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MAY, 1970

ALBERTA FOOTHILLS COAL

EXTRACTS

FROM PUBLISHED REPORTS

OF

RESEARCH COUNCIL

OF ALBERTA

WITH ANNOTATIONS

Reprint Dec./70

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COAL DIVISION

RESEARCH COUNCIL OF ALBERTA

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ALBERTA FOOTHILLS COALS

I. INTRODUCTION

Recent months have seen an explosive growth of interest in Alberta Foothills coals, chiefly those coals suitable for the manufacture of metallurgical coke. A considerable amount of geological data on coal-bearing strata in the area has emanated over the years from the Geological Survey of Canada in the form of Memoirs, Reports and Preliminary Reports; and the Canada Mines Branch has issued a number of chemical analyses of coals from producing mines in its irregular publications entitled "Analysis-Directory of Canadian Coals". However the only single compendium of information on the chemical nature and industrial value of Alberta coals has been Report 35 of the Research Council of Alberta (Stansfield and Lang, 1944), unfortunately slanted towards the defunct domestic market and in any case now out of print. The Coal Division of the Research Council is in the process of compiling a somewhat different and more up-to-date report on systematics and chemistry of Alberta coals, but this cannot be available to the general public for at least another year. Meantime there is a continuing demand for an elementary introduction to the study of coal, especially of the coals of the Alberta Foothills; and, as a temporary measure, Research Council staff has extracted, by xerocopy (chiefly from Report 35 and Report 66-5 (Campbell, 1966)), the following notes which are believed to be most pertinent to the present situation, together with a few paragraphs of annotation where necessary.

A small pack is offered for free distribution to interested parties containing the following items:

1. These annotated xerocopied notes.
2. Map, scale 1 in. = 12 miles, of presently held exploration permits, leases, and other coal properties (derived from maps published by the Alberta Department of Mines and Minerals, brought up-to-date as frequently as possible).
3. Map, scale 1 in. = 12 miles, of distribution of coal rank and coking characteristics in the Foothills belt, with outlines of all coal properties as an aid in orientation.

II. COAL RANK

Coal is a solid rock composed dominantly of organic materials. Invariably it derives from plants, usually massive woody land plants, accumulated in one place, preserved usually by burial under succeeding layers of inorganic sediment, and fossilized <u>en masse</u>.

With age and with the influence of the external physical forces pressure and temperature, coal <u>matures</u> or progresses through a sequence of degrees of transformation; these degrees of maturation are conventionally divided into a series of "<u>Ranks</u>" as follows:

Parent Plant Material
Peat
Brown Coal
Lignite
Subbituminous C Coal
Subbituminous B Coal
Subbituminous A Coal
High Volatile C Bituminous Coal
High Volatile B Bituminous Coal
High Volatile A Bituminous Coal
Medium Volatile Bituminous Coal
Low Volatile Bituminous Coal
Semi-Anthracite
Anthracite
Meta-Anthracite
Graphite

All coals of the Alberta Foothills lie within the range High Volatile Bituminous - Semi-Anthracite.

N.B. - Largely for administrative purposes, the province of Alberta has been divided into "Coal Areas" which are somewhat misleading from a scientific point of view. However, since much of the material in Report 35 is presented in terms of these areas, a map is included showing their boundaries (Fig. 3).

CANADIAN CLASSIFICATION OF COAL BY RANK

In the past the coals of Alberta were classed, and output statistics collected, under four heads:

Anthracite coal—mined at Bankhead in the Cascade area.

Bituminous coal—all coals, other than anthracite, mined from the Kootenay geological horizon in the mountains of western Alberta.

Subbituminous coal—coals mined in the foothills.

Domestic coals—coals mined in the prairies.

No exact definitions of these classes were made; and changes of classification were sometimes found advisable.

In 1934 a tentative classification, the joint work of United States and Canadian chemists, fuel technicians, geologists, and others, was adopted by the American Society for Testing Materials. This classi-

*Adapted from Coal Areas of Alberta by J. A. Allan, Research Council of Alberta No. 34, Part 5, 1943.

fication was later slightly modified. It was referred to Canadian coal operators in 1937 and as no objections were raised it was adopted for Canada in 1938.

This A.S.T.M. classification* is employed throughout this report. It might be noted that coals are not only classed by rank, a classification which indicates the degree of transformation of the original plant material towards anthracite; but are also classed by grade and by type. Grade classification gives a commercial evaluation of the coal as sold, and type classification is based on the origin of the coal; but neither of these is here discussed.

In the classification by rank, as shown in Table 1, high rank coals are classified primarily according to the percentage of fixed carbon in the dry and pure, that is mineral-matter-free, coal; whilst lower rank coals are classified according to the heat value of the mineral-matter-free coal, but moist as the coal occurs in the seam. Secondary distinctions are made according to whether the coal is agglomerating, that is forms a firm button in the volatile matter test, or otherwise; and according to the coal being weather resistant, that is loses less than 5% through disintegration in the accelerated weathering test, or otherwise.

ill. A

TABLE 1

Classification of Coals by Rank

Legend: F.C.=Fixed Carbon. B.t.u.=British thermal units.

Class	Group	Limits of Fixed Carbon or B.t.u., Mineral-Matter-Free Basis	Requisite Physical Properties
I.—Anthracitic	1. Meta-anthracite	Dry F.C., 98% or more	
	2. Anthracite	Dry F.C., 92% or more and less than 98%	
	3. Semianthracite	Dry F.C., 86% or more and less than 92%	Non-agglomerating [1]
II.—Bituminous [3]	1. Low volatile bituminous coal	Dry F.C., 78% or more and less than 86%	
	2. Medium volatile bituminous coal	Dry F.C., 69% or more and less than 78%	
	3. High volatile A bituminous coal	Dry F.C., less than 69% and moist [2] B.t.u. 14,000 [4] or more	
	4. High volatile B bituminous coal	Moist [2] B.t.u. 13.000 or more and less than 14.000	
	5. High volatile C bituminous coal	Moist B.t.u. 11.000 or more and less than 13.000 [4]	Either agglomerating or non-weathering [5]
III.—Subbituminous	1. Subbituminous A coal	Moist B.t.u. 11.000 or more and less than 13.000 [4]	Both weathering and non-agglomerating
	2. Subbituminous B coal	Moist B.t.u. 9.500 or more and less than 11.000 [4]	
	3. Subbituminous C coal	Moist B.t.u. 8.300 or more and less than 9.500 [4]	
IV.—Lignitic	1. Lignite	Moist B.t.u less than 8.300	Consolidated
	2. Brown coal	Moist B.t.u less than 8.300	Unconsolidated

1 If agglomerating, classify in low-volatile group of the bituminous class.

2 Moist B.t.u. refers to coal containing its natural bed moisture but not including visible water on the surface of the coal.

3 It is recognized that there may be non-caking varieties in each group of the bituminous class.

4 Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of B.t.u.

5 There are three varieties of coal in the high-volatile C bituminous coal group, namely, Variety 1, agglomerating and non-weathering; Variety 2, agglomerating and weathering; Variety 3, non-agglomerating and non-weathering.

*Specification D388-38.

The following formulae have been used for calculating the fixed carbon and heat value on the above bases.

$$\text{Dry, mm-free F.C.} = \frac{\text{F.C.}}{100-(M+1.1A+0.1S)} \times 100$$

$$\text{Moist, mm-free B.t.u.} = \frac{\text{B.t.u.}}{100-(1.1A+0.1S)} \times 100$$

Where:

mm=Mineral matter
B.t.u.=British thermal units
F.C.=percentage of fixed carbon
M=percentage of moisture
A=percentage of ash
S=percentage of sulphur, and

Moist refers to coal containing its natural bed moisture, but not including visible water on the surface of the coal.

The following diagram shows graphically the boundaries selected for the different classes. Coals with more than 69% fixed carbon, on the dry, mineral-matter-free basis are classified by this fixed carbon, whilst coals with lower fixed carbon are classified by their heat value on the moist, mineral-matter-free basis. The chart also shows that in some cases coals with certain percentages of fixed carbon or with certain heat values, can be placed in either of two classes according to their agglomerating and weathering properties.

It must be noted that the above is only an abbreviated description of the classification with some details omitted.

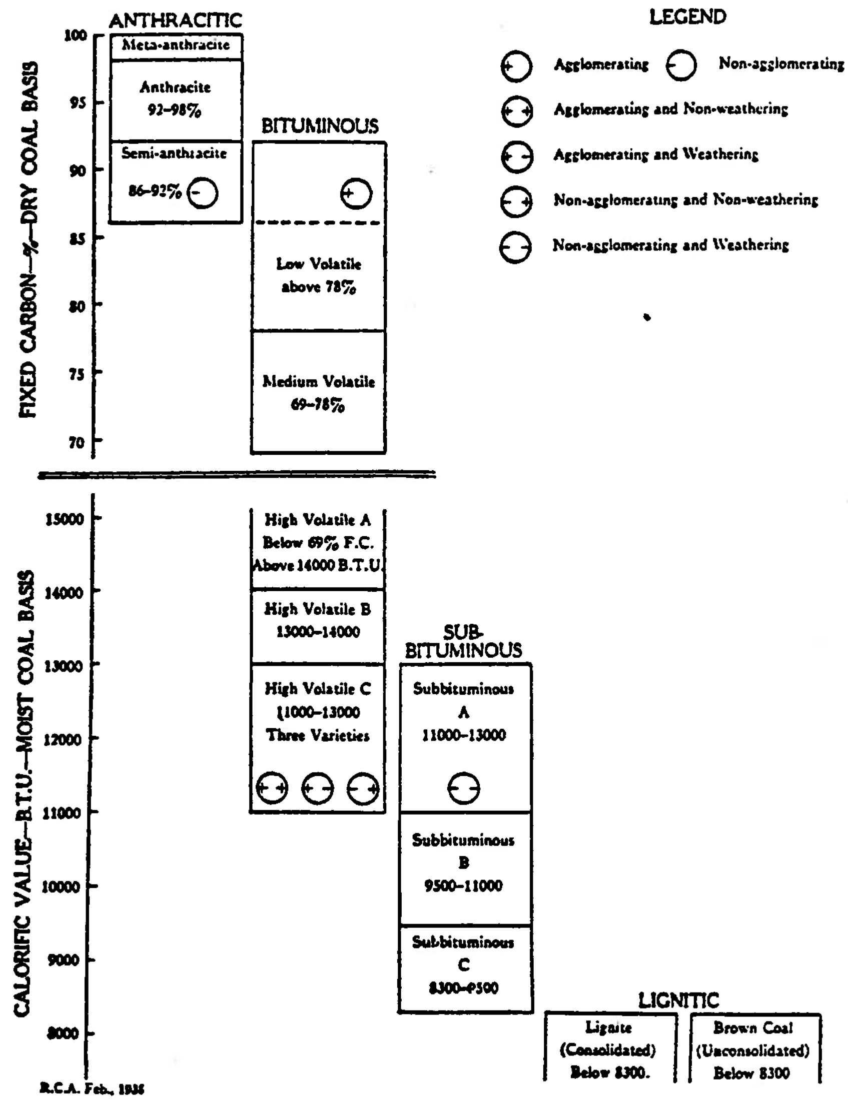

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Fig. 1.—Canadian Classification of Coal by Rank. Graphical representation of Canadian (A.S.T.M.) classification by rank, illustrating the relations of requisite physical (agglomerating and weathering) properties of overlapping groups. All analyses on the mineral-matter-free basis.

N.B. - Since publication of Report 35, the ASTM specifications for coal ranks have been slightly changed as shown in the following table extracted from the 1968 Book of ASTM Standards, Part 19 (American Society for Testing and Materials, 1968).

SPECIFICATIONS FOR CLASSIFICATION OF COALS BY RANK (D 388)

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TABLE I.—CLASSIFICATION OF COALS BY RANK.[a]

Class	Group	Fixed Carbon Limits, per cent (Dry, Mineral-Matter-Free Basis)		Volatile Matter Limits, per cent (Dry, Mineral-Matter-Free Basis)		Calorific Value Limits, Btu per pound (Moist,[b] Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	
I. Anthracitic	1. Meta-anthracite	98	...	...	2	...	...	Nonagglomerating
	2. Anthracite	92	98	2	8	...	...	
	3. Semianthracite[c]	86	92	8	14	...	...	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	...	...	Commonly agglomerating[e]
	2. Medium volatile bituminous coal	69	78	22	31	...	...	
	3. High volatile A bituminous coal	...	69	31	...	14 000[d]	...	
	4. High volatile B bituminous coal	...	...	...	...	13 000[d]	14 000	
	5. High volatile C bituminous coal	...	...	...	...	11 500	13 000	
						10 500	11 500	Agglomerating
III. Subbituminous	1. Subbituminous A coal	...	...	...	...	10 500	11 500	Nonagglomerating
	2. Subbituminous B coal	...	...	...	...	9 500	10 500	
	3. Subbituminous C coal	...	...	...	...	8 300	9 500	
IV. Lignitic	1. Lignite A	...	...	...	...	6 300	8 300	
	2. Lignite B	...	...	...	...	...	6 300	

[a] This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 per cent dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free British thermal units per pound.

[b] Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[c] If agglomerating, classify in low-volatile group of the bituminous class.

[d] Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[e] It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high volatile C bituminous group.

COAL CHARTS

The coal samples studied have been represented in three different coal charts. In Fig. 6 they are plotted according to the above classification criteria, and the classification boundaries are also shown. It might be noted that as this chart is on a mixed basis, dry for the ordinates and moist for the abscissae, combustion data could not be shown satisfactorily.

