GEOLOGY AND COAL
RESOURCES OF
SOUTHEASTERN ALBERTA

by
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and
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1977

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ABSTRACT

Investigations of relatively deep coal resources of southeastern Alberta show that four Upper Cretaceous coal zones are of interest. Two zones in the Foremost Formation, the McKay and overlying Taber, are widespread throughout the area. Seams are generally thin although coal beds in the Taber zone are locally thick in the Lake Newell, Medicine Hat and Pakowki Lake areas.

The Lethbridge zone, a prominent coal horizon at the top of the Oldman Formation, is present on both east and west flanks of the Sweetgrass Arch. It shows significant development for commercial interest only on the west flank of the structure, in the Lethbridge area.

Coal seams associated with the Horseshoe Canyon Formation are thick in a region north of Tp. 17.

Cross sections illustrate structural and stratigraphic relationships of the Upper Cretaceous strata, emphasizing the character of the included coal zones. Coal seam thickness maps are presented including indications of the best seam thickness and the aggregate footages of all seams 3 feet or more thick, in each testhole.
INTRODUCTION

A study of coal resources of southeastern Alberta was carried out in 1976 as part of a continuing coal exploration program sponsored by Alberta Energy and Natural Resources. The area of study was defined as occurring between Tps. I to 23 and R. 1 to R. 25 W4 (Fig. 1). A total of 77 test-holes were drilled to depths of between 400 and 1000 feet at a standard spacing of one hole per township. In addition, three preliminary test-holes drilled in 1975 afforded support information. The resultant data for the total program included gamma-ray, density, acoustic, neutron, self potential and dual induction focused logs. Drill cuttings were also collected and described at each site. Six testholes were cored and selected coal samples were submitted for analyses. The typical assemblage of data for the principal coreholes is provided in figure 2.

In 1977, ten additional testholes were drilled in southeastern Alberta to further evaluate the coal resources of the 1976 study area.
FIGURE 2. Core Descriptions
ACKNOWLEDGEMENTS

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J.R. Yurko supplied geological expertise during the initial stages of the program.
REGIONAL GEOLOGY AND NOMENCLATURE

Parts of three Upper Cretaceous units were evaluated during the 1976 program; the Foremost, Oldman and Horseshoe Canyon Formations. A summary of stratigraphic nomenclature used herein is presented in figure 3.

The Oldman and Foremost Formations are subdivisions of the Belly River Group and several changes in the nomenclature have taken place over the years. The older Belly River terminology was first applied by Dawson (1883) to what he described as "a series of pale, generally greyish arenaceous beds ...... which were found underlying the Pierre (Bearpaw) shales, along the Belly and Bow Rivers." Dawson (1884) informally divided his Belly River series into a "pale upper portion" and a "yellow and banded lower portion." Dowling (1917) later applied the name "Pale beds" to the upper division and introduced the name "Foremost beds" for the lower division. In addition, he included the underlying Pakowki and Milk River Formations in the Belly River series.

In 1930, Williams and Dyer reviewed and revised the stratigraphic nomenclature of the southern plains. They redefined Dawson's Belly River series as containing only the brackish water and continental deposits of the Pale beds and Foremost beds, excluding the Pakowki and Milk River beds.

Further studies of the units were carried out by Russell and Landes (1940), resulting in the name Oldman Formation being substituted for the term "Pale beds" of Dawson and Dowling. However, these workers continued the use of the term Foremost for the lower beds.

Crockford (1949) and Crockford and Clow (1965) observed that the Oldman and Foremost Formations together comprise an easily recognizable stratigraphic unit in southern Alberta but found difficulty defining the contact between the two. Further to the west in the southern Alberta Foothills, definition of a boundary was not considered possible. Therefore, the strata were
collectively referred to as the Belly River Formation.

McLean (1971) comments on work by Lerbekmo (1961), stating, "The name 'Belly River' is used by Lerbekmo as a group designation for the Oldman and Foremost Formations in the plains region, an interpretation which he indicates is generally accepted by geologists." McLean (1971) observes that 'the names 'Belly River' or 'Oldman' and 'Foremost' were applied to the same lithostratigraphic unit as 'Judith River' (Hayden, 1871), although in different regions. Precedence in use of the name 'Judith River,' ambiguity in the application of the other names, and the proven lateral continuity of this lithostratigraphic unit justify retention of the name 'Judith River' to the exclusion of the others, and its application throughout the area, including south-central, southeastern and east-central Alberta, and all regions of Saskatchewan in which the formation is present."

