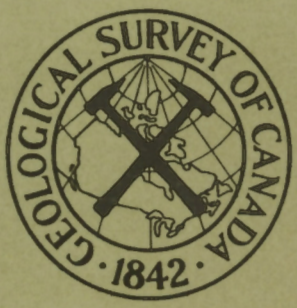

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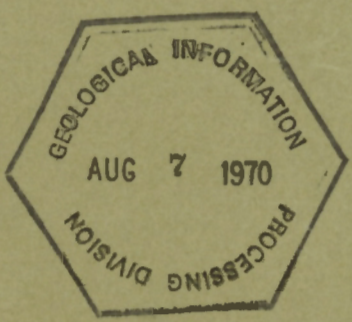

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B. A. Latour
GEOLOGICAL SURVEY OF CANADA

L. P. Chrismas
MINERAL RESOURCES BRANCH

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ABSTRACT

This report contains the results of the preliminary phase of the revision of coal resources in western Canada. The final phase of the resource study will comprise a total revision of all the resource categories (measured, indicated and inferred). The estimates of measured resources given in this paper will soon be obsolete owing to the widespread exploration in the west to prove up more resources of coking coal.

The measured coal resources of western Canada in the ground as of January 1, 1970 are estimated to total 9.8 billion tons. The resources of all categories (measured, indicated and inferred) are estimated to total 118.7 billion tons of which measured resources comprise 8.3 per cent. An older estimate of probable and possible resources prepared by B.R. MacKay in 1946 was reassessed in the light of information obtained while compiling the measured resources. The bulk of the measured resources of low and medium volatile bituminous coal, which reflects potential coking-coal resources, are located in southeastern British Columbia. Unlike the mountain areas of Alberta which are relatively inaccessible and unexplored, this part of British Columbia has received considerable attention. Considering the vast amount of unexplored land in the mountain belt of Alberta it is likely that the resources of this area will be increased substantially.

It is estimated that only 7 per cent of the measured resources of bituminous coal can be mined by surface methods, whereas all the measured subbituminous resources in Alberta and measured lignite resources in Saskatchewan lie sufficiently close to the surface for mining by surface methods.

PRELIMINARY ESTIMATE OF MEASURED COAL RESOURCES INCLUDING REASSESSMENT OF INDICATED AND INFERRED RESOURCES IN WESTERN CANADA

INTRODUCTION

This report is the first compilation of the measured coal resources in British Columbia, Alberta and Saskatchewan and includes a reassessment, based on recent data, of the probable and possible resources that were estimated in 1946.

It is intended that this preliminary paper will serve as an interim report until completion of the second phase of resource compilation, which will include detailed evaluation of all categories of resources (measured, indicated and inferred). This study originated as part of a preliminary investigation by Canada to determine the country's total energy resources comprising coal, petroleum, natural gas, uranium and water.

With the growing activity in the western Canada coal industry, a revision of coal resources for western Canada is timely. There has been rapid advancement in geological mapping and exploratory drilling, particularly in recent years, which has added to our knowledge of the coal deposits. Changes in mining technology and methods, increasing world demand for coal, and new requirements of coal quality by the consumer have all affected the exploration and exploitation of our coal resources.

The first estimate of coal resources in Canada was prepared by Dowling (1913) for the 12th International Geological Congress. Dowling estimated Canada's resources at more than 1.3 trillion tons* based on coal seams with a minimum thickness of one foot to a maximum depth of 4,000 feet from surface. A far more comprehensive study of Canada's coal resources was published by MacKay (1947) for the Royal Commission on Coal, 1946. MacKay's estimate of 49 billion tons of recoverable coal or 99 billion tons of coal in place was less than 10 per cent of Dowling's estimate. The reason for MacKay's lower estimate was that he used seam thicknesses and depths of cover that varied from coalfield to coalfield and did not include seams less than three feet thick. A later revision of MacKay's was made by Latour in 1960 for the Royal Commission on Coal, 1959. Latour included only a few changes where new information was available and also took into account tonnage produced between 1946 and 1959. Some of the economic factors that contributed to changes in the resources of some coal areas were discussed also. In the earlier coal resource studies no attempt was made to report resources of the measured or proven category. MacKay's report categorized the resources as being either probable or possible. This report is the first study in which measured resources have been tabulated.