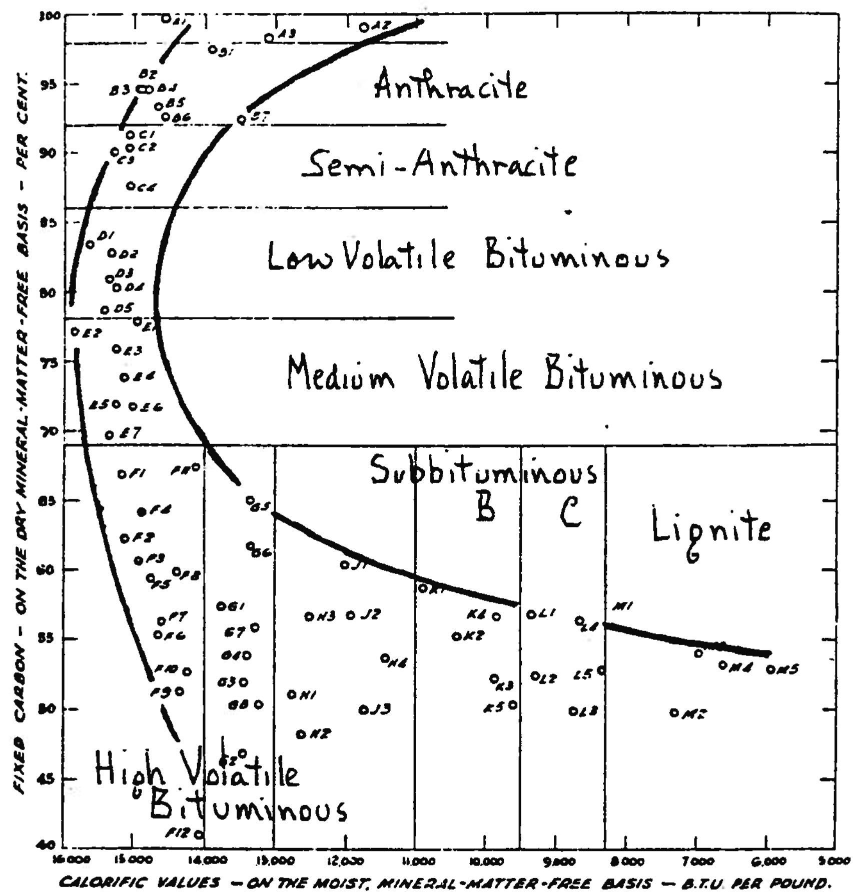

Fig. 6—Coal chart. Coals plotted on A.S.T.M. classification basis.

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III. DISTRIBUTION

(See Map B and Figure 3).

OCCURRENCE AND PRODUCTION OF ALBERTA COAL

The locations from which the different ranks of coals have been mined in Alberta are shown in Table 2 and in eight skeleton maps of the coal areas—Maps 2-9.

Table 3 shows for each rank of coal the areas where such coal has been mined. In Table 4 the coal areas are listed with the classification of the coal mined in each.

Table 5 gives the coal production in Alberta for the years 1941, 1942 and 1943, tabulated by class and area.

It can be seen, in Table 2, and in the eight skeleton maps, that the distribution of the coal ranks is irregular within the mountains forming the western boundary of the Province; but that progressively lower ranked coals are found with increasing distance east of the mountain face. Since rank and moisture content of coal are closely related, maps 10 and 11 show clearly, as might be expected, that as the distance east of the mountain face increases the moisture content also increases. Similar curves, paralleling the mountain face, could be drawn for heat content and for other analytical values.

It has been found that in Alberta the rank of the coal is primarily dependent upon the mountain building pressure to which it has been subjected, and only to a lesser degree dependent upon its geological age or the depth of the seam below the surface.

All the coals of Alberta are of Post-Carboniferous age, and therefore younger than the Carboniferous coals of Great Britain, Nova Scotia and New Brunswick, and the eastern United States. Those coals in and near the mountains, however, have been subjected to such prolonged and intense mountain building pressure that they have been converted to high rank coals, comparable with those of the Carboniferous age.

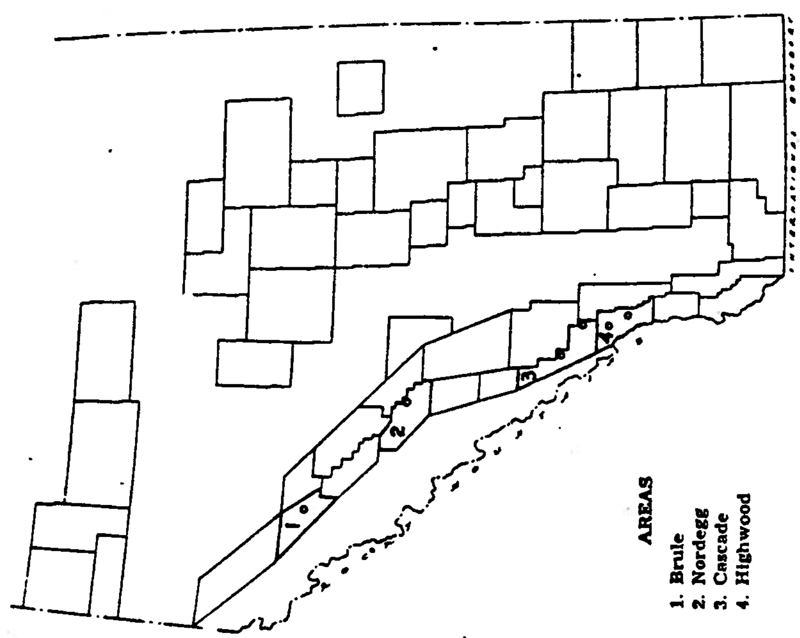
III. E

TABLE 2

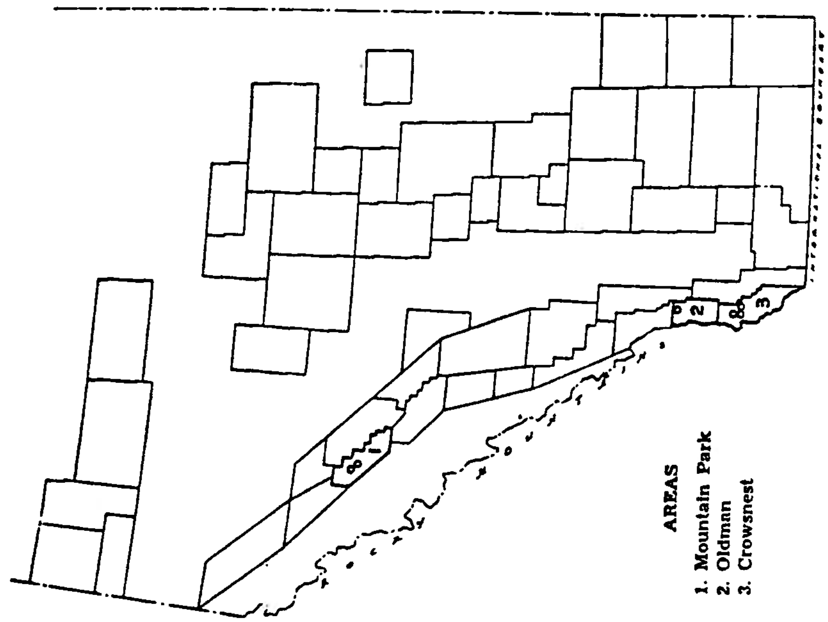
Coal Ranks and Locations Where Mined

(As shown by Sampling and Analysis)

Meta-anthracite	None
Anthracite	None
Semi-anthracite—Cascade Area	Tp. 26, R. 11, W. of 5th meridian Tp. 24 R. 10, W. of 5th meridian
Low volatile bituminous	See map 2
Medium volatile bituminous	" " 3
High volatile A bituminous	" " 4
High volatile B bituminous	" " 5
High volatile C bituminous	" " 6
Subbituminous A	" " 7
Subbituminous B	" " 8
Subbituminous C	" " 9
Lignite—Pakowki Area	Tp. 9, R. 5, W. of 4th Tp. 8, R. 3 and 4, W. of 4th Tp. 7, R. 2, W. of 4th
Brown Coal	None



Map 2.—Low Volatile Bituminous



Map 3.—Medium Volatile Bituminous

COAL CLASSIFICATION BY RANK

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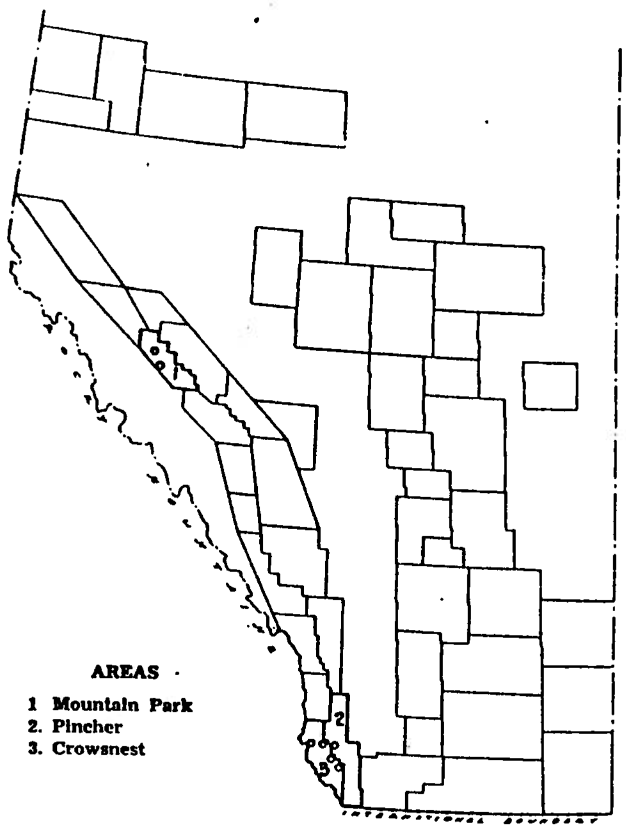
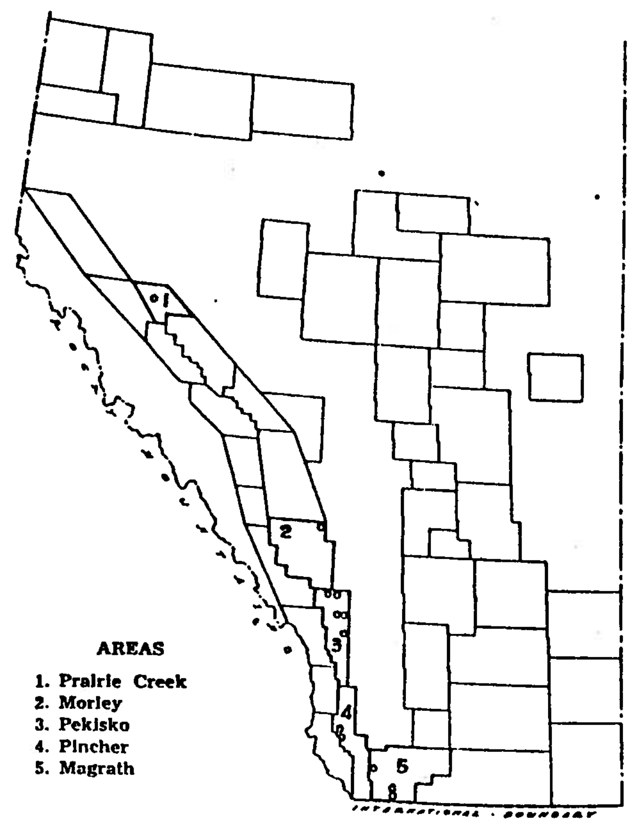


Map 4.—High Volatile A Bituminous



Map 5.—High Volatile B Bituminous

COAL CLASSIFICATION BY RANK

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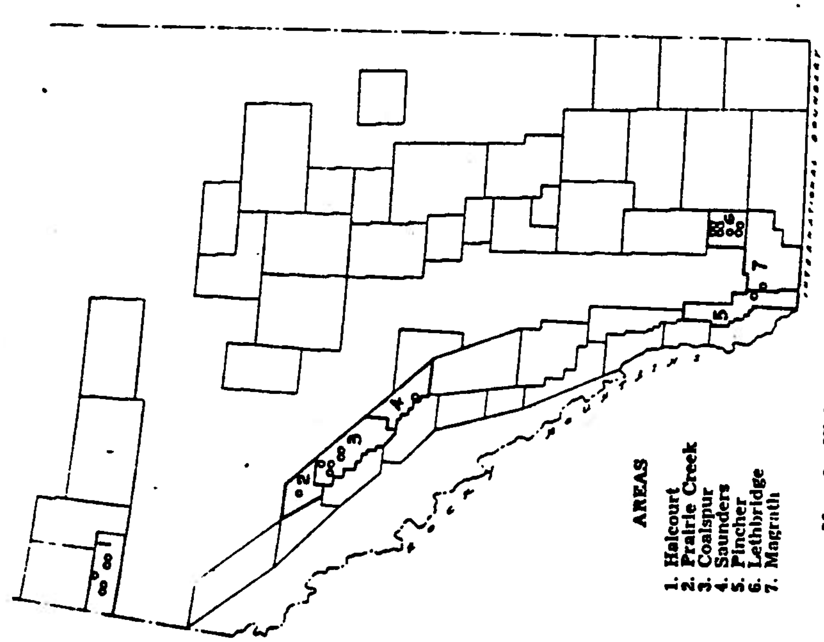
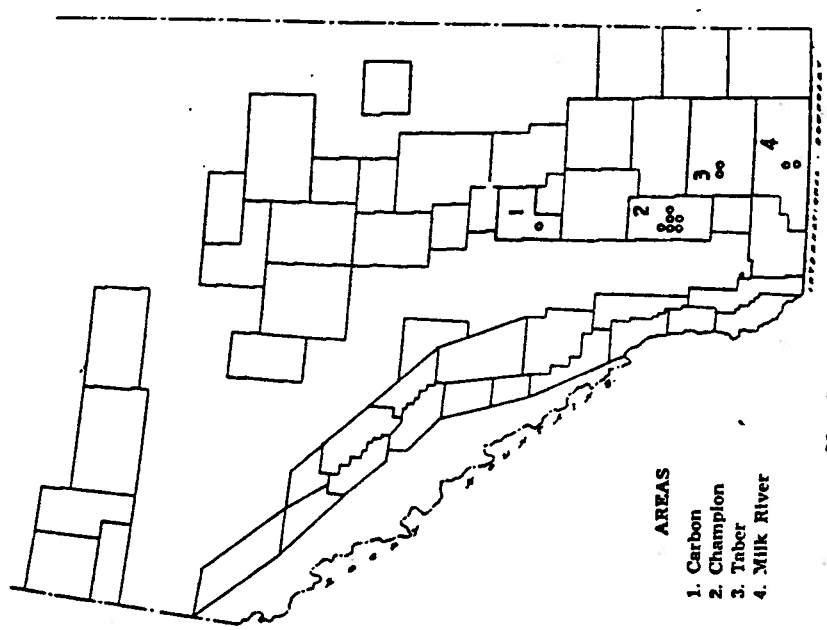


