower Paskapoo beds near the eastern boundary, but are more abundant in much lower beds occurring west of the boundary of the Paskapoo.

From observations made on the lithological character of the beds in this and other nearby areas, the writer is of the opinion that the Edmonton beds, which occur along the eastern side and which are characteristically fine-grained, light-colored shales and sandstones, are represented on the western side of the general synclinal basin by alternating sandstones and shales. These are much coarser than the Edmonton beds to the east and are very similar to the Paskapoo. It thus appears that conditions of deposition similar to those of the Paskapoo existed during at least part of Edmonton time at the present site of the outer foothills and adjacent plains. These conditions were favorable to forms of life, the remains of which occur fairly abundantly at some horizons in the Edmonton in its western development, but which migrated eastward with the migration of conditions favorable to them. Consequently, the same forms are common to the Edmonton in the outer foothills and to lower Paskapoo in the plains of Alberta. The most prolific horizons in the Edmonton in the outer foothills occur at least 2,000 feet lower than the basal Paskapoo. If these forms migrated eastward as deposition continued, evidence of such should be contained in the strata. Unfortunately, due to the general broad synclinal structure occurring east of the outer foothills most of the later Edmonton and early Paskapoo over a large part of the area is concealed. It thus appears that invertebrate remains do not afford any useful means for correlation of Edmonton and Paskapoo beds occurring on opposite sides of the general syncline in which this area occupies an axial position.

Vertebrate remains associated with the invertebrates as listed above were collected from the area to the west of this. These were largely fragmentary fish remains, and although their horizon, according to the present interpretation of the writer, is Edmonton in age, they are probably the same species as those found with the invertebrate remains in lower Paskapoo beds which occur on Red Deer river.[31]

Coal Seam Correlation.—The coal seams occurring in the Edmonton formation in the eastern part of the area are the most continuous members of the formation, and can be used as key beds for local correlation. They have also been used by Dowling and others for broad correlation of Edmonton beds in their eastern development. It was hoped that these could also be used to correlate the Edmonton with their stratigraphical equivalent in the outer foothills and adjacent plains. Such correlation could not be made until the sections exposed in the area covered in the report had been examined, and after doing this the writer is of the opinion that these seams cannot be used for such purposes with any degree of certainty. The sediments of the Edmonton formation in its eastern development indicate relatively inactive conditions of transportation, sorting and deposition and coal seams persist laterally for appreciable distances in a north and south direction. These

[31] Russell, L. S. A New Fossil Fish from the Paskapoo beds of Alberta, Am. Jour. Sci., Vol. XV, p. 103, 1928.

conditions did not extend west to the present position of the outer foothills where the Edmonton beds are much more lenticular and contain coarser sediments, resulting from more active agents of transportation and sorting. It is unlikely under such conditions that even a very thick coal seam occurring in the eastern Edmonton would be represented by similar deposits in the outer foothills.

A coal seam averaging 2 to 3 feet in thickness occurs south of Edson on McLeod river in section 11, township 53, range 17. According to the writer's interpretation of the succession, this occurs in upper Edmonton beds, and while it cannot be correlated with the "Big seam" occurring on the Saskatchewan and Pembina rivers, its horizon is believed to be approximately the same, that is, upper Edmonton.

A seam, 16 feet thick, occurs on Nordegg river[32] west of the fault taken to represent the western boundary of the Paskapoo. Its thickness is suggestive of the "Big seam" on Saskatchewan river, but structural conditions make it difficult to determine its stratigraphical position, and any attempted correlation with Edmonton seams to the east will always be uncertain.

Thick seams occur on McLeod river[33] within beds that are now thought to be of Edmonton age. These occur, however, at an horizon which has been estimated to be over 3,000 feet below the thin seam occurring south of Edson, and consequently are low in the Edmonton and possibly belong to the beds of a still earlier formation.

There is one general aspect regarding the conditions during coal deposition in Alberta that is probably of significance respecting correlation of coal seams in this area with those to the west. Many sections exposed in the plains areas of Alberta show that coal deposition was most prevalent during periods of relatively quiet conditions of sedimentation. These periods usually preceded a gradual westward advance of the Cretaceous seashore or followed immediately its gradual withdrawal. The lower part of the Edmonton formation in its eastern development was deposited during the gradual withdrawal of the Bearpaw (Upper Pierre Sea), and was a period of deposition of fine sediments, accompanied by coal seams. This feature is well exhibited in the Drumheller coal area[34] along Red Deer river, where the coal is in the Edmonton, which overlies the Bearpaw marine beds. The reverse order is exemplified by coal-bearing beds at Lethbridge, where they immediately underlie the Bearpaw shales. They are in the Pale beds, which are very similar in lithology to the Edmonton.

If such an interpretation of conditions is correct, then during early Edmonton time conditions favorable to coal deposition would have extended farther to the west than in late Edmonton time. Evidence is given above, which has been interpreted to indicate that during much of Edmonton time in the foothills, conditions of sedimentation were similar to those prevailing farther to the east in early Paskapoo time. This evidence indicates that an eastward migration of these conditions occurred during Edmonton and Paska-

[32]Sci. & Ind. Res. Coun., Alta., Rept. No. 6, p. 61, 1923.
[33]Sci. & Ind. Res. Coun., Alta., Rept. No. 15, pp. 19-22, 1926.
[34]Sci. & Ind. Res. Council of Alberta, Rept. No. 4, 1922.

poo time, and produced much coarser sediments than occur in the Edmonton in its eastern development. Consequently, if some of the thick coal seams occurring in the upper strata exposed in the outer foothills can be proven to be of Edmonton age, it is very probable that they are low in the Edmonton formation and it is not very likely that thick seams will be found occurring in upper Edmonton beds here. The conditions of sedimentation during Paskapoo time in this area and in Edmonton time in the areas to the west were not favorable to accumulation of coal-forming material in large masses over large areas. The writer is of the opinion that the thick seams in the upper Edmonton near the east boundary of the Paskapoo are not represented by similar deposits in beds of equivalent age occurring to the west in the outer foothills.

The conclusions and inferences given above apply chiefly to the area covered in this report. In some cases they have been extended to adjacent areas where observations have been previously made, but it is desired that the conclusions given should not be extended far beyond the limits of this area into many places where observations have not been made and where conditions may be different.