To make this study possible in a very limited time required ready access to the necessary detailed information. Such information, much of it

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* The short ton (2,000 pounds) is used throughout unless otherwise noted.

of a confidential nature, was freely provided by companies actively engaged in coal mining and/or coal exploration and by various Provincial government departments and agencies. The writers are grateful to all those who so generously provided information and assistance.

DEFINITIONS

In order to produce uniform results in preparing the measured resource estimates, a set of definitions and standardized procedures were adopted and followed. The definitions are similar to those used by the United States for their coal resource study completed in 1969 (see Averitt, 1969).

All the coal resource estimates are classified according to three categories based on the relative abundance and reliability of data. The categories are measured, indicated and inferred and are defined as follows:

Measured or Proven Resources

Measured resources are those for which tonnage is computed from dimensions revealed in outcrops, trenches, mine workings and drillholes. The points of observation and measurement are so closely spaced, and the thickness and extent of the coal are so well defined, that the computed tonnage is judged to be accurate within 20 per cent of the true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of coal differs from region to region according to the character of the coal beds, the points of observation are, in general, about half a mile apart.

Indicated or Probable Resources

Indicated resources are those for which tonnage is computed partly from specific measurements and partly from projection of visible data from a reasonable distance on the basis of geologic evidence. In general, the points of observation are about 1 mile apart, but they may be as much as 1 1/2 miles apart for beds of known continuity.

Inferred or Possible Resources

Inferred resources are those for which quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region and for which few measurements of bed thickness are available. The estimates are based primarily on an assumed continuity in areas remote from outcrops of beds, which in areas near outcrops were used to calculate tonnage classed as measured or indicated. In general, inferred coal lies more than 2 miles from the outcrop or from points for which mining or drilling information is available.

The indicated and inferred categories are equivalent respectively to probable and possible resource categories defined and used by MacKay. MacKay's definitions are listed below for comparison with definitions used in this study.

Probable Resources

Coal resources which by direct mining experience and by drilling continuity to existing workings and areas drilled, or extensive geological data can be reasonably expected to exist.

Possible Resources

Coal resources additional to probable resources and include coal, the reasonable existence of which is based on limited geological data and

prospecting, and coal, the recovery of which is problematical due to its inferior quality and/or its relative inaccessibility.

Classification According to Rank of Coal

The classification of coals by rank is based on the percentage of fixed carbon and calorific value (expressed in Btu per pound) calculated on the mineral matter-free basis. The rank classification scheme used for this study is that established by the American Society for Testing and Materials (A.S.T.M.,1966). This classification is shown in Table 1. Although the A.S.T.M. classification has been widely used in North America, it is not a completely suitable standard for western Canada coals. Analyses of bituminous coals from the mountains often indicate overlapping of low and medium volatile coal.

All four classes of coal (anthracitic, bituminous, subbituminous and lignitic) are found in western Canada. Because the resources of anthracite which occur only in Alberta, are small, they have been included here in the bituminous class. Classification of the resources according to the groups within the various classes, such as subdividing the bituminous class into low, medium and high volatile groups, was not considered appropriate because in western Canada the rank of an individual bituminous seam may fluctuate between medium and low volatility. In general the low and medium volatile bituminous coals occur in the westernmost part of Alberta and the easternmost part of British Columbia whereas the high volatile bituminous coal occurs in the Foothills Belt of Alberta and other small areas scattered throughout British Columbia. Consequently, for this study the bituminous coal resources were subdivided into two groups, low and medium volatile bituminous as one and high volatile bituminous as the other (see Fig. 1 for areal distribution).