Map 6.—High Volatile C Bituminous



Map 7.—Subbituminous A

COAL CLASSIFICATION BY RANK

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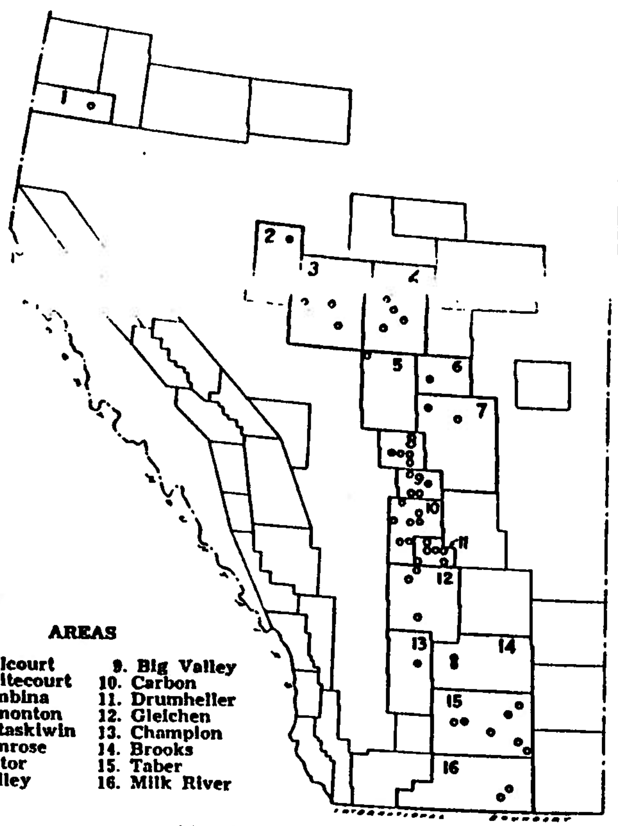
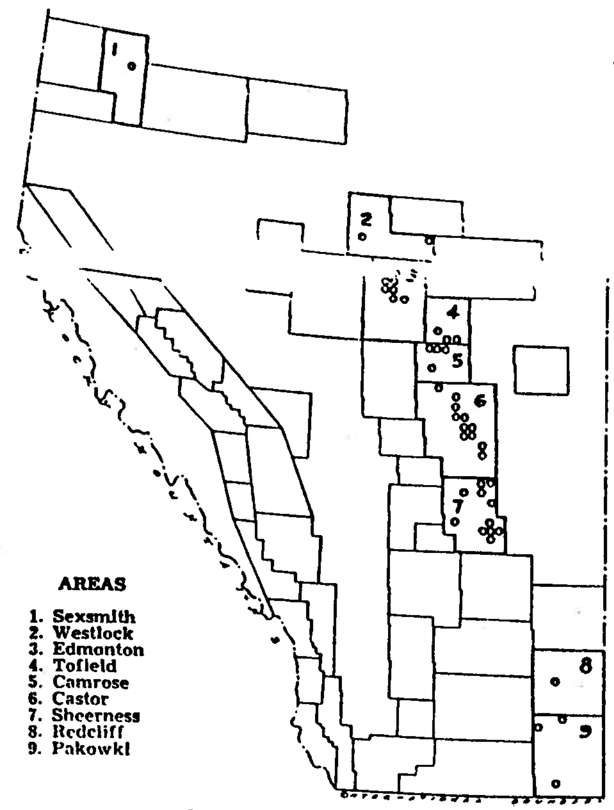


AREAS

1. Halcourt
2. Whitecourt
3. Pembina
4. Edmonton
5. Wetaskiwin
6. Camrose
7. Castor
8. Ardley
9. Big Valley
10. Carbon
11. Drumheller
12. Gleichen
13. Champion
14. Brooks
15. Taber
16. Milk River

Map 8.—Subbituminous B



AREAS

1. Sexsmith
2. Westlock
3. Edmonton
4. Tofield
5. Camrose
6. Castor
7. Sheerness
8. Redcliff
9. Pakowki

Map 9.—Subbituminous C

COAL CLASSIFICATION BY RANK

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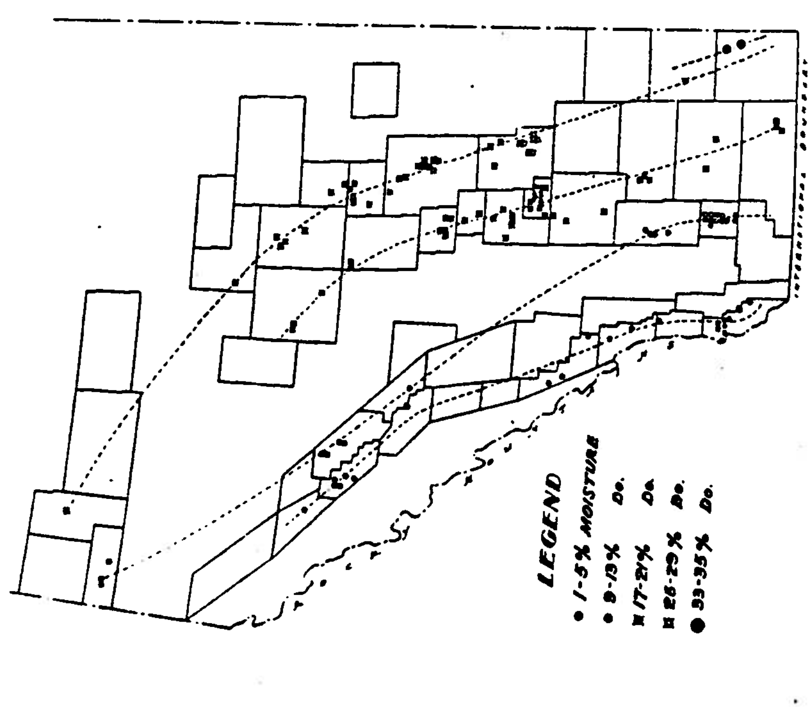
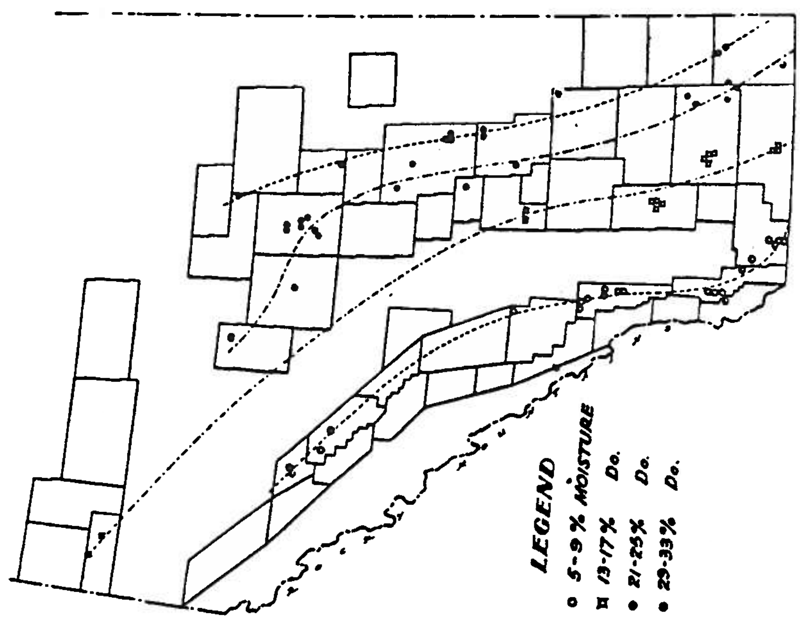


Map 10



Map 11

DISTRIBUTION OF ALBERTA COALS BY MOISTURE CONTENT

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IV. ANALYSES

PART II

Notes on Analyses, Special Tests and Terms

THE SIGNIFICANCE OF AN ANALYSIS OF COAL

Many of the qualities of a coal are revealed by its proximate, ultimate and calorific analyses. The evaluations made in a proximate analysis are conventional and do not represent actual specific constituents of the coal, nor has their determination an absolute significance. Their empirical determination, however, does give a measure of the quality of the coal and the proximate analysis is used as criterion for classification and for combustion.

The ultimate analysis is more precise than the proximate in that it determines the percentages of the elements which go to make up the coal substance. The ultimate analysis does, however, serve as a guide to the nature and rank of the coal and is often used for classification. Furthermore, the ultimate analysis of a coal is essential for calculating the amount of air required for its economical combustion and for other combustion data. It is, therefore, valuable for the efficient design and control of power plants.

The calorific analysis of a fuel gives a definite measure of the potential heat value which it contains, and is therefore a prime consideration when buying coal.

Moisture.—Moisture is inherent in the coal substance, but it may be increased by seepage in the mine or by subsequent wetting. Moisture also may be lost from coal if the coal is exposed to a dry atmosphere. High moisture in a coal usually indicates a free-burning, smokeless fuel, but otherwise moisture is a disadvantage. It is uneconomical to pay freight on water, and a high moisture coal stores badly.

Ash.—Ash is the inorganic residue remaining after complete ignition of the coal. It is derived from the mineral constitutents in the coal. Ash not only has no heating value, but may by clinkering interfere with combustion. Freight must be paid not only on coal but also on its impurities. A slag forming coal may damage furnace equipment, and removal of ashes involves expense. A low ash is essential for some uses. Some Alberta coals are naturally clean, and a number of Alberta operators are equipped to sell a washed coal.

Volatile Matter and Fixed Carbon.—Volatile matter is that portion of a coal, other than moisture, that is driven off as a gas or vapour by a heat treatment in the absence of air. The remaining material, after correction for ash content, is reported as fixed carbon. The percentage of fixed carbon divided by the percentage of volatile matter is known as fuel ratio.

The combustion characteristics, the uses for which a coal is suited and the amount of heat to be derived are dependent on the amount of fixed carbon and volatile matter. The coking property of a coal is closely tied to its volatile matter content. Both the low volatile and the high volatile, high moisture coals are non-coking, whilst the coals with intermediate volatile are the coking bituminous coals. The percentages of volatile matter and fixed carbon have also been used extensively for classifying coals. The higher rank coals are classified on a basis of fixed carbon by the A.S.T.M. standard specifications.

When coal is burned in a furnace the volatile matter coming off burns with a flame, but incomplete combustion due to lack of air causes a black smoke consisting of droplets of tar and particles of carbon. The tarry volatiles have a high heat value and such material if unconsumed represents a direct loss of heat. Part of the unburned volatiles may settle as soot in furnace casings, flue pipes and chimney where it not only interferes with heat transference, but is a distinct fire hazard. Smoke is also a public nuisance.

In order to ensure as complete combustion of the volatile matter as possible, and therefore smokeless combustion, three conditions are essential, namely, (1) sufficient air (2) intimate mixture of air and fuel, (3) sufficient secondary air over the fuel bed. The consumer can, by recognized methods of good firing, reduce the potential smoke tendencies of a coal to a minimum.

Fuels of Group I, having a large amount of fixed carbon and a relatively small amount of volatile matter, burn with a short flame; and the whole process of combustion takes place at or near the fuel bed. Such coals can be burned in domestic installations without visible smoke. Group II coals have a relatively large percentage of tarry volatile matter and therefore burn with a longer flame, producing visible smoke. These high volatile fuels are usually used on railways and for power installations where the coal can be burned efficiently and without smoke. The volatile matter of Group III coals, although high, contains a higher percentage of oxygenated compounds and burns with little smoke. The high volatile, low rank coals of Group IV and V are free-burning and smokeless when properly fired.

Calorific Value.—In the purchase of a fuel the consumer desires that coal which will give him the greatest number of recoverable heat units for his money, provided it also has suitable firing properties for his installation. The cost of a coal is largely based on its heat or calorific value. Nevertheless, a high heat value coal, if carelessly fired, or if not suited to the particular installation, may give poorer results than a lower heat value coal carefully fired and suited to the installation. The heat value of a coal is usually stated as gross B.t.u. per pound although actually the net B.t.u. is a better criterion of the recoverable heat (see page 33). Coal is sold at a price per ton, but it would be more logical if it were sold on a heat basis.

Carbon and Hydrogen.—Carbon and hydrogen are the two most important elements in the coal substance. High rank coals are high in carbon and low in hydrogen, while the low rank coals are low in carbon and high in hydrogen. Broadly speaking, the carbon of a coal may be considered as having the same significance as fixed carbon, and hydrogen as having the same significance as volatile matter, but the percentages of these elements in the coal are mainly used in exact calculations of combustion data. The higher the hydrogen content of the coal the greater the drop from gross to net calorific value.

Sulphur.—Sulphur occurs in coal in three forms namely, (1) as organic compounds in the coal substance, (2) as iron pyrites (FeS_2), and (3) as gypsum ($CaSO_4.2H_2O$). Sulphur, if present either as pyritic or as organic sulphur, contributes a trivial amount of heat when the coal is burned, but is objectionable if present in considerable amounts since the products of combustion will combine with any condensed moisture to form a corrosive liquid. Sulphur is also deleterious in fuels used for metallurgical purposes since it may pass into the metal under treatment. Some of the sulphur, however, is driven off during carbonization or coking so that there is less sulphur in coke or char than in the original coal.

Nitrogen.—Nitrogen occurs in coal to the extent of 1 to 2 per cent. Its only importance is in the recovery of ammonia from carbonization and coking processes with by-product recovery. Now, however, that most of the industrial ammonia is made synthetically the nitrogen content of most coal is not of particular significance.

Oxygen.—The amount of oxygen in a coal has an important bearing on its rank and properties. Low oxygen coals are high in rank and heat value, while high oxygen coals are low in rank and heat value. With coking coals an increase in oxygen usually means a decrease in coking quality. High oxygen coals have the merit that they are free burning and practically smokeless.

TECHNICAL DETAILS OF SAMPLING AND ANALYSIS

The following is a summary of the methods employed in sampling and analysis, for the information of samplers and analysts. These specifications are in principle those of the American Society for Testing Materials* with certain modifications to make them more exact and suited to Alberta coals.

Sampling.—The analyses in this report are, in the main, based on samples taken by the Provincial Mine Inspectors by a specified method.† These are channel samples, about 4"×3", taken across the seam, from a cleaned, fresh, working face selected to represent as closely as possible the normal output of the mine. The Inspector includes or rejects clay or shale bands or other "partings" in the seam, according as, in his judgment, these are included or excluded from the coal as shipped from the mine. The samples are crushed, to less than ½" size, and reduced by the method of cone and quarter, and then filled into quart sealers with rubber gaskets for shipment to the laboratory. The above is done quickly at the mine face to avoid loss of moisture.

Air-Drying and Preparation of Laboratory Sample. — The coarsely crushed coal, as received in the laboratory, is subjected to a preliminary partial drying, termed "air-drying", before the sample is pulverized for analysis. Air-drying is carried out, (a) to bring the coal to such a condition that it will not either lose or gain moisture appreciably during the subsequent crushing, grinding and weighing for analysis, (b) to facilitate grinding—coal cannot be ground if too moist, (c) to evaluate the moisture holding property of the coal.

A simple procedure has been developed by the R.C.A. for air-drying coal without oxidation. The coal (100-200 grams) is subjected for 48 hours to a relative humidity of 32% at 30°C in an evacuated desiccator containing a saturated solution of magnesium

*Specification D271-42.
†Research Council of Alberta, First Annual Report (1921), p. 17.

chloride, and crystals of the same, to maintain the humidity. The air-dried sample is then crushed and finely ground in a ball mill for further analysis. The use of a ball mill minimizes loss of moisture.