Pleistocene and Recent Deposits.—Some discussion has already been given to the effects of the glaciation on this area which was subjected to prolonged erosion prior to Pleistocene glaciation, resulting in an uneven surface over which the ice advanced. This area lies almost entirely within the general area over which the ice advanced from the Keewatin ice centre. Thus the drift deposits are characterized by the presence of boulders of Precambrian schists and gniesses. The western limit of this drift occurs on McLeod river at the west side of range 16.

The western edge of the Keewatin drift is not abrupt and well defined. In travelling west towards this boundary the boulders of Precambrian rocks become increasingly fewer until none are present. Furthermore, the Precambrian boulders near the western edge of this drift are all of small size averaging less than six inches in diameter.

There are no large morainal deposits, and in most of the interstream areas vegetation conceals the nature of the surface deposits. Small boulders and pebbles of Precambrian rocks are quite prevalent in the soil in the vicinity of Mahaska and Shiningbank. There are some deposits of tillite in the McLeod valley north of Peers ferry.

Recent deposits in this area consist largely of river-terrace and flood-plain deposits, and much of the glacial drift is mixed in with these. These unconsolidated beds are common along the Saskatchewan, Athabaska and McLeod rivers.

A detailed description of the Pleistocene and recent deposits of this area is a special subject which would necessitate more investigation. Observations on these deposits were made incidental to the other work, special note, however, being made on the occurrence of gravel deposits of suitable quality, quantity and acsessibility for road surfacing purposes.

CHAPTER IV.

ECONOMIC GEOLOGY.

Coal.—The mining of coal occurring in the Edmonton formation is one of the active industries within this area. The seams mined all occur in the upper Edmonton beds and are stratigraphically higher than those mined near the city of Edmonton.

There has not been any systematized mining along the Saskatchewan river, although during the winter when the river is frozen over the coal outcrops are accessible and are used to some extent by local inhabitants. These occurrences were noted and sampled on several occasions by early investigators.[35] The analyses do not give a very good idea of the quality of the coal since the samples were taken from surface outcrops.

The most noted occurrence on Saskatchewan river is the outcrop of the "Big seam" at the "Coal Arch" in legal subdivision 1, section 32, township 50, range 3. This outcrop was observed by the writer in 1927, and appears to have changed very little since it was first observed by Selwyn over 50 years ago. The present outcrop on the south side of the river exposes a small anticline. The top of the coal seam in the two limbs passes below river-level about 200 feet apart and at the crest, the base of the seam is about at river-level. The strata on both sides of this arch are very much displaced due to slumping, and the arch structure may be due to the same cause. The structure is local and further evidence of local displacement is the fact that the seam should outcrop several feet above river-level at this locality to be in alignment with the eastern projection of coal outcrops to the west. The coal seam outcrop was inaccessible for direct measurement, but appears to be about 25 feet thick and contains several shale partings.

Large masses of cinders occurring along the bottom of the valley on the north side of the river through sections 27, 26, 35 and 36, township 50, range 4, indicate the presence of this seam. Some pieces of cinder are as much as 5 feet in diameter and quantities of burned shale have been used in surfacing parts of the road constructed along the bottom of the valley.

The "Big seam" outcrops on the south side of the river in section 15 or 16, and is about 25 feet thick. This is the "Goose Encampment" occurrence mentioned and illustrated by Tyrrell.[36] It is utilized, to some extent, in winter by local inhabitants.

This is the most westerly exposure of the "Big seam" on Saskatchewan river. A higher seam mentioned previously as occurring in the Paskapoo occurs farther west in the Rocky Rapids district. This seam averages 12 feet to 15 feet thick, but apparently was

---

[35]Selwyn, R. C. Geol. Surv. Can., Rept. for 1873-74.
Tyrrell, J. B. Geol. Surv. Can., Ann. Rept., 1886, Vol. II, Pt. E.
Dowling, D. B. Geol. Surv. Can., Mem. 8E, 1910, and Mem. 53, 1914.
[36]Tyrrell, J. B. Opp. cit., p. 107E.

eroded out in many places in early Paskapoo time; consequently its lateral extent is very likely to be discontinuous.

There are other seams outcropping on the Saskatchewan in the Edmonton beds below the "Big seam." These outcrop east of "the Arch," but none occurring within this area are thick enough to be classed as commercial seams. The thickest seam contains about 3 feet of coal and occurs 100 feet above river-level in section 27, township 50, range 1. Apparently the same seam, with about the same thickness, outcrops about 40 feet above river-level in sections 7, 18 and 19, township 50, range 2. Some winter mining has been done in section 18. The outcrops of this seam on Saskatchewan river indicate that it is too thin to be of commercial importance unless it thickens appreciably in a lateral direction not traversed by the river.

The coal occurrences on Saskatchewan river are not of importance from a standpoint of immediate development, but are valuable in giving data relative to the lateral continuity of the seams that are mined at points along the railway.

The occurrence of coal seams at various points around Lake Wabamun was known for several years prior to the construction of the railway through this district. At one time there was a possibility of having a railway on each side of the lake, when both the Canadian Northern and Grand Trunk Pacific railways were building roads toward the mountains; consequently, considerable prospecting was done on the seams at various points along the north and south shores of the lake. The present development is situated along the Canadian National railway, which follows along the north shore. At present one mine, the Lakeside Coals, Ltd. (No. 1), is operating in a thick seam near Wabamun village. It is situated in legal subdivision 15, section 9, township 53, range 4, and is mining the lower part of a seam that is over 25 feet thick and which is correlated with the "Big seam" that outcrops on Saskatchewan river to the south. The mine is operated on a level entry, and the workings indicate a small dip to the south. According to the Alberta Mines Branch report this mine commenced operation in 1913 and is still producing. The seam at the mine entry is about 90 feet above the level of Wabamun lake. The cover over the seam varies with the surface irregularities, but averages 50 feet to 150 feet. The following analysis, taken from "Analyses of Alberta Coals"[37] may be taken as representative of the class and character of the coal at this mine.