In spite of such a proposal some problems in the nomenclature remain unresolved. For example, there is no significant evidence that the term Judith River finds greater acceptance than the usage of Belly River. If the latter term is retained it is presently used in a formational sense in areas where the Oldman and Foremost cannot be separated, and as group status otherwise. Although this is acceptable it seems less than satisfactory for the Belly River to share a dual role in the nomenclature.

The Oldman and Foremost Formations together form an eastward-thinning sedimentary wedge, the strata of which are composed predominantly of shales, siltstones and sandstones deposited in a non-marine, deltaic environment. It is overlain by the Bearpaw Formation and underlain by the Pakowki (Lea Park) Formation. Both are westward and northward thinning wedges of marine siltstones and shales.

The Foremost Formation consists of a series of shale, siltstone, and sandstone beds with abundant carbonaceous material, concretions and coal seams. It is brackish water in origin, and has minor intercalations of freshwater
and marine beds. Lithologic variations give the formation a distinctive, banded appearance in outcrop, which is especially noticeable from a distance. Light gray sandstones, dark gray shales, black carbonaceous shales and coal seams, pale yellow silts, and rusty-colored concretionary bands form a variable succession. The beds vary in thickness from a fraction of an inch to many feet, and some persist laterally for several miles.

Crockford (1949) indicates that four zones can be recognized within the formation. He states: "In many places, the formation is divisible on lithological grounds into members or zones. At the top there is generally a zone composed of coal seams and carbonaceous shales. This zone ranges from 80 to 220 feet in thickness, and is given such local names as Taber coal horizon, Grassy Lake lignite member, Bow Island coal member and Redcliff coal zone."

"The second zone is composed of sandstones, shales, Ostrea and Corbula beds with a few beds of carbonaceous shale. This zone is 100 to 150 feet thick. On the west flank of the Sweetgrass Arch this is underlain by another coal zone approximately 30 feet thick. This lowest zone is called the McKay coal horizon and loses its identity eastward as it passes into marine equivalent of the Pakowki Formation. The McKay coal horizon is underlain by the basal Foremost sandstone locally called the Verdigris sandstone from its occurrence in Verdigris Coulee near the town of Milk River."

The Oldman Formation, also known as the Pale Beds, is typically composed of light-colored sandstones and shales. Although the color of individual beds range from pale gray to dark brown, the general tone of outcrops, seen from a distance, is light greenish gray. The coarser beds commonly show striking crossbedding and other evidence of stream deposition, and are rather lenticular. Fossil invertebrates are almost exclusively fresh and brackish water forms and are confined to the very top of the formation.
The Formation may be divided into two members according to Crockford (1949): an upper coaly and carbonaceous member mainly of brackish-water origin varying in thickness from a few feet to 80 feet or more and commonly referred to as the Lethbridge Member, and a lower member which consists essentially of sandstones and shales. The lower sandstone and shale member makes up the majority of the Oldman Formation. The sandstones are generally poorly cemented by clay minerals and are easily weathered. They are usually fine-to medium-grained and very lenticular with poor lateral persistency. Individual sandstone lenses up to 15 to 20 feet thick are common and are typically brown weathering.

Considerable discussion has been generated regarding the contact between the Oldman and Foremost beds. Dowling (1917) states, "The contact of the Foremost beds with the Pale beds (Oldman Formation) is gradational rather than abrupt and cannot be used as a horizon for detailed mapping." In early mapping the color change between the Pale beds (Oldman Formation) and the Yellow beds (Foremost Formation) was used, however, this is not a useful method in subsurface work. Crockford (1949) says of his cross sections across the southern plains: "The varying stratigraphic position of the Oldman-Foremost contact is placed at the top of the uppermost prominent carbonaceous bed and at the place where the color change in sediments is most apparent."