Although classification of Canadian coal resources was compiled according to A.S.T.M. standards (1969) the resources can also be classified according to grade or quality, which is determined by the amount of ash, sulphur or other deleterious constituents in the coal. For this study specific data were not recorded regarding the actual coal quality of the resources. Considerable information is available (Tibbetts and Lloyd, 1969; Swartzman, 1956), however, to demonstrate that coals in western Canada are generally low in sulphur. In fact, rarely does a western Canada coal have greater than 1.0 per cent sulphur. The maximum ash content reported by the companies for subbituminous coals was 30 per cent and for bituminous coal this figure was considerably less.

Specific Gravity of Coal

In order to standardize the tonnages reported by each company and to determine the weight of unbroken coal in the ground, apparent specific gravities, as given in Table 2, were used in determining the measured resources for coal of different rank. This is in contrast to the study by MacKay where an average apparent specific gravity of 1.29 was used in calculating the probable and possible resources for all ranks of coal. For this study MacKay's resource estimates were adjusted to correspond to the specific gravities used here.

TABLE 1

SUMMARIZED A.S.T.M. CLASSIFICATION OF COALS BY RANK

Class Group	Fixed Carbon* per cent		Volatile Matter* per cent		Calorific* Value Btu	
	Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than
Anthracitic	86			14		
Bituminous						
Low volatile bituminous	78	86	14	22		
Medium volatile bituminous	69	78	22	31		
High volatile bituminous		69	31		10,500	14,000
Subbituminous					8,300	11,500
Lignitic					6,300	8,300

* - Dry, Mineral – Matter Free Basis

TABLE 2

SPECIFIC GRAVITY AND WEIGHT OF COAL OF DIFFERENT RANKS

Rank	Sp. Gr.	Tons per Acre Foot	Tons per sq. Mile Foot
Anthracite	1.47	2,000	1,280,000
Bituminous	1.32	1,800	1,152,000
Subbituminous	1.30	1,770	1,132,000
Lignite	1.29	1,750	1,120,000

(From Averitt, 1969)

Thickness of Coal Seams

The total thickness of coal seams used in calculating tonnages for the measured resources does not include rock partings (layers of shale, sandstone or other noncombustible mineral matter) that are one foot or

greater in thickness. Rock partings less than one foot thick were included in the total seam thickness since in mining it is difficult to separate thin partings from the coal.

For the Saskatchewan and Alberta plains area seams three feet thick, as reported by MacKay, were not included in this survey. Probable and possible resources of MacKay's were converted to indicated and inferred categories only when the reported seam thickness was greater than five feet. For the Foothills Belt of Alberta and the mountain areas of Alberta and British Columbia the minimum seam thickness used in calculating reserves was five feet. The thickness of the coal seams reported by the companies in nearly all instances, was greater than the cut-off limit imposed for this study.

Stripping versus Underground Resources

In the plains areas of Saskatchewan and Alberta all the measured resources are potentially mineable by strip-mining methods under present economic and technologic conditions. All measured resources lie within 150 feet of the surface and it is conservatively estimated that the average depth of the measured resources given in this report lie between 50 and 100 feet from surface. In most cases companies proving up measured resources by drilling have not attempted to outline resources at depths in excess of 150 feet.

In the foothills and mountain areas of Alberta and British Columbia and in the interior of British Columbia, the measured resources occur as both stripping-coal and underground-coal resources. A few companies are not yet in a position to report resources on the basis of mining methods, therefore it was not possible to list actual tonnages mineable by strip and by underground methods for this report. Based on limited information from selected properties in the producing or near producing stages, however, it is estimated that seven per cent of the measured resources of coking coal can be mined by strip methods and the remainder by underground methods.

It should be emphasized that, although coal in the measured resource category reflects mineable resources under present conditions, these resources are not totally recoverable. No attempt was made to apply a recovery percentage of any of the resource estimates. To use current recovery percentages might not be applicable to coal resources that will not be mined until some date in the distant future in light of changing technology and related economic factors. Coal that might not be recoverable today at competitive costs may become competitive in the future. However, current average recovery percentages established in the context of today's technology and economics should be reasonably applicable to coal deposits that are presently mineable. In both Canada and the United States it is generally accepted that strip-mining yields an average recovery of about 80 per cent as compared to 57 per cent (Lowrie, 1968) for underground mining.