	Usual Classification—Domestic.		
Proximate Analysis:	Typical.	Maximum.	Minimum.
Moisture ..... %	21.8	22.1	21.7
Ash ..... %	8.1	8.6	7.8
Volatile Matter ..... %	28.4	28.8	28.0
Fixed Carbon ..... %	41.7	41.8	41.4
Calorific value, gross, B.T.U. per lb.	8,680	8,710	8,620
Moisture in air-dried coal ..... %	12.8	13.0	12.7
Sulphur ..... %	0.2	0.2	0.2
Fuel Ratio	1.45	1.50	1.45
	Non-coking.		

[37] Sci. & Ind. Res. Coun., Alta., Rept. No. 14, 1925.

The following is a section of the seam at the Lakeside mine:

Bedrock and surface deposits	60ft.-100ft.
Clay shale	2 ft. 4 in.
Coal with hard shale	4 ft. 3 in.
Clay parting	0 ft. 3 in.
Coal	2 ft. 0 in.
Clay parting	0 ft. 2 in.
Coal with hard shale	6 ft. 0 in.
Coal	10 ft. 0 in.

The operations are confined largely to the lower 10 feet of coal, and about seven and one-half feet are mined.

The same seam is known to occur at several points along the south side of Lake Wabamun, and the reports of the Alberta Mines Branch contain a record of several small mines that have operated for short periods in this district. The relative inaccessibility to railway transportation has prevented a further development here. and apparently the greater part of their output was consumed locally. A notable feature regarding the local structure around Lake Wabamun is indicated by the fact that at the south-west end of the lake the seam is at lake-level, part of it being submerged during high-water periods. The seam is well exposed along the lake shore in sections 4 and 5, township 53, range 5, where it has been prospected. This indicates that at least locally the seam dips to the south or south-west, since at the Lakeside mine it is about 90 feet above lake-level. The approximate level of the outcrop of the "Big seam" on Saskatchewan river also indicates a dip to the south, for if the seam were flat-lying it would outcrop on Saskatchewan river in the vicinity of Rocky Rapids. An upper seam does occur on the Saskatchewan at Rocky Rapids, but the seam at Lake Wabamun is represented by the coal outcrops in section 15, township 50, range 4.

Massive sandstones believed to be Paskapoo form a high bank along the north shore of Lake Wabamun from Seba Beach east beyond Fallis station, or in general all the way across township 53, range 5. These are well exposed in the railway cut east of Seba station and in the peninsular point extending south of Fallis station. Here the sandstones extend almost to lake-level, and in some places must overlie the coal seam since it rises to the east and north toward Wabamun station. In fact, it is very possible that the seam has been eroded in places prior to the deposition of these sandstones. This evidence makes it uncertain whether the seam is continuous from the lake to Saskatchewan river since it may have been eroded in several other places in a similar manner. This factor has to be considered in making estimates of reserves in this area.

There are some low areas bordering lake Wabamun on the south. It is possible that in some of these the cover on the seam is very thin and that stripping methods could be utilized to advantage in mining. Recent lake sediments are common in these low places, and were deposited at times when the lake was higher and larger. It is possible that at such times the seam was exposed to lake erosion, and consequently the quality of the coal may not be as good as in places where the bedrock cover has not been removed.

West of Lake Wabamun coal was mined for a time at Gainford by the Gainford Collieries, Ltd. This mine was operated by a

vertical shaft 135 feet deep, and the coal was obtained from a seam which occurs below the thick seam mined at Wabamun. According to the Mines Branch report, the mine was opened in 1912 and closed in 1914. The seam is reported to have been 8 feet thick. The proximity of Isle lake and the presence of underground water channels made operating difficult and expensive. The writer is indebted to Mr. L. C. Stevens for information regarding the mine, which has been closed for a number of years.

Some other small mines have operated in the Gainford district, but have not continued operations for any length of time, and the production from them has been small. Most of these have been temporary openings in the thick upper seam, which occurs near the surface here.

The occurrence of coal on Pembina river has been known for many years and is recorded in the earliest geological reports[38] on areas including this district. This coal is mined at Evansburg by the Pembina mine of the North American Collieries. This mine has been in operation since 1910. The upper or "Big seam" occurs here, and was mined for some time, but at present operations are confined to a lower seam. This seam is reached by a shaft 310 feet deep. The bottom of the upper seam is here 270 feet below the surface, or at an approximate elevation of 2,250 feet. A section of the lower seam in the Pembina mine is as follows:

Coal	1 ft. 6 in.
Clay	0 ft. 0 in-4 in.—Average 1½ in.
Coal	(mined) 5 ft. 6 in.
Clay	0 ft.—1 ft.
Coal	0 ft.—1 ft.

Although the thicknesses of the coal and partings vary locally, the above section is fairly representative for this mine. The average thickness of the whole seam with partings is about 7 feet 6 inches. The upper seam is here reported to be about 21 feet thick, but contains several clay partings.

The following, taken from "Analyses of Alberta Coal"[39] may be taken as representative of the character of the coal that is here being mined:

	Usual Classification—Domestic.		
Proximate Analysis:	Typical.	Maximum.	Minimum.
Moisture %	19.0	20.0	17.9
Ash %	10.8	11.9	7.6
Volatile Matter %	27.4	28.6	26.1
Fixed Carbon %	42.8	43.8	41.1
Calorific value, gross, B.T.U. per lb.	8,960	9,280	8,710
Moisture in air-dried coal %	14.6	16.0	13.9
Sulphur %	0.3	0.3	0.3
Fuel Ratio	1.55	1.65	1.45
	Non-coking.		

The seams mined at Evansburg outcrop on Pembina river to the north, as shown on the accompanying map. The top of the upper or "Big seam" first appears at water-level in legal subdivision 2, section 33, township 53, range 7, and almost the whole seam is exposed in legal subdivision 7 of this section. Here the outcrop exposes a seam about 27 feet thick with a 3-foot shale parting 4 feet

[38] McEvoy, J. Geol. Surv. Can., Ann. Rept., 1898, p. 25D.
[39] Sci. & Ind. Res. Coun., Alta., Rept. No. 14, p. 47, 1925.

from the top and several thinner shale partings in the lower 20 feet. Disconnected outcrops show the presence of this seam downstream into the southern part of section 10 township 54, range 7, the bottom rising gradually above river-level in a northerly direction. The banks of the Pembina are eroded and are not nearly so high here as at Evansburg; consequently, only the beds below the upper seam are exposed to the north.