McLean (1971) lists the characteristics for differentiation of the Oldman and Foremost Formations. The most significant differences include:

a. Oldman strata are generally lighter-colored.

b. Coal and carbonaceous beds are more prevalent throughout the Foremost beds, whereas coal is common only in the uppermost portion of the Oldman Formation.

c. Cross-bedding is more common in the Oldman Formation.

d. Fossils, mainly brackish-water types are common in the Foremost Formation, while fresh-water types prevail in the Oldman Formation.
For the purpose of this report the contact is placed immediately above the top of the Taber coal horizon and below basal Oldman sandstones. As will be shown later, this horizon is relatively easy to recognize, remains at a consistent stratigraphic position, and is not dependent upon coloration parameters for definition.

The contact of the Bearpaw and Oldman Formations is ordinarily sharp and easy to identify whereas the contact between the Foremost and Pakowki beds is not always obvious. Crockford (1949) placed the basal contact of the Foremost at the base of the lowest prominent sandstone below the lowest carbonaceous bed, and above marine shales.

The Horseshoe Canyon formational terminology is derived from Irish (1970). A generalized description of the stratigraphy and historical development of nomenclature for this unit is included in Holter, Chu and Yurko (1975). The 1976 drilling program, as applied to investigation of the Horseshoe Canyon Formation is, in fact, an extension of this work. South of the area in which drilling was carried out the nomenclature changes. The St. Mary River Formation (Dawson, 1884), together with the underlying massive sandstones of the Blood Reserve Formation (Russell, 1932), are equivalent to the Horseshoe Canyon and occur immediately above the marine Bearpaw Formation.

The predominant structure within the area is the Sweetgrass Arch, a north plunging anticline which trends north-northeast (Fig. 4). Its southern culmination is the uplift of Little Belt Mountains, southeast of Great Falls, Montana, within which Paleozoic and older rocks are brought to surface. In Alberta the arch is broader and the axis bifurcates to also form a northeast trending branch called the Bow Island Arch (Tovell, 1958; McLean, 1971). The anticlinal plunge averages 20 to 30 feet to the mile to the north, although southerly bedding dips are very exceptional. Essentially, the southern Alberta plains are structurally part of the northern flank of the Kevin-Sunburst dome.
The Sweetgrass Arch in southern Alberta bears a number of subsidiary folds. Along the western margin of the area the dips increase to between 50 to 100 feet per mile and this continues to the axis of the Alberta syncline which lies west of the arch. Subsidiary folds also occur on the flanks of the Alberta syncline, most of them having a trend that parallels the axis of the main structure. Many small local structures are present within the study area and these are documented by Russell and Landes (1940).
COAL MINES

A number of small mines formerly produced subbituminous coal within the study area and figure 5 illustrates the distribution of the mines (including some parcels licensed for mining) in relationship to the regional geology. The mine information is derived from Campbell (1964) and locations are plotted to no greater detail than whole sections enclosing the individual mines.

Abandoned Foremost mines are widely scattered throughout the area (see Campbell, 1964, 1974). Mines near Taber (Tp. 10, R. 16 W4) were operating until recently. Coal mining operations of note were also active south of Brooks (Tp. 14, R. 13 W4), south of Suffield (Tp. 12, R. 10 W4) and at Medicine Hat.

Coal mines producing from the Lethbridge Member of the Oldman Formation were centred in two main regions. Considerable mining was formerly carried out in the Lethbridge area, almost exclusively by underground methods. Detailed information on the coal field is available in Crawford (1947). The Bow City area (Tp. 17, R. 17 W4) has been active until the present with strip mining being carried out to meet the light demands for a local domestic coal supply.

The most important Horseshoe Canyon mines were located in the McGregor Lake - Travers Reservoir areas (particularly Tp. 14, R. 21 W4). Significant mine sites were also located near Vulcan (Tp. 15, R. 23 W4), Cluny (Tp. 21, R. 21 W4), and Bassano (Tp. 20, R. 19 W4). More detailed descriptive information is available from Campbell and Almadi (1964).
The lateral persistence of the Foremost coal seams has been demonstrated to some extent by Crockford (1949) between an area south of Lethbridge to Medicine Hat, and between Farrow (Tp. 20, R. 25 W4) and McNeill (Tp. 20, R. 1 W4). Considerable useful detail was furnished from outcrop studies along the South Saskatchewan River between Bow Island (Tp. 11, R. 11 W4) and Medicine Hat.

Shallow occurrences of Upper Cretaceous coals in southeastern Alberta were investigated and reported on by Campbell (1974). An emphasis was placed on the study of Foremost coals and comprehensive shallow drilling coverage is provided in the report. No specific studies were devoted to correlation of the zones but the widespread distribution of seams is apparent.