PROCEDURE FOR GATHERING MEASURED RESOURCE DATA

In order to ascertain as quickly as possible the measured resources of coal in western Canada, each company was asked for specific data relating to its property. Estimates of coal resources in the ground according to the

definition of measured resources was obtained from most companies. The reliability of the data was assessed in each case by determining the spacing of control data such as drillholes, outcrops, adits and trenches. Also considered were specific gravity, thickness of overburden for strip-coal resources and thickness of coal seams. In other cases, resources were calculated from technical data such as drill logs and coal isopach maps and compared with data obtained from the company. Reliability of the tonnage calculations was determined by comparison with data obtained from other companies for the same area.

Resource estimates could have been tabulated for areas much smaller than the broad areas used in this report. However, the broad areas were deliberately used in order to ensure the anonymity of the confidential information provided by the companies so that the resources of an area cannot be identified as those of a specific company.

In Canada, it is normally not considered to be the responsibility of the federal or provincial governments to carry out field programs including drilling to prove up measured coal resources. However, the Research Council of Alberta, as part of a continuing industry-supported survey of the province's potential strip-coal resources, is in the process of assessing Alberta's coal resources based on drillholes spaced on 2-mile centres. This, of course, is not close enough to determine resources of the measured category according to the definition used for this report.

DISTRIBUTION OF RESOURCES

Coal resources in western Canada are estimated at 118.7 billion tons of coal in place as shown in Table 3. Of this total 8.3 per cent or 9.8 billion tons are considered measured resources; 42.4 per cent or 50.3 billion tons are indicated resources; and 49.3 per cent or 58.6 billion tons are inferred.

For the three western provinces the resources are divided as follows: British Columbia 50.1 per cent, Alberta 39.8 per cent and Saskatchewan 10.1 per cent. Alberta contains by far the largest distribution of coal. Many areas in Alberta, wherein coal measures are known to occur, have not been readily accessible. Thus, future exploration will undoubtedly add to Alberta's resources.

In Figure 1 the general areal distribution by rank of high potential coal deposits of western Canada is shown. Estimated resources by rank and province are tabulated in Table 4. Low and medium volatile bituminous coal, which constitutes the largest resource according to rank, makes up 72.6 per cent of the total resources. Resources of low and medium volatile bituminous coal reflects potential resources of coking coal located mainly in the Inner Foothills Belt of Alberta and in southeastern British Columbia. High volatile bituminous coal resources occurring in the interior basins of British Columbia and the Outer Foothills Belt of Alberta make up 8.1 per cent of the total resources. Subbituminous coal representing 8.4 per cent of the total resources occurs only in the plains area of Alberta. Lignite coal comprises 10.9 per cent of the total western Canada resources. Most of the lignite coal is contained in the extensive coal measures in southern Saskatchewan but a small deposit of lignite coal is known in a basin in central British Columbia.