An outcrop occurring on the north side of the stream in legal subdivision 2, section 15, township 54, range 7, exposes seams which occur in the strata below the thick upper seam. A generalized section here is as follows:

Soil, and recent material		15 ft. 0 in.
Coal, impure		2 ft. 8 in.
Coal, clean		6 ft. 0 in.
Sediments		45 ft. 0 in.
Coal seam		
Impure coal	0 ft. 6 in.	
Clean coal	4 ft. 3 in.	
Clay	0 ft. 6 in.	
Coal	0 ft. 6 in.	
		5 ft. 9 in.
Sediments		40 ft. 0 in.
Coal seam		
Coal	1 ft. 2 in.	
Coal, impure	1 ft. 0 in.	
Coal	0 ft. 10 in.	
		3 ft. 0 in.
Sediments		18 ft. 0 in.
Coal		1 ft. 6 in.
Sediments		5 ft. 0 in.

River-level.

There are few exposures in section 10 to the south of here, and there is some uncertainty in regard to the stratigraphical relation of these seams to the thick seam occurring in section 33. The highest seam given in the section above may be part of the thick upper seam, in which case the second highest seam would represent the seam now being mined at Evansburg. It is also possible that the upper seam in this section is the same as that mined at Evansburg, in which case the third highest seam would possibly occur below the mine workings at Evansburg and may also be of commercial thickness there. Farther downstream, however, in legal subdivision 1, section 14, township 54, range 7, the upper seam of the section exposed in section 15 appears thicker, since less has been eroded from the top. This seems to indicate that the upper seam in the section given above is really a part of the thick upper seam.

There are no other thick seams present in the outcrops of Edmonton beds occurring north of section 14, township 54, range 7, as far north as Sangudo, although thin seams usually less than 2 feet thick occur at several places. The farthest north occurrence, and the lowest stratigraphically, is a 2-foot seam which outcrops near river-level in legal subdivision 16, section 33, township 55, range 7. A second seam of about the same thickness occurs about 40 feet above river-level at this same locality. North of here as far as Sangudo the river bank is low and few outcrops of rock occur. In the districts traversed by the Pembina river in this area the thicker

seams are in the upper Edmonton beds similar to the occurrences on Saskatchewan river.

Coal is known to occur at points between the Pembina and Athabaska rivers. A seam has been mined in the north-east quarter of section 22, township 57, range 9, south-west of Mayerthorpe. At the time of our visit in August, 1926, the mine was not in operation and the entry had caved in considerably. The seam appears to have a total thickness of about 8 feet, of which about 5 feet are mined. Several clay partings are also present. The country is quite flat in the vicinity of the mine, which is situated on a small creek, and the cover at no place is over 50 feet thick and usually is much less.

This seam cannot be definitely correlated with those on the Pembina, but it very probably occurs in upper Edmonton beds. It is also very likely that coal seams occur near the surface at several points between this point and Evansburg. This part of the country is for the most part not well settled, and is fairly heavily wooded, but as agricultural development takes place it is likely that seams will be found in several places which may serve to supply local demands at least.

Edmonton beds outcrop along the Athabaska in the northern part of this area and thin seams of coal occur in these beds. A seam about 3 feet thick outcrops about 140 feet above the river-level in the south-west quarter of section 34, township 59, range 10. It here overlies a section of beds typical of the Edmonton formation, but is overlain by buff, massive sandstones which are not common in the Edmonton formation in its eastern development. Thin seams at about the same horizon occur on the north side of the river below the ferry in section 1, township 60, range 12. No mining has been done recently in this district, although the Alberta Mines Branch lists a mine as having been opened in legal subdivision 7, section 5, township 59, range 11, south of Whitecourt.

Seams of commercial thickness are reported to occur on the Athabaska 9 to 12 miles above Whitecourt. This district was not examined by the writer, and no data regarding their thickness and stratigraphical position were obtained. Dawson,[40] in an early report, records the occurrence of an upper seam 10 feet thick and a lower seam 3 feet thick separated by 20 feet of beds. As far as the writer can ascertain these seams have not been examined and reported on since Dawson's visit many years ago; consequently their exact position cannot be given. At present they occur in an unsettled, timbered area at least 10 miles beyond the end of the railway at Whitecourt, and it is not likely that they will be opened in the near future.

The McLeod was examined from Whitecourt south and a description of the geology along this stream is given above. As previously noted, the exposures of Edmonton beds along the lower part of this stream are too few and discontinuous to determine whether thick coal seams are present in the uppermost Edmonton beds in this part of the area. This could only be proven by extensive prospecting. Should seams of commercial thickness be found, they very likely would occur in an unsettled area 10 to 15 miles

[40]Dawson, G. M. Geol. Surv. Can., Rept. of Progress, 1879-1880, p. 126B.

south of Whitecourt and would not be of importance from a standpoint of immediate development.

Summarily, it may be stated that the upper Edmonton beds occurring east of the Paskapoo boundary in most of this area carry thick seams of coal. These seams are developed to greatest extent at points along the railway. Apparently the seams have considerable lateral extent, but it is also possible that this lateral continuity is interrupted by the presence of massive Paskapoo sandstones which were deposited on an eroded surface in the Edmonton. This factor must be considered in making estimates of reserves. One seam of commercial thickness occurs in the Paskapoo beds on Saskatchewan river. Its lateral continuity has been broken by erosion which was followed by deposition of massive sandstones, and consequently the possible reserve from this seam is very indefinite.

The erosion of the upper Edmonton beds appears to have been less extensive in the Evansburg district than elsewhere along the eastern boundary of the Paskapoo in this area. At Evansburg the massive Paskapoo sandstones are much higher above the upper seam than at Lake Wabamun or on Saskatchewan river, and consequently there is less danger of it having been eroded out near Evansburg.

The general elevation of the thick upper seam in the Edmonton formation taken at several places indicates a small dip to the south and west, as is shown by the following data. At the Lakeside mine the approximate elevation of this seam is 2,470 feet. South of Seba Beach the bottom of the seam is below lake-level, or at an approximate elevation of 2,370. On Saskatchewan river it outcrops at an elevation below 2,300 feet and at Evansburg it is at an elevation of about 2,250 feet.