All determinations made subsequently on this air-dried laboratory sample have to be calculated to the "as received" basis with consideration of the moisture loss during air-drying.

Moisture.—The ground, air-dried sample is used for this and subsequent determinations. The moisture remaining at this stage is determined by the loss in weight when one gram of the sample is dried for one hour, at 106°C, in a rapid stream of dry natural gas, and cooled in an evacuated desiccator.

The total moisture, to be reported as the moisture in the coal "as received", is calculated from the percentage loss of weight during air-drying, and the percentage loss in the moisture determination on the air-dried sample.

Capacity Moisture.—A simple procedure has also been developed* by the R.C.A. whereby it is possible to distinguish between the true water of the coal substance, termed capacity moisture, and the free or adventitious water. The method employed is as in air-drying—exposure for 48 hours at 30°C, in an evacuated desiccator and controlled humidity—but in this case 5 gram portions are used, and successive portions are dried at some ten humidities ranging between 11% and 98% relative humidity, by use of a suitable selection of salts. A fresh portion of the original sample, crushed to 14 mesh size, is used for this determination. The moisture held by the coal after attaining equilibrium with the controlled humidity, is determined by drying in vacuum, at 105-110°C, for three hours.

The retained moisture in each portion, plotted against the relative humidity to which it was brought to equilibrium, gives a series of ten points which lie along a curve. This curve if extrapolated from the 98% humidity point to 100% humidity, gives the capacity moisture of the coal.

As a routine method it has been found, based on several hundred full curve determinations, that the percentage moisture retained in this test by a coal dried over a saturated solution of potassium sulphate (97.6% relative humidity), when multiplied by $\frac{100}{98.6}$ gives the capacity moisture of the coal. A test over a saturated solution of ammonium nitrate (60% relative humidity) is also made in routine analyses as a further measure of the moisture holding capacity of the coal.

Ash.—One gram portions of the laboratory sample are completely burned in an electric muffle furnace—with free access of air—at a temperature of 725±25°C.

Volatile Matter.—Two alternative methods are used for this determination according to the character of the coal. The quick heat method is used for all high rank, low moisture coals. The pre-heat method is used for all high moisture coals. The boundary has been chosen so that coals, from any area where samples have been tested that retain more than 10% moisture after air-drying to 60% humidity, are tested by the pre-heat method. Coals which are close to the boundary line are found to give from 1 to 1½% less volatile

*E. Stansfield and K. C. Gilbart. Trans. A.I.M.M.E., Coal Division (1932), pp. 125-147.

matter by the pre-heat method than by the quick heat method. Lethbridge Area coals, which are in this category, are now tested by the pre-heat method.

A vertical electric furnace* is employed for both methods. This is closed at the top, and the crucible is introduced into the furnace from below. Standard practice is to use a furnace open at the top. This inversion gives an initial heating of the coal from the top and thus reduces the tendency to spark. It also gives a very steady temperature, less convection currents and consequently a less oxidizing atmosphere.

In the quick heat method one gram portions of the laboratory sample are each heated for seven minutes at a temperature of 950±20°C in a 20 c.c. platinum crucible with a well fitting, capsule shaped lid. The loss in weight represents the moisture and volatile matter in the coal. If the loss due to moisture is subtracted the remainder is volatile matter.

High moisture coals, if tested by the quick heat method, spark badly and the results are erroneous. A pre-heat method is therefore employed. In the method used until recently, one gram portions were each weighed into a platinum crucible as before; but the crucible set on a cold 3" scorifier which was placed in an electric muffle furnace at 800±25°C. It was left in the pre-heat furnace for five minutes and immediately transferred to the volatile matter furnace, and heated for six minutes at 950±20°C.

The above method, in general, gave remarkably concordant results, but a few exceptional samples have been noted, which tended to spark even by this method. A revised method therefore has been adopted recently which works well even with such samples. The temperatures towards the opening at the bottom of the furnace were calibrated, and the crucible is given its preheat by moving it up into the furnace by timed steps as follows: 3 minutes at 500°C, 2 minutes at 700°C, 1 minute at 850°C, and 6 minutes at 950°C. The temperatures were measured by a thermocouple touching the side of the crucible just above the level of the coal.

This method is in accordance with the A.S.T.M. method of D271-42, but is far more specific. The results are in close agreement with those by the earlier method.

Fixed Carbon.—The non-volatile residue left in the platinum crucible in the volatile matter determination is fixed carbon and mineral impurities. The percentage of this residue, minus the percentage of ash as found above, gives the percentage of fixed carbon. The nature of the above residue is recorded as a guide to the coking properties of the coal.

Proximate Analysis.—The four percentages thus found in the air-dried coal—moisture, ash, volatile matter, and fixed carbon—add up to 100, and constitute the analysis known as "proximate". The values thus found can be calculated to the "as received" basis by allowance for the moisture lost in air-drying, or calculated to the "dry" basis by elimination of the moisture in the air-dry analysis.

The ratio of fixed carbon divided by volatile matter is known as "fuel ratio".

Calorific Value.—The gross calorific value is determined by the complete combustion of the coal in compressed oxygen in a bomb

*Research Council of Alberta, Tenth Annual Report (1929), p. 17.

calorimeter.* The bomb is of stainless steel, 315 c.c. volume, and the bomb and calorimeter have a water equivalent of 2,250 grams. A weight of coal is taken estimated to give a rise of 2.5°C, and oxygen is charged to 375 lbs. per sq. in., or to 400 lbs. for difficultly combustible fuels. This gives at least five times as much oxygen as is theoretically required for the combustion. A platinum hair wire and a short cotton thread are used for firing, and the temperature rise is measured with a standardized Beckmann thermometer. The water equivalent of the calorimeter is restandardized, using standard benzoic acid, with each fresh oxygen cylinder. The cooling correction is found from the initial and final rates of cooling by means of a nomogram. The usual corrections are made for firing heat; thermometer bore irregularities, setting factor, and emergent stem; and for sulphur and nitrogen. The calorific value is calculated by the following equation which permits ample accuracy with a slide rule:

Calorific value,

$$\text{in B.t.u. per lb.} = 10{,}000 + \frac{R}{W} 4{,}050 + \frac{8{,}100 - 10{,}000\,W}{W}$$

This is derived from the equation $\text{B.t.u./lb.} = \frac{(2+R)\ 2250 \times 1.8}{W}$

where weight of coal in grams=W
the rise in temperature=2°+R° Centigrade, and
the water equivalent of the calorimeter=2250 grams.

The equation is suitably adjusted whenever a change is made in the water equivalent.

The net calorific value is calculated by deducting from the gross value 91.2 B.t.u. per pound for each one per cent of hydrogen in the coal.

Ultimate Analysis.—This analysis determines the elements carbon, hydrogen, sulphur, nitrogen and oxygen. The percentages of these elements, together with the percentage of ash found in the proximate analysis, are assumed to add up to 100%. The determinations are made on the air-dried laboratory sample, and the results later calculated to the "as received" and "dry" bases.

Carbon and Hydrogen.—These elements are determined, as in the regular method for the analysis of organic compounds, by burning a fifth of a gram of the coal in a current of pure, dry oxygen and collecting and weighing the carbon dioxide and the water produced. The R.C.A. has developed a modification of the apparatus† which has been found to be conducive to ease of operation, prolonged life of the quartz combustion tube, and consistently good results even in the hands of beginners.

Sulphur.—The method normally employed for sulphur determination is the Eschka process as specified by the A.S.T.M. Recently, with low sulphur coals—below 0.5%—the sulphur has been determined in the rinsings from the bomb calorimeter by precipitation with benzidine hydrochloride followed by titration with standard alkali. These results have been found to be in reasonable agreement with those of the Eschka process, and the saving in time is considerable.

Nitrogen. — The method employed is the Kjeldahl-Gunning method as specified by the A.S.T.M.

*E. Stansfield and J. W. Sutherland. Can. Jour. Research. Vol. 3 (1930), pp. 464-472.
†E. Stansfield and J. W. Sutherland. Can. Jour. Research. Vol. 3 (1930), pp. 318-320.

Oxygen.—No satisfactory method has yet been devised for the determination of oxygen. The percentage reported as oxygen in an ultimate analysis is merely the value obtained by subtracting from 100 the sum of all the other percentages, including that of ash.

Moisture.—Moisture is not included as such in an ultimate analysis, as the hydrogen and the oxygen of the water are included in the reported values of these elements.

Fusion Temperatures of Coal Ash.—Two methods have been used for the determination of the fusibility of coal ash, one according to A.S.T.M. specifications, the other a modification thereof. In the latter method the conditions specified by the A.S.T.M. with respect to size and shape of cones, rate of heating and atmosphere are followed exactly, but, instead of only heating 3 or 4 cones at once and closely watching their behaviour, a batch of 20 or more different cones are simultaneously heated to some prearranged temperature, and then rapidly cooled and withdrawn from the furnace. Similar batches are likewise heated to other temperatures until for each ash a series of cones is obtained heated to temperatures at 45°F (25°C) intervals, and covering the range from the initial deformation to the fluid temperature, or to the maximum temperature obtainable in the furnace. The series can then be arranged in order and examined at leisure for the fusion characteristics. Fig. 4, p. 43.

Two furnaces have been used, a No. 3 gas-fired Melter's Furnace, and a molybdenum wound, electric, resistance furnace. Some difficulties are experienced with the gas-fired furnace at temperatures above 2600°F, but the electric furnace can be heated to 2800°F without difficulty.

The A.S.T.M. specifications call for a mildly reducing atmosphere around the cones. In both methods employed by the R.C.A., and in both furnaces, this required atmosphere is ensured by vapourizing a methyl alcohol-water mixture, containing 51% of alcohol by volume, and passing the vapours through a refractory tube into the ash cone chamber. The alcohol is decomposed, also some of the steam, producing a mixture containing about 50% reducing gases (hydrogen and carbon monoxide), and 50% oxidizing gases (steam and carbon dioxide).

MOISTURE AND CAPACITY MOISTURE

All coals contain moisture which is definitely part of the coal substance. Coal may also have free moisture, on the surface, and in the cracks if, for example, the mine from which the coal was taken is a wet mine; but, on the other hand a sample of coal may have been partially dried before it reaches the chemist. A coal analysis therefore may show either more moisture or less moisture in the sample than the true moisture of that coal.

A method was developed* in 1931, in the laboratories of the Research Council of Alberta, by which a distinction can be made between the moisture that really belongs to the coal and additional or free, surface moisture. The same method will also indicate if there has been a partial drying of the moisture of the coal, but in this case the true moisture cannot be determined if the partial drying has been more than slight. A coal which has been notably dried will not take up again as much moisture as it held originally.

The true or inherent moisture of a coal has been called the "capacity moisture" of the coal and defined as the least moisture in the coal that will give a relative humidity of 100%, or in other words, will behave as though free moisture were present.

Capacity moisture is of great importance in coal classification, and of lesser importance in ordinary analyses. Nevertheless in many analyses reported from these laboratories, the capacity moisture is given where this differs notably from the actual moisture found in the sample; as it is certain that free moisture will evaporate from the coal more easily than will inherent moisture, and therefore is less of a drawback.

It is of interest to note that far more samples have been received here showing excess moisture than have been received showing partial drying. In this report "typical moistures" are not intended to include free moisture.

GROSS AND NET CALORIFIC VALUES

When the coal is burned in a bomb calorimeter, as in the determination of its calorific value, the products of combustion are cooled to room temperature, and the steam is condensed to water and thus gives up its latent heat to the calorimeter. In the ordinary combustion of coal, on the contrary, the products of combustion enter the chimney at too high a temperature for the steam to have condensed, so that not only the sensible heat of the gases, but also the latent heat of the steam is lost. The loss of sensible heat can be minimized by combustion control and by the use of suitable equipment, so this loss can fairly be charged against the plant and its operation. The loss of latent heat, however, cannot be avoided in ordinary practice, so it is unfair to charge this loss against the plant. Two calorific values are therefore recognized:

Gross calorific values in which the products of combustion are assumed cooled to ordinary temperatures (60°F), and the steam condensed to water as in the calorimeter determination.

Net calorific values in which the products of combustion are assumed cooled to ordinary temperatures, but with the steam uncondensed. Net calorific values, in B.t.u. per pound, are calculated from gross calorific values, in the same units, by deducting 91.2

*F. Stansfield and K. C. Gilbart, Trans. A.I.M.M.E., Coal Division (1932), pp. 125-147.

B.t.u. per pound for each one per cent of hydrogen in the coal as fired. This figure allows for another slight correction which need not be explained here.

If two coals are compared, of equal gross calorific value, but one with low, and the other with high hydrogen content, it will be found that the former is distinctly the better fuel. Two coals of equal net calorific value, on the contrary, will be found to be nearly equal in fuel value regardless of their hydrogen content.

Gross calorific values are generally used in Canada and in the United States, but the net values give a better picture of the relative commercial values of different types of coal, and are often used in some other countries. The adoption of the net value has been delayed in America because its calculation requires the hydrogen content of the coal, and this is seldom known.

Gross calorific values are given in this report, unless the contrary is stated. The approximate deduction to be made for the coal of each area, or district, to give the net value, is generally given. The deduction ranges from about 2% to 9% of the gross heat value of Alberta coals.

MINERAL MATTER IN COAL AND ASH OF COAL

The mineral matter in a coal is not the same as the ash left when the coal is burned, either in composition or in weight. The relation between them varies; but, on an average, ten parts of mineral matter leaves only 9 parts of ash.

All ordinary analyses, proximate and ultimate, show the percentage of ash of the coal, not the percentage of mineral matter in the coal. This is standard procedure, well understood by all coal chemists, and the matter is quite immaterial to the ordinary coal consumer.

Whenever it is necessary to calculate an exact analysis of pure coal, as for example for purposes of coal classification, the matter is quite different, and it is necessary to convert the ash per cent of the coal to a mineral matter percentage. This change also involves a change in the volatile matter percentage. The relation between mineral matter and ash is discussed at greater length in Part V under "Coal as analyzed and as pure coal".

The slope of a mean line drawn through the points in the curve of Fig. 2 gives a measure of the ratio of mineral matter to ash, and this graphical method is regularly employed by the R.C.A. to determine this ratio. The equations given in the analytical section for calculating the modified calorific value of coal all contain a factor based on the relation of mineral matter to ash. This ratio has been found to vary with Alberta coals from 1.0 to 1.3 but the average value is slightly above 1.1.