Structure cross sections 1 to 5 (Figs. 7 to 10) illustrate the relationships of coal zones along an east-west line across the study area.

The McKay zone shows significant development over much of the area and varies from 70 to 90 feet in thickness. As many as eight thin seams have been noted within this unit. The zone normally occurs 200 to 250 feet below the Taber zone. To the east the McKay is not present due to lateral facies changes to deltaic sandstone and Pakowki marine shales. The shales occur progressively higher in the stratigraphic section towards the east to such an extent that the McKay disappears and the Taber zone is located immediately above the Pakowki Formation within the southeastern portion of the study area.

The Taber zone is the highest indication of coal in the Foremost and varies between 60 and 100 feet thick where it is not influenced by post-Cretaceous erosion. As many as five seams are present in the zone, although few exceed three feet in thickness. Along the lines of section
chosen for study the Taber zone is consistently developed with the exception of a region between Tps. 13 and 15. Extensive erosion has removed the upper part of the Foremost Formation here.

Section A-B (Fig. 11) confirms the existence of the Taber zone towards an area south of Medicine Hat. The additional 1977 drilling in the extreme southeast corner of the province, in townships 2 and 3, range 1 to 3 west of fourth meridian, indicates thinning of the Taber zone in this direction.

Only very minor stringers of coal were noted between the Taber and McKay zones throughout the area.
OLDMAN FORMATION COAL SEAMS

The upper part of the Oldman Formation was penetrated in several testholes on the west flank of the Sweetgrass Arch along a line between the Magrath area (Tp. 4, R. 21 W4) and the Bassano region (Tp. 22, R. 17 W4; see figures 6, 12, 13 and 14). The major coal seams associated with the formation occur in the Lethbridge Member, as delineated by Russell and Landes (1940). The member underlies the Bearpaw Formation and is up to 80 feet thick. For the purpose of this report only that portion of the member that includes all the significant coal seams and carbonaceous beds is outlined and is herein called the Lethbridge coal zone. In most cases the zonal and member units are approximately the same. The zone is present across the entire area and may include up to 60 feet of strata including as many as four coal seams. The seams are generally thin and lack lateral persistence except in the Lethbridge area. The major seam in the Lethbridge area has been referred to as the Lethbridge (Crawford, 1947) or Galt seam and is readily traceable between Tps. 7 and 12. North of this area seams are thin and erratically developed with the exception of Tps. 16 and 17 where the coal beds are locally thick.

One supplementary testhole was drilled in 1977 in the north central region of the study area (Tp. 20, R. 15 W4). In this testhole (12-77) a four-foot seam of the Lethbridge coal zone was encountered. The 1976 testhole to the west of hole 12-77 (76-76) showed two and three-foot seams, which may suggest an eastward thickening of the Lethbridge zone in this area. Further drilling to the east of this hole 12-77 could provide valuable information about the Lethbridge zone, however, due to the restrictions on drilling in the Suffield gas block, no holes were drilled in this area.

The Lethbridge coal zone was tested on the eastern flank of the Sweetgrass Arch at three locations (THs. 102, 103 and 107-76). The zone is prominently developed but considerably thinner than to the west. The included seams are thin and erratic. Supplementary test drilling on this eastern flank in 1977 (THs. 2, 4, 6, 7, and 8-77) confirmed the eastward thinning of the Lethbridge coal zone.
HORSESHOE CANYON FORMATION COAL SEAMS

A drilling pattern was established between Hussar (Tp. 24, R. 20 W4) to Lethbridge to evaluate the Horseshoe Canyon coal seams. Well control and lines of section are shown in figure 6. Cross sections H to K (Figs. 16, 17 and 18) illustrate correlative units between the study area of Holter, Chu and Yurko (1976; TH 95-75, NE Sec. 20-24-20 W4) and the southern limits of coal occurrences. The coal-bearing intervals adopted herein are similar to those employed in this previous study. They are arbitrary groupings of seams and stringers separated by relatively barren sections of strata.

Relationships between the well-documented Drumheller area and the region of test hole 95-75 are poorly understood because of the general absence of coal in the intervening area. Between one and four coal-bearing intervals are defined within the study area to as far south as Tp. 13. To the south of this area the coal is largely absent due to nondeposition.