Building Stone.—Several companies at various times have been interested in the possibility of utilizing some of the massive Paskapoo sandstones for building purposes. Those occurring in the lower Paskapoo near the eastern boundary of the formation have been considered most favorable, and for a time a quarry was operated in these beds which outcrop on Pembina river near Evansburg and Entwistle (Plate 1A). Most of the product was used in Edmonton buildings. The physical properties of this sandstone are given in detail by Parks[41] in his report on "Building and Ornamental Stones in Canada." This quarry was opened near the top of the river bank on the east side of the river in legal subdivision 3, section 20, township 53, range 7. The upper part of the section here consists of:

20 ft. soil and partly decomposed sandstones.
45 ft. massive sandstone, fairly uniform in hardness, some lenses weather to hard, nodular masses, apparently case-hardened.
125 ft.-150 ft. shales and sandy shales interbedded.

The quarrying was confined to the 45-foot member. Only occasional quarrying has been done since 1914, and several blocks of sandstone which were left on the quarry floor have entirely disintegrated, indicating that this rock is not very resistent to weathering. The massive sandstone is poorly jointed vertically and the bedding planes are irregular, due to cross-bedding. In fact, in

[41]Parks, W. A. Dept. of Mines, Mines Branch Publication No. 388, pp. 241-249, 1916.

a distance of 520 feet to the south of the quarry only the lower 20 feet of the 45-foot bed is a true sandstone, the upper part being very argillaceous. To the north, however, the sandstone is continuous along the top of the bank to the former crossing point of the Canadian Northern railway in legal subdivision 5, section 29, township 53, range 7. Some samples of the harder phases of this sandstone were examined petrographically. A brief description is as follows:

(1) Clastic constituent, 60-70% composed of:

Quartz	20-25%
Chert and quartzite	15-20%
Feldspars	20-25%

Some muscovite and altered biotite.

The average size of grain is one quarter to one-half millimetre in diameter. All grains are angular to subangular. The feldspars on the whole are unaltered.

(2) Cementing material, 30-40%, mostly carbonate (calcite). Apparently considerable argillaceous material mixed with the carbonate cement.

As suggested above, these harder phases may be case-hardened, and consequently would not be as porous as the softer phases. This case-hardening apparently has resulted from precipitation of some of the cementing carbonate.

At present it does not seem likely that the Paskapoo sandstones in this area will be utilized for building purposes to any appreciable extent in the near future. They would not have a wide market in Alberta since sandstones of similar composition and of the same age are much more extensively quarried in southern Alberta, and are available at many places.

Gravel.—Since the proposed Jasper highway crosses this area the possibility of local occurrences of gravel suitable for road surfacing is of importance. Most of the exposed gravel deposits occur in the valleys of the major streams. It is, however, quite possible that there are occurrences of gravel resulting from glacial action which were deposited in some of the interstream areas in places not too far removed from the main highways. No important deposits of this nature were observed, but the occurrence of such deposits just outside the area make their occurrence within it quite probable. The gravel deposit at Heatherdown in the south-west quarter of section 7, township 54, range 1, is only 5 miles from the present Jasper highway. The gravel from here is used quite extensively by the building trades in Edmonton. It is very likely that prospecting would reveal the presence of similar deposits closer to the highway.

Placer Gold.—Gold has been recovered by placer methods from the Saskatchewan river-bed deposits at various times, but in recent years very little placer mining has been done on this river west of Edmonton. This placer mining has usually been on a small scale by "panning" or "grizzly" methods.

Tyrrell[42] mentions that traces of gold were found in the analyses of clays and burned shales associated with the outcrop of the "Big

[42]Tyrrell, J. B. Geol. Surv. Can., Ann. Rept., Vol. II, 1886, p. 109E.

seam" at Goose Encampment. This is just east of the boundary of the Paskapoo formation on Saskatchewan river. Tyrrell also states:

> "It has long been known that this is about the highest point on the river where gold can be washed out of the gravel and sand bars in paying quantities, and prospectors on that account have been led to examine the banks in this vicinity very closely."

Since then, however, placer gold has been reported to occur in tributary streams above the mouth of the Brazeau, although no important recovery has been reported from these occurrences.

During the last four years the McLeod River Mining Corporation, Ltd., has carried on systematic prospecting for gold along McLeod river from its mouth up beyond the west boundary of this area. Placer gold occurs in the gravels of the stream bed, and has been recovered at several points on a small scale by individual "washers." The plan of the above company has been to test out the most likely places of gold accumulation with a view to development and recovery at such places where values are highest. The results of this company's operations to date are naturally of a private nature, but they are still actively engaged in prospecting during the open-water season.

The occurrence of gold in the streams beds in this area is of interest since it is known that the headwaters of these streams do not flow through areas where primary gold occurs. The headwaters of the streams rise in the Rocky Mountains, which are largely composed of Paleozoic limestones and shales; consequently it is fairly certain that none of the gold is coming from the areas traversed by the upper parts of the streams. It appears that the gold now found in the stream-bed deposits is derived from the upper Cretaceous and early Tertiary beds through which the valleys of these streams have been eroded; consequently the gold is being derived from "fossil placers."

The gold in the Saskatchewan is very fine, indicating that it has probably been subjected to several cycles of erosion. In the opinion of the writer the gold is derived from the erosion of the coarser phases of the Edmonton, Paskapoo and younger beds. Although Tyrrell reported traces of gold in analyses from burned Edmonton beds associated with coal seams, it is possible that this gold was derived from early river deposits of the Saskatchewan, as these burned beds occur along the lower part of the valley. It does not seem likely that the Edmonton formation in its eastern development would contain much, if any, gold, since its sediments are very fine and indicate relatively quiet agents of transportation and deposition. The Paskapoo or the Edmonton in its western development, which is much like the Paskapoo lithologically, are much more likely to carry the gold in the fossil placer state.