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TABLE 22

Fusion Data for Ash of Alberta Coals

Area	District	Softening Temperature Low. °F	Softening Temperature High °F	Softening Interval °F	Flowing Interval °F	Samples Tested
Ardley		2030	2410	80	120	14
Big Valley		2190	2460	70	140	7
Brooks		2130	2370	70	160	3
Brule		+2600	....	....	.....	1
Camrose		1980	2380	90	70	15
Carbon		1970	2400	70	140	22
Cascade	A	2550	+2770	....	.....	3
	B	2140	+2770	120	150	11
Castor		2010	2360	70	80	20
Champion		1900	2180	50	50	8
Coalspur	A	2050	2170	40	130	7
	B	2090	2450	70	100	20
Crowsnest	A & C	2630	+2770	....	.....	35
Drumheller		1850	2370	60	110	69
Edmonton		1970	2470	60	120	34
Gleichen		2010	2370	60	110	6
Halcourt	A	2460	2600	180	130	2
	B	2200	2460	100	160	4
Highwood		+2600		....	.	4
Lethbridge		2060	2420	80	140	23
Magrath		2190	2280	90	70	2
Milk River		1960	2200	90	190	6
Mountain Park		2280	+2700	140	130	21
Nordegg		2600	+2800	....	......	11
Pakowki		1920	2300	50	60	8
Pekisko		2150	2550	90	150	11
Pembina		2280	2460	70	110	12
Pincher	A	2330	+2600	80	170	4
Prairie Creek	A	2150	2340	80	100	6
	B	2100	2120	50	230	2
Redcliff		1880	2120	80	80	7
Saunders		2010	2260	60	80	12
Sexsmith		2070	....	60	70	1
Sheerness		1980	2320	50	70	17
Taber	A & B	2100	2490	60	90	11
	C	1870	2380	60	130	3
Tofield		2050	2270	50	60	7
Westlock		2050	2240	60	100	2
Wetaskiwin		2030	2420	90	100	3
Whitecourt		2180	....	90	190	1

Explanation of terms given on page 42.

V. COKE

Most of the recently expanded coal exploration activity in Western Canada has had the objective of discovering new sources of coal suitable for manufacturing metallurgical coke.

When coal is decomposed by heat in complete or partial absence of air ("carbonized"), it is converted into a number of new products. These include gases, liquids (tars and liquors) and solid residue which, if friable is called char and if coherent is termed COKE.

It should be remembered that metallurgical coke is used in tall blast furnaces which are chemical reactors where high-temperature gas-solid reactions occur. In order for such reactions to proceed, the solids in the reactor must not collapse under the weight of the overlying column of solid reagents (often over 100 feet high) and thereby prevent the free passage of gas. Thus, to be valuable in metallurgical processes a coke must be so coherent that it possesses considerable mechanical strength.

Quantification of coke quality is very difficult but one commonly used preliminary criterion is the Free Swelling Index, a parameter derived by the following procedure (extracted from Francis, 1961).

CRUCIBLE SWELLING TEST FOR COALS

The property of swelling is usually measured in a simple manner by the crucible swelling test, described in B.S.1016—Part 12, 1959.

In this test, one gram of air-dried coal, freshly ground to pass a 72-mesh sieve by means of a coffee mill (so as to obtain approximately equal proportions through 72 on 120, through 120 on 240 and through 240 mesh sieves), is placed in a standard silica crucible and lightly tapped so as to level the surface of the coal. The covered crucible is then supported on a crucible triangle and heated above a Teclu burner flame so that the temperature of the inner surface of the base of the crucible reaches 800° C within 1½ minutes and 820° C within 5 minutes of lighting the burner. After the flame from the burning volatile matter has died out, or for 2½ minutes, whichever is the greater period of time, the crucible is cooled and the coke button removed and compared with the standard numbered profiles shown in Fig. A.2.

The result is recorded as a *swelling number*, which is the number of the standard profile most nearly corresponding to the coke button obtained under test, taking the average of five determinations.

If the residue is unswollen but coherent, it is removed from the crucible and tested to find out whether or not it will support a 500 gm. weight. If the coke button supports the weight, or merely cracks into two or three hard, coherent, pieces, the swelling number of the coal is 1. If the coke button disintegrates under the 500 gm. weight, the swelling number of the coal is ½. If the residue in the crucible is non-coherent, the swelling number of the coal is zero.

The dimensions of the squat form silica crucible used are as follows:

External height	26 mm. ± 0·5 mm.
External diameter at top	51 mm. ± 0·75 mm.
Internal diameter at base	> 11 mm.
Capacity	Approx. 17 ml.

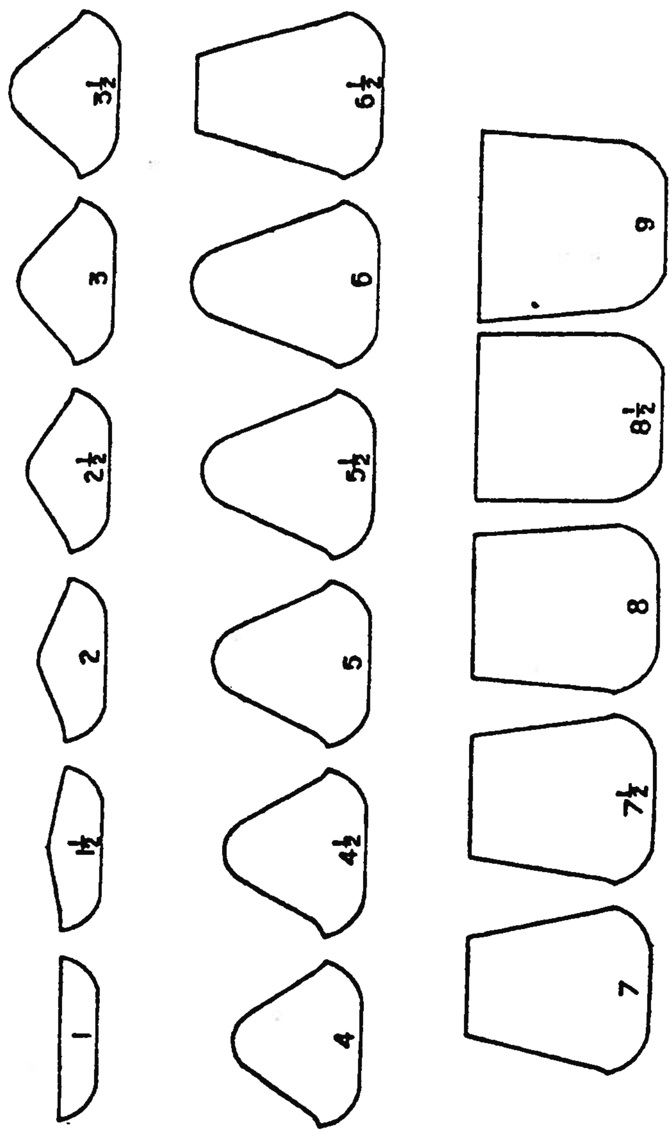

Figure 1.

FIG. A.2.—Standard Profiles and Corresponding Swelling Numbers.
(British Standards Institution)

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The flame used in the test, with coal gas of calorific value 500 B.Th.U. per cubic foot, should be adjusted so that the total height is 12 in. long and the blue control cone is 6 in. long. The test is then carried out with the crucible just above the tip of the blue cone and the flame is protected from draughts by a cylinder of asbestos cement, or other suitable material, 6 in. long and 4 in. diameter.

In laboratories not supplied with gas, an approximate idea of the swelling number can be obtained by carrying out the test in the standard crucible heated in a muffle furnace at 820° C for 2½ minutes. B.S. 1016, Part 12, 1959, also contains details of an electrically heated furnace, designed by Gayol and Pire[17], in which the crucible swelling number may be determined as an alternative standard to the gas heating method described above. In this furnace the rate of heating is adjusted so that the inner surface of the base of the crucible is heated to 810° C ± 10° C in 1½ minutes and to 820° C ± 5° C in 2½ minutes.

As a rule, strong cokes are only formed by carbonization of coals in the range High Volatile A Bituminous – Low Volatile Bituminous, i.e. coals with fixed carbon content about 65% to 85%.

Figure 2 shows the relationship between the Free Swelling Index and coal rank (indicated by the dry mineral matter-free fixed carbon content) in coals of the Alberta Foothills. It should be noted that coking coals occupy an area on the diagram rather than a curve, so that there will always be an element of uncertainty regarding the relationship. In practice, a coking test is always necessary; other parameters cannot be depended on to indicate coking quality.

Other methods of quantifying at least some aspects of coke quality are the Audibert-Arnu Dilatometer Test and the Gieseler Plastometer Test.

As coals are heated up, they first pass through a range of "preliminary plasticity" (usually someplace between 410°C and 490°C) in which the coal material becomes soft. With increasing temperature, the volatiles (gases and condensable liquids) escape and the residue becomes solid. As a gross over-simplification, it may be said that the nature of the high-temperature solid is determined by the viscosity of the softened coal when in the temperature range of "preliminary plasticity". Also, compatibility of coals in coking blends is controlled to a great extent by similarity of their preliminary plasticity ranges; thus a coal with a wide plasticity range will have greater value in blending than a coal with a narrow range.

One important fact to note is that coking quality of any coal is reduced or destroyed by oxidation; even a degree of oxidation too small to determine analytically can degrade the coke significantly, and coal seams will be affected in

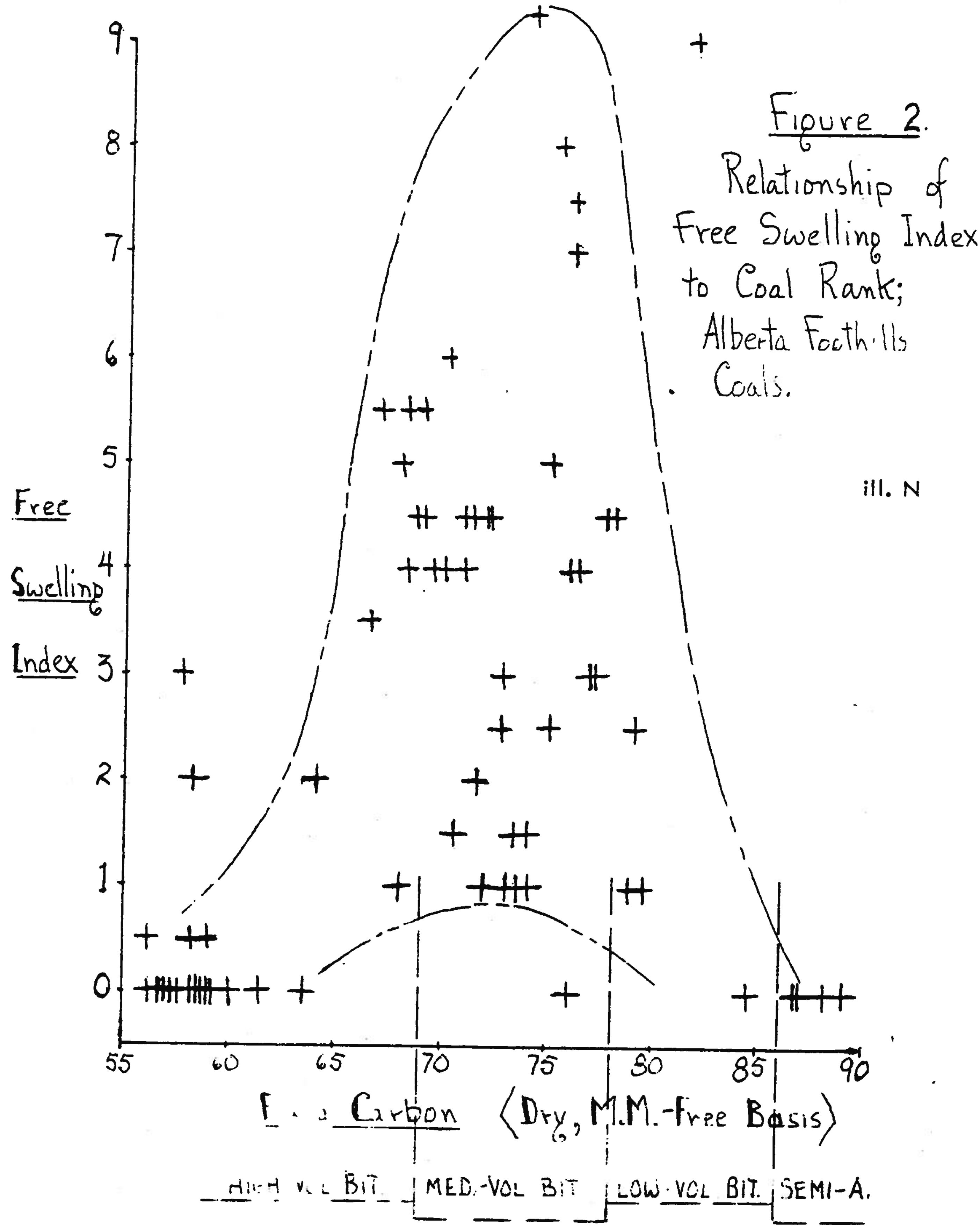


Figure 2. Relationship of Free Swelling Index to Coal Rank; Alberta Foothills Coals.

proportion to their proximity to the outcrop. In consequence of this, two precautions ought to be taken when prospecting for coking coal:

(a) for definitive coke determination, samples should be taken from beyond the weathered zone, either by tunnelling or by drilling; as a rule of thumb, they ought to be taken more than 50 feet in from the nearest rapidly eroding surface (e.g. a creek-cut) or more than 200 feet in from the nearest slowly eroding ground surface (e.g. a gentle hill slope);

(b) if drilling is the preferred method of sample collection, a method ought to be chosen which keeps the sample protected from oxidation at the time of bottom-hole cutting and during up-hole transportation, either by keeping it as a large core or, if it must be in the form of small cuttings, by submerging it in an oxidation-retarding medium such as water, drilling mud, engine exhaust fumes, or natural gas; definitive coke determinations ought not be made on samples which have been collected by straight air drilling of any kind. *

In practice, various coals are mixed or blended before charging into the coking retorts; the exact nature of the blend, and the exact temperature treatment are matters of operator's custom and preference. From this, two facts emerge:

(1) exact "Coke Quality" can only be determined in close cooperation with the potential user;

(2) coals which by themselves are only marginally coking or even non-coking, may be valuable to a given operator as blending stock.

The pertinent section of RCA Report 35 does not consider coke as a metallurgical reagent but it is included below for other information which it contains.

CARBONIZATION

The following is taken largely from a paper by E. Stansfield on Carbonization and Briquetting of Alberta Coals.**

Carbonization of coal is a decomposition by heat in a complete absence, or limited supply, of air, with the object of converting the coal into new products of greater value. The principal products primarily obtainable are: a solid residue which may be either a coke or a char; an organic liquid compound or tar; a watery liquid product commonly termed ammonia liquor; and a gas.