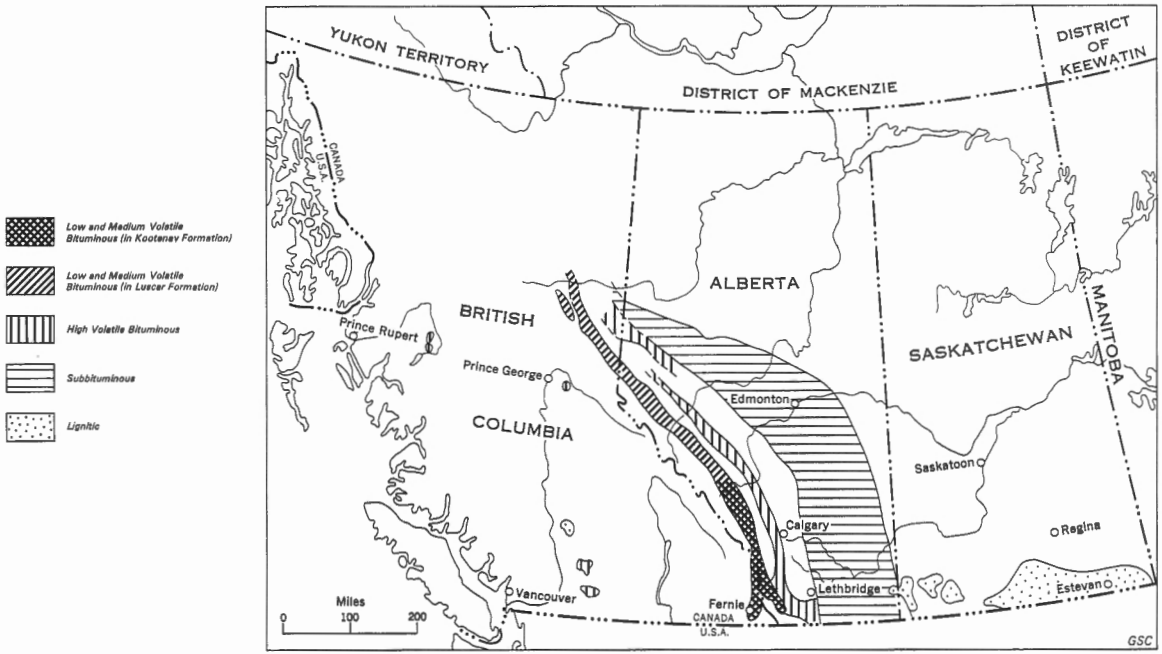

Figure 1. General areal distribution by rank of high potential coal deposits of western Canada.

British Columbia

In the last few years a great flurry of exploration and development by a number of companies has added significantly to our knowledge of the coal resources of southeastern British Columbia. The province now ranks first in terms of measured and total coal possessing some 50 per cent of western Canada's resources. Although the province contains many small widely distributed, coal deposits, recent activity has been directed mainly at the more extensive deposits in southeastern British Columbia.

Southeastern Area

The coal deposits of the southeastern part of the province are situated near the Alberta-British Columbia border adjacent to the Crowsnest coalfield of Alberta. In fact, the southeastern coal deposits are an extension of the Inner Foothills Coal Belt of Alberta being displaced by a large thrust fault.

In this region there are two significant areas of occurrence. The first and most important is the Fernie coal basin within the Crowsnest coalfield. For the most part coal in this area is medium volatile bituminous in rank although it does range into the low volatile bituminous rank. Most of this coal makes excellent metallurgical coke and it is on this basis that coal companies have recently signed long term contracts for the export of large volumes of coking coal to Japan. It is anticipated that additional sales for export will be forthcoming for coal from this area, which at present contains Canada's largest known resources of coking coal. In the vicinity of Natal, within the Fernie coal basin, coal mining has been carried on for many years by underground and strip methods. Here the coal seams range up to 50 feet in thickness and average about 20 feet.

The second area of importance is a new area so far as past production is concerned. It is the Upper Elk River area, which lies 30 miles north of Natal. Although this area does not have a history of production, a number of companies have been active in attempting to outline measured resources along the Elk Valley.

Based on information obtained during this study, resources that were previously assigned by MacKay to the Flathead River area were eliminated.

South-central Area

Only three small coal basins, Tulameen, Merritt-Nicola and Hat Creek contain measured resources in south-central British Columbia. The thick, near-surface coal seams at Hat Creek are lignitic and represent a large potential energy resource for thermal power generation. The other two deposits contain high volatile bituminous coal which has only weak coking characteristics, but possibly may be blended with other coking coals to produce a suitable metallurgical coke. In both Tulameen and Merritt districts coal production has been intermittent during the last 50 years. MacKay, in his 1946 resource estimate, included resources for some of the smaller detached basins in this area. Coal in these areas has not been included as resources because the information does not meet the standards set for inclusion as a resource.

Central Area

The only areas in central British Columbia considered to contain coal resources are the Telkwa area and Bowron River areas. All other areas which MacKay used in his resource estimate have been eliminated. The resources shown in Table 5 are extremely small and consist of high volatile bituminous coal. For many years coal has been mined from the Smithers area mainly for local markets.