It is not known whether the Edmonton and Paskapoo beds were derived from areas which contained primary gold, and it is possible that they were derived at least in part from pre-existing sedimentary formations in which there may have been gold as a "fossil placer." A consideration of these factors has a bearing on the possibility of the occurrence of "fossil placers" in the Edmonton or Paskapoo beds. If the gold now occurring in the Edmonton or Paskapoo strata was derived from primary lodes then very possibly

there may be rich placers in these formations in places not yet discovered. If, on the other hand, the gold in these formations was derived from previous placers, then there is little likelihood of the occurrence of rich fossil placers in the Edmonton and Paskapoo. Under such conditions of origin, the gold would tend to be widely distributed both vertically and laterally, and the writer is of the opinion that this is more likely to be the correct interpretation. It should be noted also that a large amount of the Edmonton and especially the Paskapoo has been eroded from this part of Alberta, and that the gold now occurring in the streams may be in large part residual from this erosion.

It might be suggested that the gold was carried in with the glacial deposits derived from the areas underlain by Precambrian rocks. If such were the case the gold would very likely be much more erratic in its distribution and in general much coarser than that found today in the Saskatchewan and McLeod river beds.

In much of the area at least 2,000 feet of Paskapoo beds have been removed by erosion and possibly a considerable thickness of younger beds. The uplands to the north of Athabaska river, namely, the Swan Hills in the vicinity of Lesser Slave lake, are capped by coarse conglomeratic sediments which are younger than the Paskapoo. The presence of these coarse phases of sediments so far removed from their source indicates that stronger transporting agents were active in times following the Paskapoo and Edmonton in these areas. It is believed that these coarse sediments also covered this area, which is not far removed from the Swan Hills, but preglacial erosion removed these upper sediments. If the gold were derived originally from areas to the west which were the source of the sediments, the agents which succeeded in transporting coarser sediments so far east in post-Paskapoo time would also be able to transport more gold, providing it were available at the source. These considerations seem to indicate that it is possible that most of the gold now found in these areas may have been transported and deposited with post-Paskapoo beds, since these contain coarser material at points much farther to the east than do earlier rocks underlying this and adjacent areas. The removal by erosion of large thicknesses of these later beds from this area would leave gold as residual if it had been present in the eroded strata.

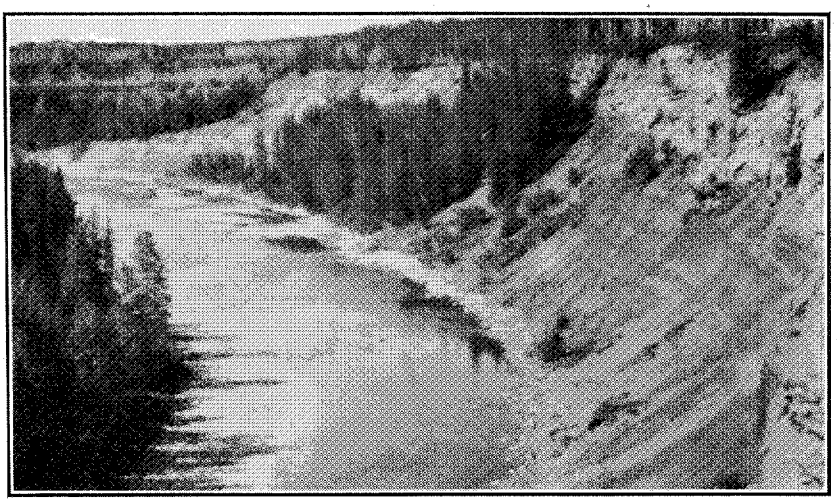
Sufficient data have not yet been obtained to determine which of the above possibilities is most nearly correct, further than to state that the gold at present is not being derived from a primary lode. It may be finely disseminated in the sediments of the Edmonton and Paskapoo formations.

Water Power.—Some preliminary surveys were made a number of years ago in the vicinity of Rocky Rapids with a view to the construction of an hydro-electric plant. Several sites were considered, the most favorable of which was located in section 33, township 47, range 7, where the Saskatchewan valley is comparatively narrow and steep-sided. The valley here is about 200 feet deep. The stream is about 500 feet wide and a low terrace about 700 feet across makes a total of 1,200 feet as the width of the bottom of the valley. The geological facts to be considered at any point

along the Saskatchewan in this district are that the strata are flat-lying, comparatively soft and lenticular in character. Damming the Saskatchewan at any point above Rocky Rapids would not interfere with any other established industry, since the areas that would be affected are not inhabited and are not likely to be for many years.

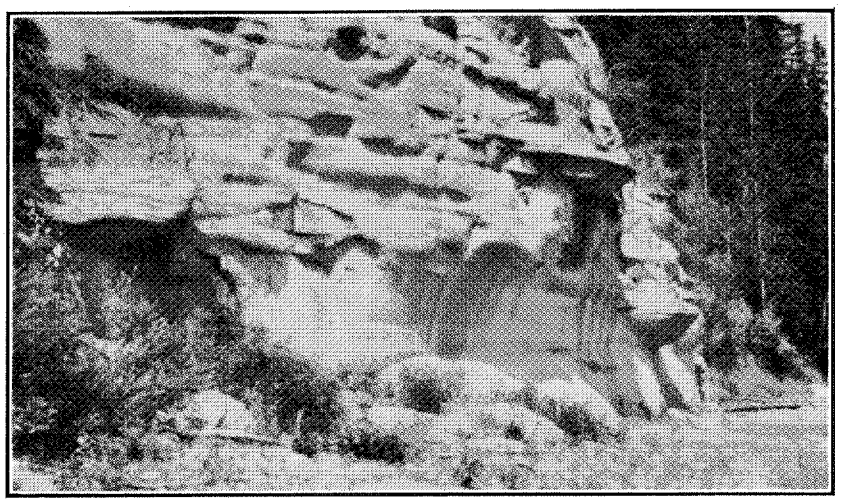
One other location may have hydro-electric possibilities, namely, the Lobstick river west of Evansburg. Chip lake, a natural reservoir, is drained by this stream. The difference in elevation between Chip lake and the mouth of Lobstick river is over 250 feet and the steepest stream-gradient occurs in the east half of township 53, range 8. If Chip lake carries a sufficient quantity of water for supplying an hydro-electric plant, it appears that a favorable dam-site could be selected in the Lobstick valley, a short distance west of Evansburg.