The original coal may be a smoky fuel; the coke or char is normally smokeless. Coke can be used for many metallurgical

*Canadian Chemistry and Process Industries. 27 (1943), p. 676.

†Investigations of Canadian Coals, B. F. Haanel and R. E. Gilmore. The Engineering Journal. XX (1937), p. 513.

**Trans. C.I.M. & M. Vol. XL (1937), p. 35.

* But see also page 68, par. (f).

and other processes for which coal is impossible or unsuitable. and it can be converted readily into a gaseous fuel. The tar may have value as a liquid fuel, and certain tars are the raw materials of the extremely important coal-tar industry, which gives dyes, chemicals. resins, flavours, explosives, and other products too numerous to mention. The gas, also, is a clean fuel, which can be piped to place of need and be used efficiently.

From any kind of coal, the relative amounts, and the chemical and physical characteristics, of the products can be widely varied at will by changes in the conditions of carbonization; even wider variations in the products can be made by variations in the kinds of coal treated. It should hardly need stating, however, that the sum of the weights of the products must be equal to the weight of the raw material—coal, water and, sometimes, air; and that the potential heat values of the products must be less than the potential heat value of the coal charged.

Two kinds of carbonization are commonly recognized, high-temperature carbonization (H.T.C.) and low-temperature carbonization (L.T.C.). The first is characterized as a heat treatment at a temperature of about 1,800°F. and the latter at about 1,000°F. Actually, the one kind may blend into the other and a "medium-temperature" carbonization is sometimes recognized with a temperature of the order of 1,300°F. It is better to regard L.T.C. as a treatment designed to give the more free-burning solid product, and, or, the higher yield of tars obtainable by the use of lower temperatures; rather than to set a definite temperature limit between the two processes. In general, the walls of the retort will not exceed 1,300°F. in L.T.C. When a coal is carbonized, the higher the temperature of carbonization the higher the ignition temperature of the coke or char and the less it is free-burning. For the open-grate fire and some other uses, a free-burning fuel is desirable. When coal is heated gradually, a comparatively large quantity of a "primary tar" is produced. If this primary tar is more strongly heated by contact with the hot walls of the retort or by passing over hot coke, it suffers a decomposition, with the deposition of carbon and the formation of gas and secondary tar. The secondary tar yield must therefore be less in amount than the primary tar yield from the same coal; but it should be noted that it is the secondary tar from bituminous coal which is the raw material for the coal-tar industry. The primary tars are more oily, and are sometimes referred to as "tar oils".

H.T.C., with suitable coal. is characterized by giving a strong coke, a tar with good marketable value, and a large yield of gas of medium calorific value.

The H.T.C. industry is a very large and well established industry in most of the commercial countries of the world where suitable coking bituminous coals are available. Comparatively little reference is made to this industry in the press. L.T.C. is in striking contrast. During the past forty years, at frequent intervals, sometimes in one place and sometimes in another, it has received wide publicity and has been heralded as a coming process which was going to revolutionize the coal industry, with great profit to the localities where it was to be introduced. Very many millions of dollars have been spent, most of them wasted, but the low temperature carbonization industry is still trivial in comparison with that of high temperature.

When a bituminous coal is heated in absence of air, it may soften and become plastic at a temperature between 700° and 800° F. It also decomposes with the evolution of gases and vapours. These gases and vapours give the plastic material a frothy or cellular structure and, as it decomposes, the plastic material soon hardens into the cellular material called coke. Decomposition begins at a temperature below the softening temperature and, if the coal is heated very slowly, the fusible material may so completely decompose below its softening temperature that the coal never softens at all. The decomposition temperature and velocity, and the softening temperature, of different coals, show notable variations. If the softening temperature is low and the decomposition temperature is high, the coal will coke readily; if these conditions are reversed, the coal may not coke at all. But a normally poor coking coal can sometimes be made into good coke by heating so rapidly that the softening temperature is reached before the fusible constituents have had time to decompose. A non-coking coal may fail to coke because of the reversed order of softening and decomposition temperatures, or because of scarcity of fusible constituents. In the latter case, only by a drastic change of the chemical character, as for example by partial hydrogenation, can it be converted into coke. Wood is a typical example of a non-fusing material. When pieces of wood are heated they shrink but do not soften or otherwise change their shape, and the charcoal finally produced retains the shape, and even the grain, of the original wood. Non-coking coals behave in a similar fashion, and, by analogy, the solid product of their carbonization is called char.

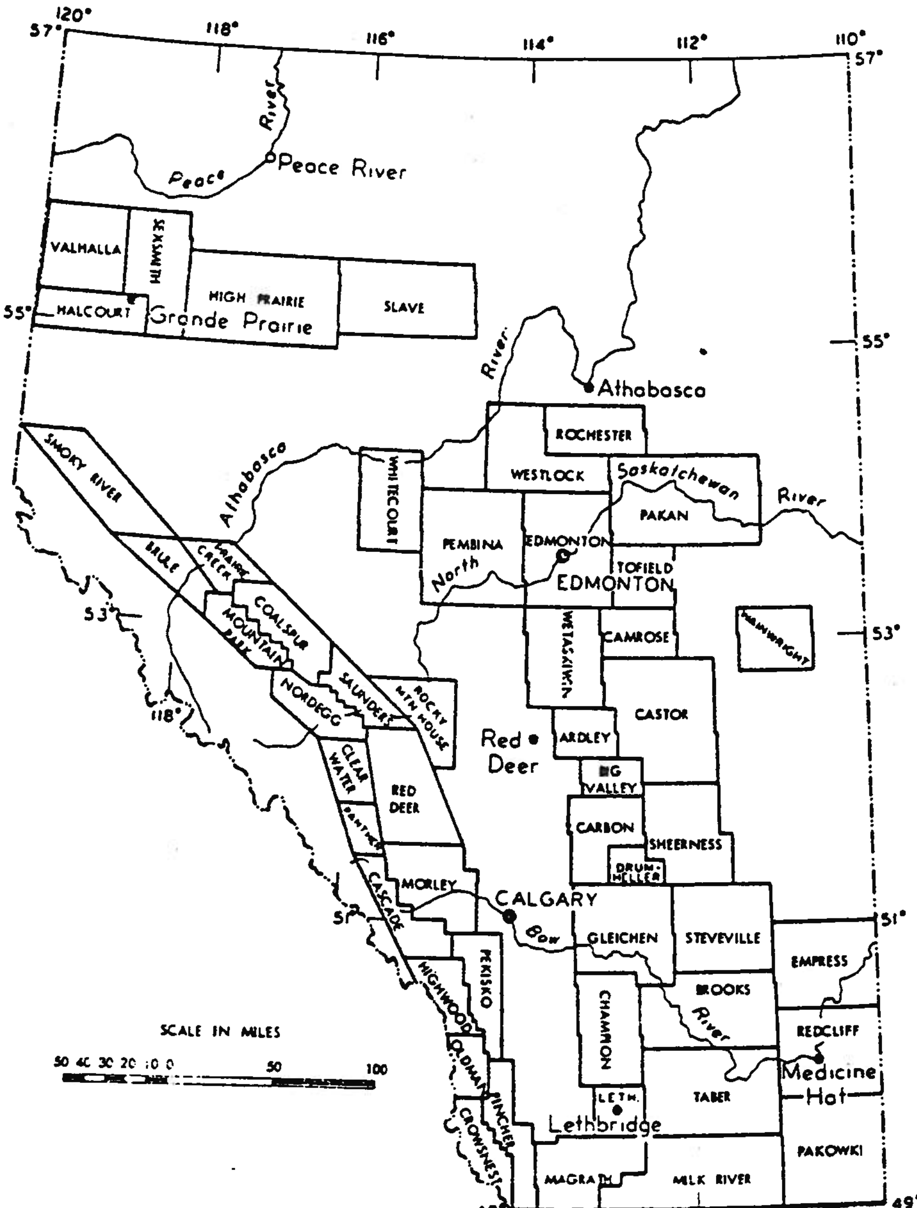


Figure 3 Coal Areas of Alberta.

VI. FOOTHILLS AREAS (STANSFIELD AND LANG)

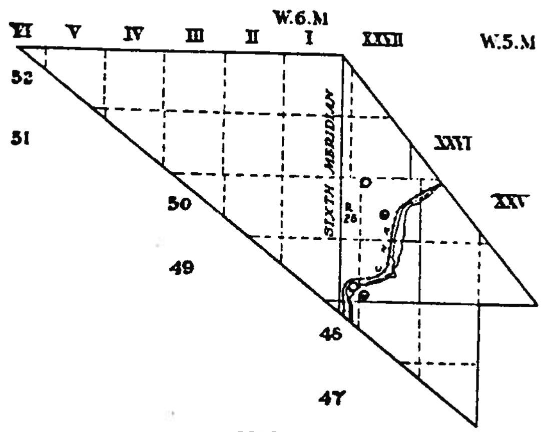
Following is extracted information on all Foothills administrative "Coal Areas" from Research Council of Alberta Report 35 (Stansfield and Lang, 1944).

BRULE AREA

No mine has operated since 1928. The coal previously mined is the type generally known as bituminous, steam coal; it is coking and weather resistant. The Canadian classification is Low Volatile Bituminous. The coal occurs in the Kootenay horizon; more than one seam has been mined.

In addition to the typical analyses given below reference has been made to coal from this area in the following sections of this report: fusibility of coal ash, coal sizing, carbonization (L.T.C.) and smithy coal.

Map 19 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.



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MAP 19

Scale: 20 miles to 1 inch. For symbols see page 93.

Typical Analyses

Proximate		Ultimate (with 1.0% moisture)	
Moisture	% 1.0	Carbon	% 76.2
Ash	% 13.9	Hydrogen	% 4.9
Volatile matter	% 18.8	Sulphur	% 0.4
Fixed carbon	% 66.3	Nitrogen	% 1.2
		Oxygen	% 3.4
		Ash	% 13.9

Fuel ratio (FC/VM), 3.5.

Calorific value, gross, in B.t.u. per lb., 13,170.

The net calorific value of this coal is approximately 450 B.t.u. per lb. lower than the gross value.

CASCADE AREA

The coal mined is a short flame, bituminous, steam coal, but is also suitable for domestic use. It is smokeless, non-coking and weather resistant. Most of the coal, according to the Canadian classification, is Low Volatile Bituminous, but some Semianthracite is also mined. There are at least twelve seams, eight of importance, all in the Kootenay horizon.

Two mines were operated in 1943. The output was 343,000 tons.

The operating mines are on the main line of the Canadian Pacific Railway. A briquetting plant is operated and 90,000 tons of coal were briquetted in 1943.

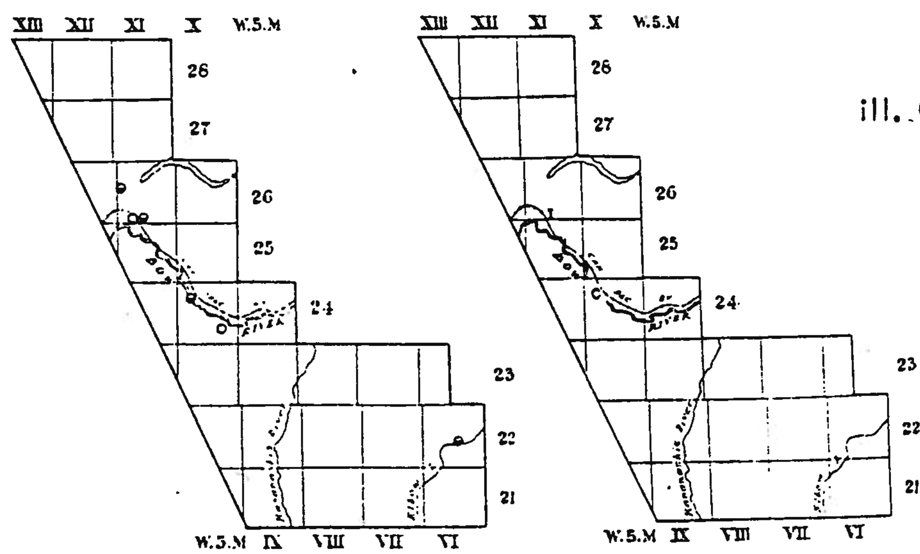
In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: pulverizability and grindability, fusibility of coal ash, and solubility in alkalies.

Map 24 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

Map 25 shows the location of operating mines graded by output in 1943.

Because of wide differences in analyses of coals from separate points, the area has been subdivided into 3 districts wherein similar coals occur. The districts are given, by townships, below the maps.

RESEARCH COUNCIL OF ALBERTA 105



MAP 24 MAP 25

Scale: 20 miles to 1 inch. For symbols see page 93.

District	Township	Range
A	26	XI
B	24	X
C	22	VI

DISTRICT A

The coal that has been mined—Canadian classification—is Semianthracite

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10
Specific gravity	1.36	1.42
Tons per hundred cubic feet	4.20	4.40
Tons per acre foot	1,840	1,920

Typical Analyses

Proximate			Ultimate (with 1.5% moisture)		
Moisture	%	1.5	Carbon	%	82.7
Ash	%	7.9	Hydrogen	%	3.8
Volatile matter	%	10.4	Sulphur	%	0.7
Fixed carbon	%	80.2	Nitrogen	%	1.2
			Oxygen	%	3.7
			Ash	%	7.9

Fuel ratio (FC/VM), 7.7.

Calorific value, gross, in B.t.u. per lb., 14,170.

The net calorific value of this coal is approximately 350 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon $= 89.0 - 0.89(M+1.06A)$
Volatile matter $= 100 - (M+A+FC)$
Calorific value, B.t.u./lb. $= 15{,}800 - 158(M+1.12A)$

DISTRICT B

This is the largest producing district in the area.
Canadian classification—Low Volatile Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.34	1.39	1.44
Tons per hundred cubic feet	4.15	4.30	4.50
Tons per acre foot	1,820	1,880	1,940

Typical Analyses

Proximate			Ultimate (with 1.8% moisture)		
Moisture	%	1.8	Carbon	%	82.0
Ash	%	7.9	Hydrogen	%	4.2
Volatile matter	%	14.2	Sulphur	%	0.8
Fixed carbon	%	76.1	Nitrogen	%	1.6
			Oxygen	%	3.5
			Ash	%	7.9

Fuel ratio (FC/VM), 5.4.

Calorific value, gross, in B.t.u. per lb., 14,050.

The net calorific value of this coal is approximately 380 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	85.0 — 0.85(M+1.11A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	15,700 — 157(M+1.11A)

DISTRICT C

This district, remote from the railway, is not at present producing.

Canadian classification—Low Volatile Bituminous

One sample, from a mine now closed, had the following analysis:

Moisture	%	2.8
Ash	%	9.8
Volatile matter	%	16.4
Fixed carbon	%	71.0

Fuel ratio (FC/VM), 4.3.