Northeastern Area

The coal resources of northeastern British Columbia occur in two small basins, Butler Ridge to the north of the Peace River and Hasler Creek to the south. These basins are part of what is commonly referred to as the Peace River Coalfield. Although the resource potential of this area is fairly small a number of mining exploration companies are evaluating the coal occurrences of the area.

Alberta

The preliminary estimate of the coal resources of Alberta indicates that the province contains about 40 per cent of the coal resources in western Canada or about 47 billion tons. Most of the resources are of bituminous coal, but coals of all ranks from lignitic to anthracitic occur in the province. High volatile bituminous and higher rank coals, which constitute the greatest part of the resources, are located in the foothills belt and the mountain areas, whereas the subbituminous resources occur in the central plains.

Because of the wide distribution of coal in Alberta the coal resources are listed according to three main districts: Plains Region, Outer Foothills Belt and Inner Foothills Belt.

Plains Region

The generally flat-lying seams of subbituminous coal of the Plains Region occur in both the Upper Cretaceous Edmonton Formation and Belly River Group rocks. For the most part the coal resources for this region are considered to represent those that can be recovered by strip-mining technique. Previously, the Drumheller and Edmonton areas were the main producing areas in this region and, most of the coal was produced from underground mines. Now, only a small mine in the Drumheller area and a small mine in the Edmonton area produce underground coal, and the bulk of current production is supplied from strip mines in the Halkirk-Forestburg and Wabamun Lake districts.

It was thought that the coal seams underlying the Plains Region maintained their thicknesses over large areas with only very minor disturbance. Recent exploration suggests that though the coal zones are persistent over large areas the seams within the zones are quite lensy. Also, in some instances glaciation has partially or entirely eroded the near surface seams and in other instances has fractured the coal, caused pronounced undulations in the roof and floor of the seam or faulted the seam with considerable distortion.

In the Plains Region the opportunity exists for the delineation of far more coal resources, but the problem is the mantle of glacial drift that covers the bedrock throughout most of the area. Delineation of coal resources requires detailed drilling which the companies are not prepared to do until they can foresee much larger potential markets for subbituminous coal. The present main use of subbituminous coal is for mine-site thermal power generation. Therefore development will to a large extent depend on an adequate reservoir of water before development of much of the coal resources can begin.

Outer Foothills Belt

The Outer Foothills Belt contains coal of high volatile bituminous rank. This coal is not good coking coal and, in the past, was used in large quantities by the railways, as well as for residential and industrial fuel. Most of the production in this belt came from the Coalspur and Saunders areas with small amounts from the Pincher Creek and Pekisko areas. No mines are presently producing in this belt, and little or no exploration or development is being done as indicated by the absence of measured resources for this area in Table 6.

Inner Foothills Belt

Alberta's largest coal resources lie within this region. The Inner Foothills has been subdivided into two groups: (1) southern part, which is defined by the areal distribution of the coal-bearing Kootenay Formation; (2) northern part, which is defined by the areal distribution of the coal-bearing Luscar Formation. The coal within these groups ranges from medium to low volatile bituminous in rank and much of it is suitable for carbonizing for the metallurgical market. Mines that are presently producing coal in this belt are located at Coleman in the Crowsnest area, at Canmore in the Cascade area, at Luscar in the Mountain Park area, and at Grande Cache in the Smoky River area. Considerable exploration is being done along the total length of the belt.

The coal measures in this belt are exceedingly folded and faulted resulting in extreme irregularity in seam thickness and sometimes complete truncation of the seams. Mining is difficult owing to the frequently encountered methane gas and associated bumps and the steeply pitching seams. In most cases, the coal must be mined by underground methods unless a near surface, shallow-dip-slope can be found. Considering the vast amount of unexplored land in this area it is foreseeable that the resources of this area could be increased substantially and eventually comprise the largest resource of coking coal in western Canada.