The more prominent coal seams occur within approximately 150 feet of stratigraphic section 30 to 300 feet above the underlying Bearpaw Formation.
COAL RESOURCES

The widespread nature of the drilling program limits the degree to which specific estimates of coal reserves can be carried out. Several generalizations can be made, however, with regards to the distribution of coal and the areas of better development of the seams. Figure 19 shows the thickness and depth parameters for the best (thickest) coal seam in each of the testholes. The values given on the map include the thicknesses of shale partings. Data on the aggregate thickness of coal penetrated at each drill site is presented on figure 20.

Coal seams in the Foremost Formation are generally thin, seldom exceeding 4 feet in thickness. The only areas which contain significant coal beds as delineated by this study are: south and east of Lake Newell (Tps. 12 to 14, R. 15 and 16 W4), south and west of Medicine Hat (Tps. 6 to 8, R. 11 to R. 13 W4) and north of Pakowki Lake (Tp. 7, R. 7 W4).

Aggregate thicknesses of seams are greatest in the same areas as those outlined for the "best" seams. The numbers of seams 3 feet thick or greater present in any given testhole may vary between one and four. A table listing individual seam thicknesses and depths is provided with figure 20.

Thick seams of coal within the Lethbridge zone are restricted to a limited area west and north of Lethbridge. The maximum amount encountered was 10 feet in the Galt seam in TH 29-76 (NE 11-8-11-21 W4). Because of the relatively abrupt change in dip towards the west the depth to the zone increases sharply away from the subcrop region. Seams of commercial thickness are undoubtedly present west of R. 23 W4 but no efforts were made to evaluate such deep western occurrences. No individual Lethbridge zone seams of commercial thickness were encountered elsewhere within the area.
The thicknesses of the best coal seams associated with the Horseshoe Canyon Formation may be as much as 14 feet (TH 56-76, NE 21-18-23 W4). Average values are much lower, however, and thicknesses of 5 feet or slightly greater are confined to Tp. 15, R. 22 W4 and areas immediately north and south of the Crowfoot Indian Reserve (Tps. 19 to 23). The depths of these seams are highly variable, ranging from 189 to 877 feet.
CONCLUSIONS

Four prominent Upper Cretaceous coal-bearing units are recognized within the study area; the McKay and Taber zones of the Foremost Formation, the Lethbridge zone of the Oldman Formation, and the Horseshoe Canyon Formation. The north plunging Sweetgrass Arch divides the study area into two structural regions. The Taber zone is more or less uniformly developed across the entire area whereas the McKay zone disappears to the east due to the lateral change of basal Foremost beds to marine facies of the underlying Pakowki Formation. Seams in both zones are generally thin and of limited economic significance. Some thick coal beds are found in the Taber zone, however, and these are located in the Lake Newell, Medicine Hat and Pakowki Lake areas.

The Lethbridge coal zone is recognized on both sides of the arch but is of greatest commercial interest on the western flank, particularly in the Lethbridge area.

Coal seams in the Horseshoe Canyon Formation are well developed in the northwest part of the study area, on the west side of the Sweetgrass Arch.
REFERENCES


LEGEND

TERTIARY AND CRETACEOUS
Cc Cypress Hills Formation
Tkc - R einazor Formation
Tkp Paskapoo Formation
Tkw Willow Creek Formation

CRETACEOUS

Kom St Mary River Formation
Kmp Blood Reserve Formation
Kmc Horseshoe Canyon Formation
(including Whitewood and Battle Formations)

CRETACEOUS (cont.)

Krb Whitewood and Battle Formations
Keb Entrada Formation
Kbt Bearpaw Formation
Kom Oldman Formation
Kfm Foremost Formation
Kpk Pekisko Formation
Kmr Milk River Formation

Geology after Irish, 1950; Russell, 1940; and Stewart, 1943

FIGURE 6
AREA OF STUDY AND LINES OF CROSS SECTION

SYMBOLS

- 1976 Test Hole
- 1975 Test Hole
- 1977 Core Hole

Black Unit Boundary
1977 Test Hole

SCALE

0 5 10 15 20 25 30 35 40 KILOMETRES

To accompany Alberta Research Council Research by M.E. Moher and M. Chu
FIGURE 16
CROSS SECTION H-I
Date: April 20...