Calorific value, gross, in B.t.u. per lb., 13,680.

COALSPUR AREA

The coal mined has been called Subbituminous; it is used both for power production and for domestic heating. It is free burning, slightly smoky, non-coking and weather resistant coal. According to Canadian classification it is High Volatile C Bituminous. Several seams are known, all in the Belly River horizon, but production is largely from three.

All mines opened in this area are on the Coal Branch of the Canadian National Railway. Six mines (two stripping pits) were operated in 1943 and the output was 713,000 tons. Coal cleaning plants are operated.

Volume Weight Relation

Solid coal as in seam

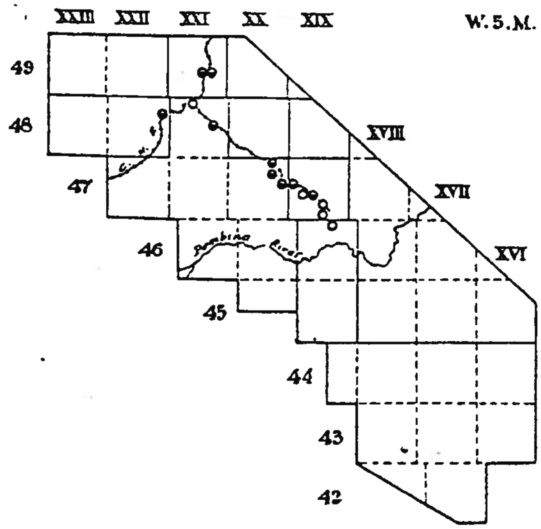
Percentage of Ash	5	10	15
Specific gravity	1.35	1.40	1.44
Tons per hundred cubic feet	4.20	4.35	4.50
Tons per acre foot	1,840	1,900	1,960

In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: storage (oxidation), pulverizability and grindability, fusibility of coal ash, solubility in organic solvents, microstructure and spores, coal sizing, and carbonization (L.T.C.).

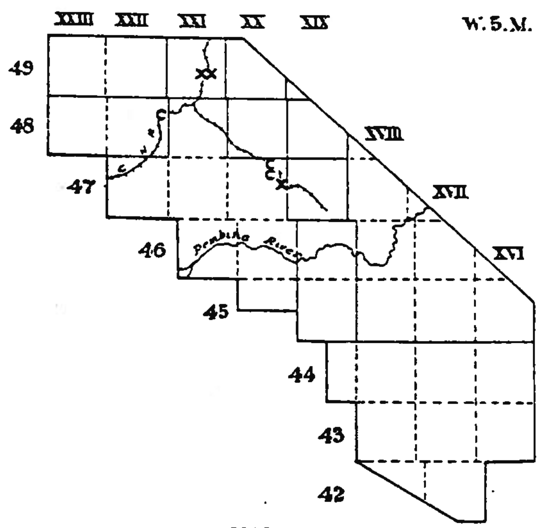
Map 30 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

Map 31 shows the location of operating mines graded by output in 1943.

Because of wide differences in analyses of coals from separate points, the area has been subdivided into 3 districts wherein similar coals occur. The districts are given, by townships, below the maps.



MAP 30



MAP 31

Scale: 20 miles to 1 inch. For symbols see page 93.

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District	Township	Range
A	49	XXI
B	48	XXI-XXII
	47	XX
C	47	XIX

DISTRICT A

Canadian classification—High Volatile C Bituminous

Typical Analyses

Proximate		Ultimate (with 10.0% moisture)	
Moisture	% 10.0	Carbon	% 61.7
Ash	% 10.8	Hydrogen	% 5.0
Volatile matter	% 34.1	Sulphur	% 0.2
Fixed carbon	% 45.1	Nitrogen	% 0.5
		Oxygen	% 21.8
		Ash	% 10.8

Fuel ratio (FC/VM), 1.30.

Calorific value, gross, in B.t.u. per lb., 10,570.

The net calorific value of this coal is approximately 460 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	= 59.0 — 0.59(M+1.26A)
Volatile matter	= 100 — (M+A+FC)
Calorific value, B.t.u./lb.	= 13,900 — 139(M+1.29A)

DISTRICT B

In this district coal cleaning plants are operated!

Canadian classification—High Volatile C Bituminous

Typical Analyses

Proximate		Ultimate (with 8.3% moisture)	
Moisture	% 8.3	Carbon	% 65.15
Ash	% 9.2	Hydrogen	% 4.95
Volatile matter	% 34.8	Sulphur	% 0.2
Fixed carbon	% 47.7	Nitrogen	% 0.8
		Oxygen	% 19.7
		Ash	% 9.2

Fuel ratio (FC/VM), 1.35.

Calorific value, gross, in B.t.u. per lb., 11,240.

The net calorific value of this coal is approximately 450 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	= 58.0 — 0.58(M+1.04A)
Volatile matter	= 100 — (M+A+FC)
Calorific value, B.t.u./lb.	= 13,800 — 138(M+1.12A)

DISTRICT C

The mines in this district have been closed.

Canadian classification—High Volatile C Bituminous

Typical Analyses

Proximate		Ultimate (with 11.0% moisture)	
Moisture	% 11.0	Carbon	% 60.5
Ash	% 12.5	Hydrogen	% 5.0
Volatile matter	% 31.8	Sulphur	% 0.2
Fixed carbon	% 44.7	Nitrogen	% 0.9
		Oxygen	% 20.9
		Ash	% 12.5

Fuel ratio (FC/VM), 1.40.

Calorific value, gross, in B.t.u. per lb., 10,400.

The net calorific value of this coal is approximately 460 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	61.0 — 0.61(M+1.26A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	14,000 — 140(M+1.18A)

CROWSNEST AREA

The coal mined is a bituminous, steam coal; it is coking and weather resistant. Most of the coal, according to the Canadian classification, is Medium Volatile Bituminous, but some High Volatile A Bituminous is also mined.

There are at least five seams of coal; but only three are of importance. All mines now operating are mining Kootenay horizon coal; but one small mine, now closed, mined Belly River horizon coal.

Eight mines were operated in 1943 and the output was 2,000,000 tons. The principal mines are on the Crowsnest line of the Canadian Pacific Railway. Several of these mines have coal cleaning plants, and at one mine there is a briquetting plant. At another mine a coke oven plant is operated and 101,000 tons of coal were coked in 1943.

In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: storage (oxidation), pulverizability and grindability, fusibility of coal ash, solubility in organic solvents, solubility in alkalies, coal sizing, carbonization (L.T.C.) and smithy coal.

Map 32 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

Map 33 shows the location of operating mines graded by output in 1943.

Because of wide differences in analyses of coals from separate points, the area has been subdivided into 4 districts wherein similar coals occur. The districts are given, by townships, below the maps.

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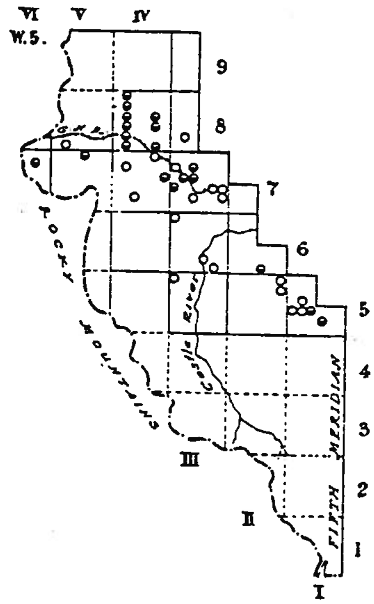
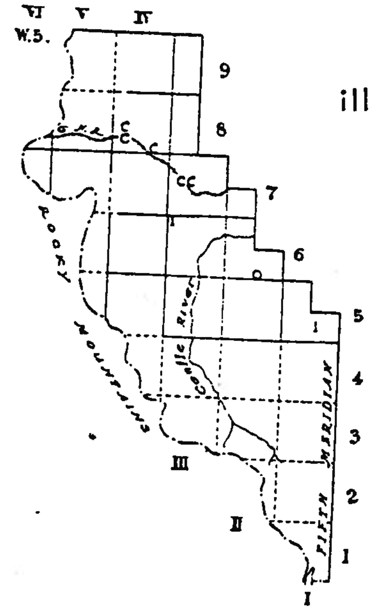


MAP 32



MAP 33

Scale: 20 miles to 1 inch. For symbols see page 93.

District	Township	Range
A	8	IV
	7	VI
B	7	V
C	7	III-IV
	6	III
D	6	II
	5	I

DISTRICT A

This is one of the two main producing districts in the area; three seams have been mined. A briquetting plant, coke ovens, and coal cleaning plants are operated in this district.

Canadian classification—Medium Volatile Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.30	1.36	1.41
Tons per hundred cubic feet	4.05	4.25	4.40
Tons per acre foot	1,760	1,840	1,920

Typical Analyses

Proximate		Ultimate (with 1.5% moisture)	
Moisture	% 1.5	Carbon	% 73.6
Ash	% 14.3	Hydrogen	% 4.4
Volatile matter	% 23.6	Sulphur	% 0.5
Fixed carbon	% 60.6	Nitrogen	% 1.1
		Oxygen	% 6.1
		Ash	% 14.3

Fuel ratio (FC/VM), 2.6.

Calorific value, gross, in B.t.u. per lb., 12,860.

The net calorific value of this coal is approximately 400 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	74.0 — 0.74(M+1.16A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	15,700 — 157(M+1.16A)

DISTRICT B

No mine at present operating in this district.

Canadian classification—High Volatile A Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.30	1.34	1.39
Tons per hundred cubic feet	4.05	4.15	4.30
Tons per acre foot	1,760	1,820	1,880

Typical Analyses

Proximate		Ultimate (with 4.0% moisture)	
Moisture	% 4.0	Carbon	% 67.65
Ash	% 13.9	Hydrogen	% 5.15
Volatile matter	% 35.5	Sulphur	% 1.2
Fixed carbon	% 46.6	Nitrogen	% 2.0
		Oxygen	% 10.1
		Ash	% 13.9

Fuel ratio (FC/VM), 1.30.

Calorific value, gross, in B.t.u. per lb., 12,100.

The net calorific value of this coal is approximately 470 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	57.0 — 0.57(M+1.02A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	15,000 — 150(M+1.10A)

DISTRICT C

This is one of the two main producing districts in the area; three seams have been mined. Coal cleaning plants are operated in this district.

Canadian classification—Medium Volatile Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.29	1.36	1.42
Tons per hundred cubic feet	4.00	4.25	4.40
Tons per acre foot	1,760	1,840	1,920

Typical Analyses

Proximate		Ultimate (with 1.5% moisture)	
Moisture %	1.5	Carbon %	72.8
Ash %	14.3	Hydrogen %	4.6
Volatile matter %	24.2	Sulphur %	0.5
Fixed carbon %	60.0	Nitrogen %	1.1
		Oxygen %	6.7
		Ash %	14.3

Fuel ratio (FC/VM), 2.5.

Calorific value, gross, in B.t.u. per lb., 12,830.

The net calorific value of this coal is approximately 420 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon = $71.0 - 0.71(M + 1.18A)$

Volatile matter = $100 - (M + A + FC)$

Calorific value, B.t.u./lb. = $15{,}500 - 155(M + 1.10A)$

DISTRICT D

This is a relatively unimportant district, and the mines are distant from the railway.

Canadian classification—High Volatile A Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.33	1.37	1.42
Tons per hundred cubic feet	4.15	4.25	4.40
Tons per acre foot	1,800	1,860	1,920

Typical Analyses

Proximate		
Moisture	%	3.3
Ash	%	10.2
Volatile matter	%	31.3
Fixed carbon	%	55.2

Ultimate (with 3.3% moisture)		
Carbon	%	72.8
Hydrogen	%	5.0
Sulphur	%	1.7
Nitrogen	%	1.0
Oxygen	%	9.3
Ash	%	10.2

Fuel ratio (FC/VM), 1.75.

Calorific value, gross, in B.t.u. per lb., 12,940.

The net calorific value of this coal is approximately 460 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon $= 64.0 - 0.64(M + 1.03A)$
Volatile matter $= 100 - (M + A + FC)$
Calorific value, B.t.u./lb. $= 15{,}200 - 152(M + 1.14A)$

HIGHWOOD AREA

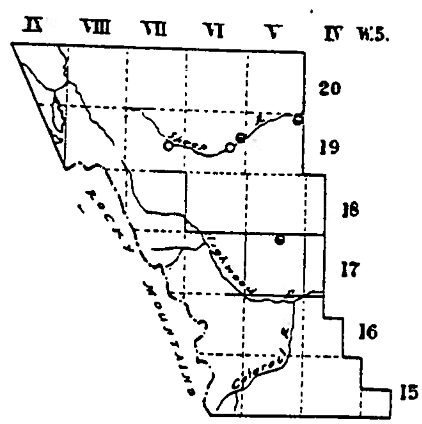
This area has so far been little developed, but if given railway connection to the Calgary-Macleod branch of the Canadian Pacific Railway might become an important producer.

The coal is a short flame, bituminous, steam coal; weather resistant. It is, according to Canadian classification, Low Volatile Bituminous.

Data with regard to the seams, and locations of prospects, are given in Research Council of Alberta Report No. 34 (1943), Part V, page 171.

No mine was operated in 1943.

Map 43 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.



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MAP 43

Scale: 20 miles to 1 inch. For symbols see page 93.

Typical Analyses

Proximate		Ultimate (with 1.8% moisture)	
Moisture	% 1.8	Carbon	% 77.3
Ash	% 12.3	Hydrogen	% 4.1
Volatile matter	% 16.3	Sulphur	% 0.6
Fixed carbon	% 69.6	Nitrogen	% 1.1
		Oxygen	% 4.6
		Ash	% 12.3

Fuel ratio (FC/VM), 4.3.

Calorific value, gross, in B.t.u. per lb., 13,360.

The net calorific value of this coal is approximately 370 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

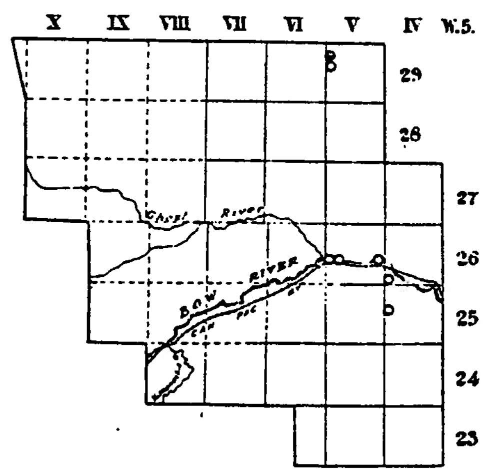
The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	81.0 — 0.81(M+1.00A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	16,000 — 160(M+1.20A)

MORLEY AREA

This area, traversed by the main line of the Canadian Pacific Railway, had no producing mines in 1943; the seams occur in the Belly River horizon.