Plate 1A



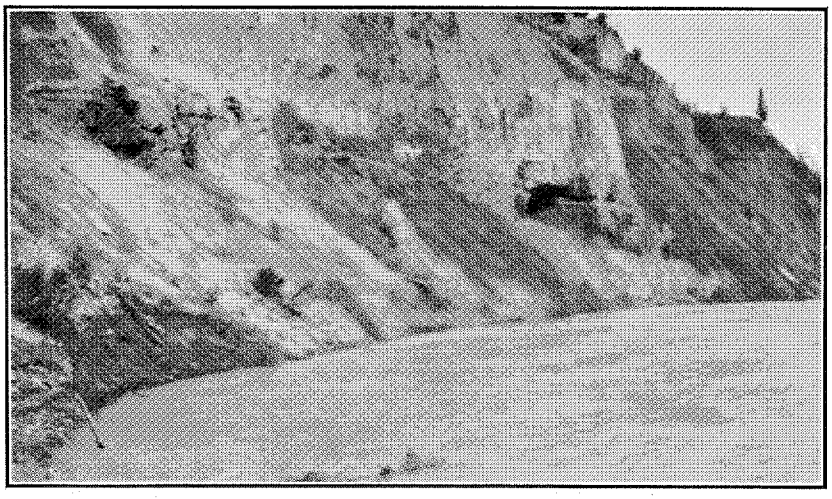
Paskapoo sandstones exposed on Pembina river near Evansburg.

Plate 1B



Paskapoo sandstones exposed on McLeod river in section 21, township 57, range 13.

Plate 1C



Coal seam in the Paskapoo beds at Rocky Rapids on the Saskatchewan river.

INDEX

LIST OF PUBLICATIONS

OF

THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA.

EDMONTON, ALBERTA

REPORTS—GEOLOGICAL SURVEY DIVISION

By Dr. J. A. Allan, Professor of Geology, University of Alberta.

No. 1 (1919); pp. 104—A summary of information with regard to the mineral resources of Alberta.

No. 2 (1920); pp. 138+14. Supplements the information contained in Report No. 1.

No. 4 (1921); GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA; pp. 72, and 6-color map (Serial No. 1). **Price $1.00.**

No. 6 (1922, Part I); GEOLOGY OF THE SAUNDERS CREEK AND NORDEGG COAL BASINS, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 76, and 2-color map (Serial No. 2). **(Out of print.)**

No. 7 (1922, Part II); AN OCCURRENCE OF IRON ON THE NORTH SHORE OF LAKE ATHABASKA, by J. A. Allan and A. E. Cameron; pp. 40; two maps (Serial Nos. 3 and 4). **Price 25 cents.**

No. 9 (1923); GEOLOGY ALONG BLACKSTONE, BRAZEAU AND PEMBINA RIVERS IN THE FOOTHILLS BELT, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 48, and 6-color map (Serial No. 5). Continuation of the field work in the area described in Report No. 6. **Price 75 cents.**

No. 11 (1924); GEOLOGY OF THE FOOTHILLS BELT BETWEEN McLEOD AND ATHABASKA RIVERS, ALBERTA, by R. L. Rutherford; pp. 61, and 8-color map (Serial No. 7). One inch to two miles. Continuation of the area described in Report No. 9. **Price 75 cents.**

No. 13; GEOLOGY OF RED DEER AND ROSEBUD SHEETS, by J. A. Allan and J. O. G. Sanderson. Two geological maps in 8 colors. Scale, one inch to three miles. Serial No. 8 Red Deer Sheet and No. 9 Rosebud Sheet. Five structure sections. **(Report in preparation.)**

Map No. 10 (1925); GEOLOGICAL MAP OF ALBERTA, by J. A. Allan. In 14 colors. Scale one inch to 25 miles.

No. 15; GEOLOGY OF THE AREA BETWEEN ATHABASKA AND EMBARRAS RIVERS, ALBERTA, by R. L. Rutherford; pp. 29 and 3-color map (Serial No. 11). One inch to two miles. Eastward extension of field survey described in Report No. 11. **Price 50 cents.**

No. 17; GEOLOGY ALONG BOW RIVER BETWEEN COCHRANE AND KANANASKIS, ALBERTA, by R. L. Rutherford; pp. 46 and 9-color map (Serial No. 12). Scale one inch to one mile. **Price $1.00, or map alone 50 cents.**

No. 19; GEOLOGY OF THE AREA BETWEEN NORTH SASKATCHEWAN AND McLEOD RIVERS, ALBERTA, by R. L. Rutherford; pp. 37 and 3-color map (Serial No. 13). Scale 1 inch to 3 miles. **Price 50 cents.**

ANNUAL REPORTS OF COUNCIL

No. 3 (for the calendar year 1920); pp. 36. **Price 5 cents.**

No. 5 (for the calendar year 1921); pp. 86. **Price 35 cents.**

No. 8 (for the calendar year 1922); pp. 64. **Price 35 cents.**

No. 10 (for the calendar year 1923) with 4-color map of Alberta coal areas; pp. 76. **Price 50 cents.** Map No. 6 only, **15 cents.**

No. 12 (for the calendar year 1924); pp. 66. **Price 35 cents.**

No. 16 (for the calendar year 1925); pp. 65. **Price 35 cents.**

No. 20 (for the calendar year 1926); pp. 53. **Price 25 cents.**

No. 22 (1927); pp. 49. Reviews the work done during 1926 under the auspices of the Research Council. Results are reported with respect to specific gravities determinations and other special tests of coals; to the coking qualities of Alberta coals; and to the briquetting of coal. Seven geological field surveys are referred to with some results of a survey in the Grand Prairie district. The use of asphalt emulsions for highway surfacing is also discussed in some detail. **Price 25 cents.**

REPORTS—FUELS

No. 10A (1923); COMBUSTION OF COAL FOR THE GENERATION OF POWER, by C. A. Robb, Professor of Mechanical Engineering, University of Alberta. Multigraphed copies only. **Price 50 cents.**

No. 14 (1925); pp. 64. ANALYSES OF ALBERTA COALS, with 18 maps and 2 charts. By E. Stansfield, R. T. Hollies, and W. P. Campbell. **Price 25 cents.**