Saskatchewan

Coal, all of lignitic rank, is widely distributed across the extreme southern part of Saskatchewan. These coal deposits are on the northern fringe of a large coal basin that has its centre in North Dakota. All of the coal is contained in the Ravenscrag Formation of early Tertiary age.

It is estimated that the province contains 10 per cent of the coal resources of western Canada or about 12 billion tons. Of this amount 292 million tons are in the measured category and all of this is located around Estevan which is the only area where detailed exploration has been carried out. This exploration has been directed at locating coal that can be strip-mined and all of the measured resources are considered to be within the current limits that apply to strip-mining.

In the Estevan area eight seams are known to occur, and the upper seven are each more than 4 feet thick. Only the upper four seams have been worked and at any one locality only two seams have been mined due to glacial erosion of some seams and too great a depth of overburden over the others.

TABLE 3

COAL RESOURCES OF WESTERN CANADA BY PROVINCE
(thousands of short tons)

Province	Measured	Indicated	Inferred	Total
British Columbia	7,328,600	11,175,400	40,953,000	59,457,000
Alberta	2,203,900	32,096,100	12,940,200	47,240,200
Saskatchewan	291,500	7,024,000	4,698,400	12,013,900
Western Canada Total	9,824,000	50,295,500	58,591,600	118,711,100

TABLE 4

COAL RESOURCES OF WESTERN CANADA
BY RANK AND PROVINCE
(thousands of short tons)

Province	Measured	Indicated	Inferred	Total
Low and Medium Volatile Bituminous				
Alberta				
Inner Foothills Luscar Formation	542,000	7,426,500	3,535,400	11,503,900
Inner Foothills Kootenay Formation	440,100	12,193,700	3,831,100	16,464,900
Alberta Total	982,100	19,620,200	7,366,500	27,968,800
British Columbia	6,943,000	10,775,000	40,480,100	58,198,100
Rank Total	7,925,100	30,395,200	47,846,600	86,166,900

TABLE 4 (cont'd.)

Province	Measured	Indicated	Inferred	Total
		High Volatile Bituminous		
Alberta				
Outer Foothills		6,278,600	3,043,700	9,322,300
British Columbia	45,600	100,400	172,900	318,900
Rank Total	45,600	6,379,000	3,216,600	9,641,200
		Subbituminous		
Alberta	1,221,800	6,197,300	2,530,000	9,949,100
		Lignitic		
British Columbia	340,000	300,000	300,000	940,000
Saskatchewan	291,500	7,024,000	4,698,400	12,013,900
Rank Total	631,500	7,324,400	4,998,400	12,953,900
Grand Total	9,824,000	50,295,900	58,591,600	118,711,100

TABLE 5

COAL RESOURCES OF BRITISH COLUMBIA
(thousands of short tons)

District	Measured	Indicated	Inferred
Southeastern Area	6,930,500	10,402,300	40,033,200
South-central Area	373,600	395,900	353,200
Central Area	12,000	4,600	119,700
Northeastern Area	12,500	372,600	446,900
British Columbia Total	7,328,600	11,175,400	40,953,000

TABLE 6

COAL RESOURCES OF ALBERTA
(thousands of short tons)

District	Measured	Indicated	Inferred
Plains Area	1,221,800	6,197,300	2,530,000
Outer Foothills Belt		6,278,600	3,043,700
Inner Foothills Belt			
North (Luscar Fm.)	542,000	7,426,500	3,535,400
South (Kootenay Fm.)	440,100	12,193,700	3,831,100
Alberta Total	2,203,900	32,096,100	12,940,200

TABLE 7

COAL RESOURCES OF SASKATCHEWAN
(thousands of short tons)

District	Measured	Indicated	Inferred
Estevan	291,500	1,044,400	487,200
Radville Block		2,352,000	1,008,000
Willowbunch Block		2,408,000	2,184,000
Wood Mountain Block		616,000	672,000
Pinto Butte Block			44,800
Eastend Block		570,000	268,800
Cypress Lake Block		33,600	33,600
Saskatchewan Total	291,500	7,024,000	4,698,400

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