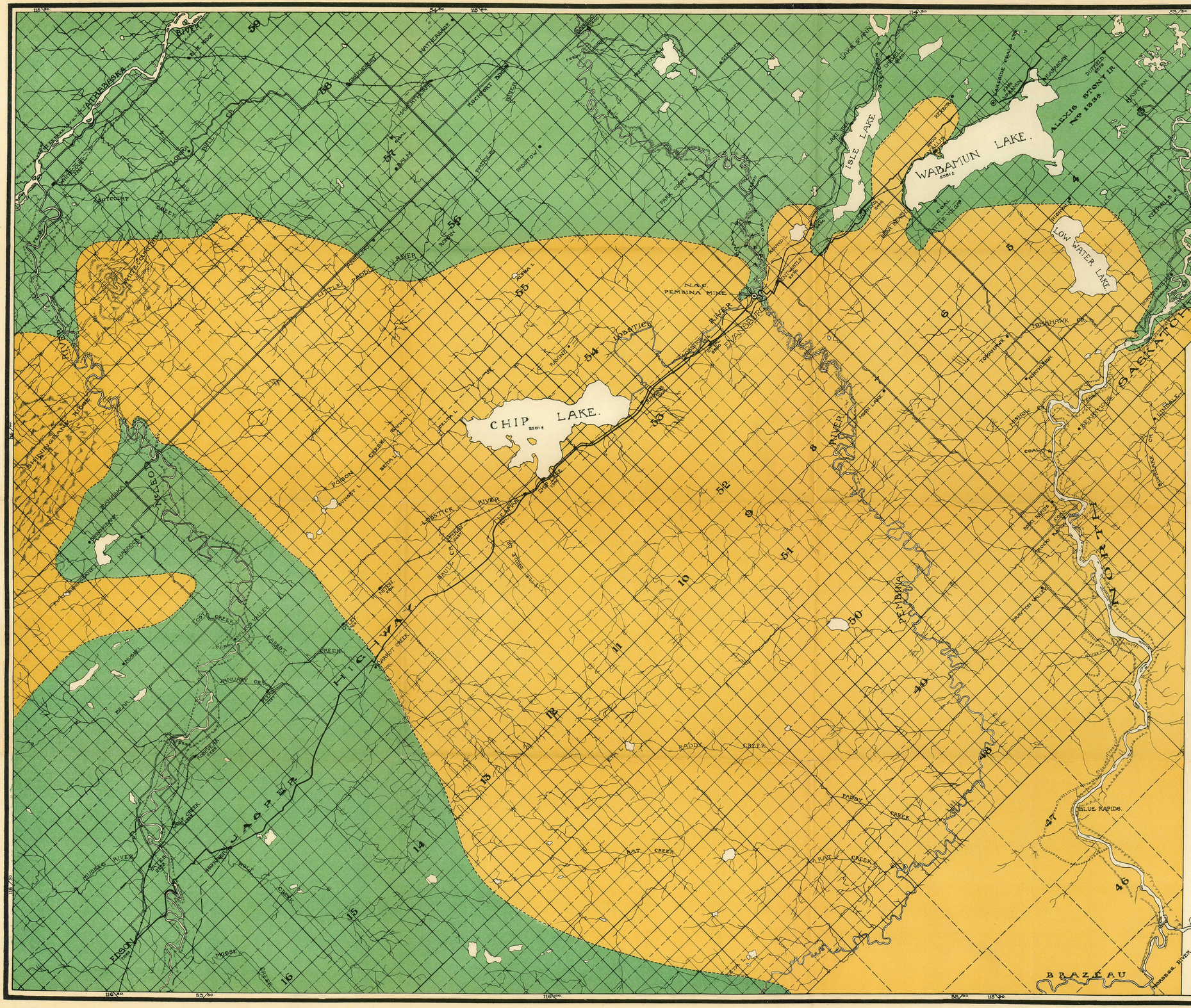
REPORTS—ROAD MATERIALS

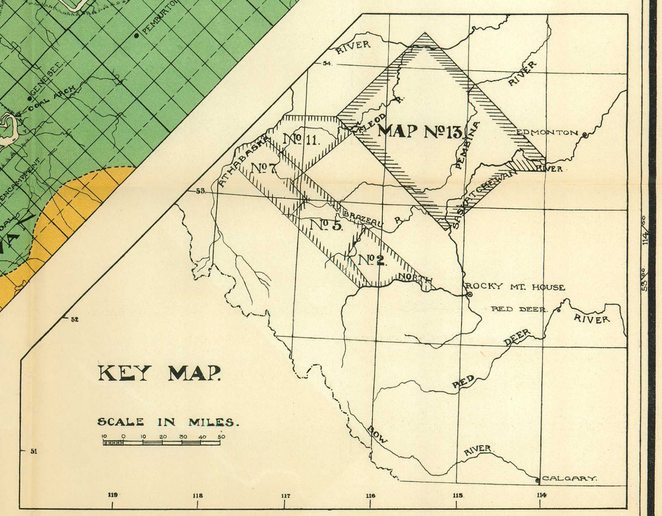
No. 18. THE BITUMINOUS SANDS OF ALBERTA, by K. A. Clark and S. M. Blair.

Part I—Occurrence, pp. 74. **Price 25 cents.**

Part II—Separation, pp. 36. **Price 25 cents.**

Part III—Utilization (in preparation).





Scientific and Industrial Research Council of Alberta

GEOLOGICAL SURVEY DIVISION

J. A. ALLAN, Geologist

GEOLOGICAL MAP

OF

THE AREA BETWEEN

NORTH SASKATCHEWAN

AND

McLEOD RIVERS

ALBERTA

LEGEND AND SYMBOLS

- Paskapoo
- Edmonton
- Geol. Boundary (APPROXIMATE)
- Main Highway
- Secondary Roads
- Abandoned Rly. Grade

SCALE. 1 inch---3 Miles

3 2 1 0 3 6

SOURCES OF INFORMATION

Geology by R. L. Rutherford 1926 and 1927

Base Map from Sectional Maps and Township Plans

To Accompany Report No. 19

1928

Map No. 13