Map 49 shows the location of all recorded mines opened, and also indicates a mine from which a sample has been obtained.



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MAP 49

Scale: 20 miles to 1 inch. For symbols see page 93.

The Canadian classification for sample (1) is High Volatile B Bituminous and for sample (2) from Morley Indian Reserve, location not shown on map, is High Volatile A Bituminous.

Two samples received had the following analyses:

Proximate

		(1)	(2)
Moisture	%	7.3	3.2
Ash	%	12.2	11.8
Volatile matter	%	33.3	36.3
Fixed carbon	%	47.2	48.7
Fuel ratio (FC, VM)		1.4	1.35
Calorific value, gross, in B.t.u. per lb.		11,290	12,770

MOUNTAIN PARK AREA

All mines operating are mining bituminous steam coal; it is coking and weather resistant. According to the Canadian classification, two ranks of coal are mined—Medium Volatile Bituminous and High Volatile A Bituminous.

There are several seams of coal being mined, all in the Kootenay horizon. Four mines were operated in 1943 and the output was 843,000 tons.

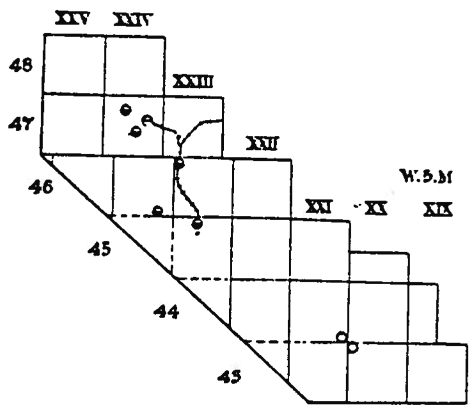
All the mines are on the Coalspur line of the Canadian National Railway. Coal cleaning plants are operated at three mines.

In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: storage (oxidation), pulverizability and grindability, solubility in organic solvents, coal sizing, and carbonization (L.T.C.).

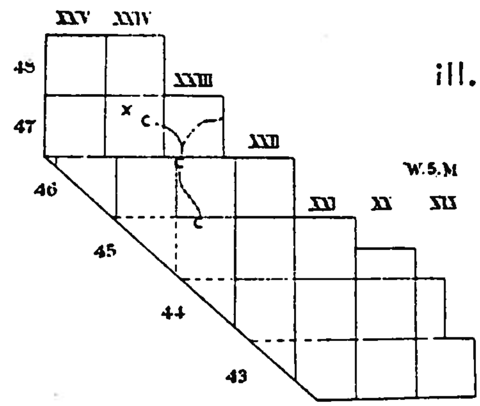
Map 51 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

Map 52 shows the location of operating mines graded by output in 1943.

Because of wide differences in analyses of coals from separate points, the area has been subdivided into 3 districts wherein similar coals occur. The districts are given, by townships, below the maps.



MAP 51



MAP 52

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Scale: 20 miles to 1 inch. For symbols see page 93.

District	Township	Range
A	47	XXIV
B	46	XXIII
C	45	XXIII

DISTRICT A

The coal mined in this district, according to Canadian classification, is mainly Medium Volatile Bituminous, but some High Volatile A Bituminous was mined from one entry.

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.31	1.38	1.45
Tons per hundred cubic feet	4.10	4.30	4.50
Tons per acre foot	1,780	1,880	1,960

Typical Analyses

Proximate		Ultimate (with 1.6% moisture)	
Moisture	% 1.6	Carbon	% 76.35
Ash	% 12.8	Hydrogen	% 4.35
Volatile matter	% 20.7	Sulphur	% 0.3
Fixed carbon	% 64.9	Nitrogen	% 1.1
		Oxygen	% 5.1
		Ash	% 12.8

Fuel ratio (FC/VM), 3.1.
Calorific value, gross, in B.t.u. per lb., 13,310.
The net calorific value of this coal is approximately 400 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	76.0 — 0.76(M+1.02A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	15,900 — 159(M+1.15A)

DISTRICT B

Canadian classification—High Volatile A Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.29	1.35	1.41
Tons per hundred cubic feet	4.00	4.20	4.40
Tons per acre foot	1,740	1,840	1,920

Typical Analyses

Proximate			Ultimate (with 1.8% moisture)		
Moisture	%	1.8	Carbon	%	77.1
Ash	%	10.8	Hydrogen	%	4.7
Volatile matter	%	28.3	Sulphur	%	0.3
Fixed carbon	%	59.1	Nitrogen	%	1.1
			Oxygen	%	6.0
			Ash	%	10.8

Fuel ratio (FC/VM), 2.1.
Calorific value, gross, in B.t.u. per lb., 13,500.
The net calorific value of this coal is approximately 430 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	69.0 — 0.69(M+1.16A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	15,700 — 157(M+1.13A)

DISTRICT C

Canadian classification—High Volatile A Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.29	1.33	1.38
Tons per hundred cubic feet	4.00	4.15	4.30
Tons per acre foot	1,740	1,800	1,860

Typical Analyses

Proximate		Ultimate (with 2.0% moisture)	
Moisture	% 2.0	Carbon	% 75.8
Ash	% 10.8	Hydrogen	% 4.8
Volatile matter	% 26.0	Sulphur	% 0.5
Fixed carbon	% 61.2	Nitrogen	% 1.2
		Oxygen	% 6.9
		Ash	% 10.8

Fuel ratio (FC/VM), 2.4.

Calorific value, gross, in B.t.u. per lb., 13,490.

The net calorific value of this coal is approximately 440 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon $= 71.0 - 0.71(M+1.10A)$

Volatile matter $= 100 - (M+A+FC)$

Calorific value, B.t.u./lb. $= 15{,}600 - 156(M+1.07A)$

NORDEGG AREA

The one mine operating is mining a short flame, bituminous, steam coal. This coal may coke when fired but is not used for making coke; it is weather resistant. The Canadian classification of this coal is Low Volatile Bituminous.

There are at least five seams in this area, but only two are now being mined, both in the Kootenay horizon.

The mine in the area is on the Brazeau branch of the Canadian National Railway. The output for 1943 was 321,000 tons. A coal cleaning plant and a briquetting plant are operated; 118,000 tons of coal were briquetted during 1943.

Volume Weight Relation

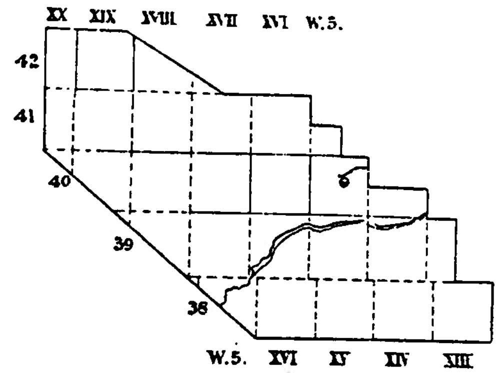
Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.32	1.36	1.41
Tons per hundred cubic feet	4.10	4.25	4.40
Tons per acre foot	1,780	1,840	1,900

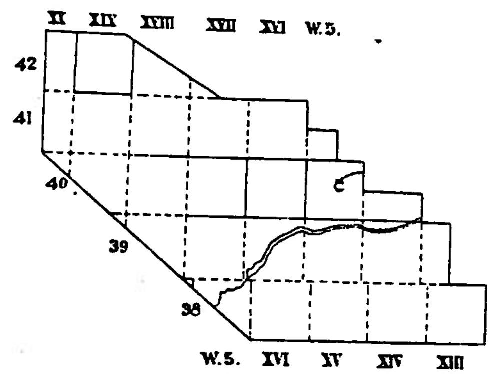
In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: storage (oxidation), pulverizability and grindability, fusibility of coal ash, solubility in organic solvents, and solubility in alkalies.

Map 53 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

Map 54 shows the location of operating mines, graded by output in 1943.



MAP 53



MAP 54

ill. W

Scale: 20 miles to 1 inch. For symbols see page 93.

Typical Analyses

Proximate		Ultimate (with 1.5% moisture)	
Moisture	% 1.5	Carbon	% 80.5
Ash	% 9.4	Hydrogen	% 4.3
Volatile matter	% 15.6	Sulphur	% 0.5
Fixed carbon	% 73.5	Nitrogen	% 1.2
		Oxygen	% 4.1
		Ash	% 9.4

Fuel ratio (FC/VM), 3.7.

Calorific value, gross, in B.t.u. per lb., 14,030.

The net calorific value of this coal is approximately 390 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon $= 83.0 - 0.83(M+1.06A)$

Volatile matter $= 100 - (M+A+FC)$

Calorific value, B.t.u./lb. $= 15{,}900 - 159(M+1.10A)$

OLDMAN AREA

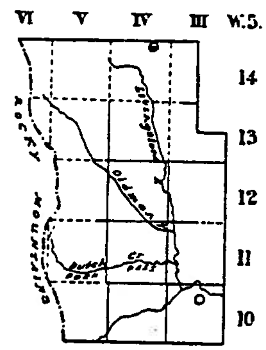
There are no operating mines in this area. The coal is a bituminous steam coal, weather resistant. According to the Canadian classification it is Medium Volatile Bituminous. There are no railways serving the area.

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10
Specific gravity	1.29	1.33
Tons per hundred cubic feet	4.05	4.15
Tons per acre foot	1,760	1,800

Map 55 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.



ill. X

MAP 55

Scale: 20 miles to 1 inch. For symbols see page 93.

Typical Analyses

Proximate		Ultimate (with 3.9% moisture)	
Moisture %	3.9	Carbon %	74.2
Ash %	11.5	Hydrogen %	4.5
Volatile matter %	22.4	Sulphur %	0.7
Fixed carbon %	62.2	Nitrogen %	1.0
		Oxygen %	8.1
		Ash %	11.5

Fuel ratio (FC/VM), 2.8.

Calorific value, gross, in B.t.u. per lb., 13,000.

The net calorific value of this coal is approximately 410 B.t.u. per lb. lower than the gross value.

PEKISKO AREA

The coal mined has been called subbituminous; it is largely used locally for domestic heating, but is also suited for power production. It has coking tendencies and is weather resistant. According to Canadian classification it is High Volatile B Bituminous.

Several seams are known, all in the Belly River horizon. Two mines were operated in 1943 and the output was 12,000 tons. No railway enters this area.

Volume Weight Relation

Solid coal as in seam

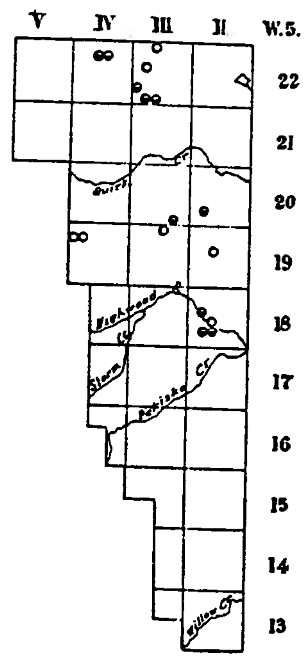
Percentage of Ash	5	10
Specific gravity	1.31	1.36
Tons per hundred cubic feet	4.10	4.25
Tons per acre foot	1,780	1,840

In addition to the typical and modified analyses given below reference has been made to coal from this area in the following section of this report: storage (oxidation).

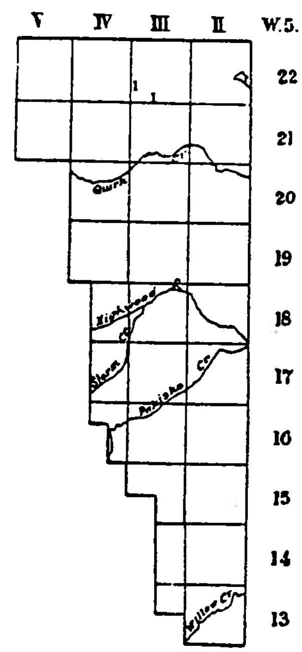
Map 59 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

Map 60 shows the location of operating mines graded by output in 1943.

Because of wide differences in analyses of coals from separate points, the area has been subdivided into 2 districts wherein similar coals occur. The districts are given, by townships, below the maps.



MAP 59



MAP 60

Scale: 20 miles to 1 inch. For symbols see page 93.

ill. Y

District	Township	Range
A	20-22	III-IV
B	18-20	II

DISTRICT B

Canadian classification—High Volatile B Bituminous

Typical Analyses

Proximate		Ultimate (with 8.0% moisture)	
Moisture	% 8.0	Carbon	% 67.25
Ash	% 9.2	Hydrogen	% 5.55
Volatile matter	% 36.1	Sulphur	% 0.6
Fixed carbon	% 46.7	Nitrogen	% 1.8
		Oxygen	% 15.6
		Ash	% 9.2

Fuel ratio (FC/VM), 1.30.

Calorific value, gross, in B.t.u. per lb., 12,060.

The net calorific value of this coal is approximately 510 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon = $59.0 - 0.59(M + 1.40A)$

Volatile matter = $100 - (M + A + FC)$

Calorific value, B.t.u./lb. = $14{,}800 - 148(M + 1.14A)$

PINCHER AREA

The coal mined has been called subbituminous; it is sold locally for domestic heating. It is a fair coking coal and is weather resistant. Three ranks of coal occur according to Canadian classification; the present production is High Volatile A Bituminous but High Volatile B, and High Volatile C Bituminous have also been mined.

Several seams are known, all in the Belly River horizon; but only two of these are of workable thickness. One mine was operated in 1943 and the output was 500 tons. This mine lies on the Crowsnest Branch of the Canadian Pacific Railway.

Volume Weight Relation

Solid coal as in seam

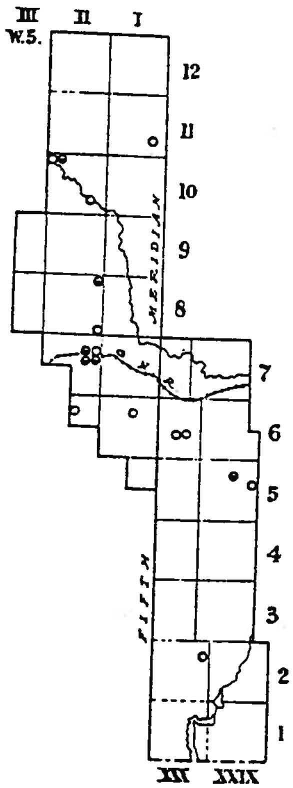
Percentage of Ash	5	10	15
Specific gravity	1.30	1.34	1.38
Tons per hundred cubic feet	4.05	4.15	4.30
Tons per acre foot	1,760	1,820	1,860

In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: solubility in organic solvents, solubility in alkalies.

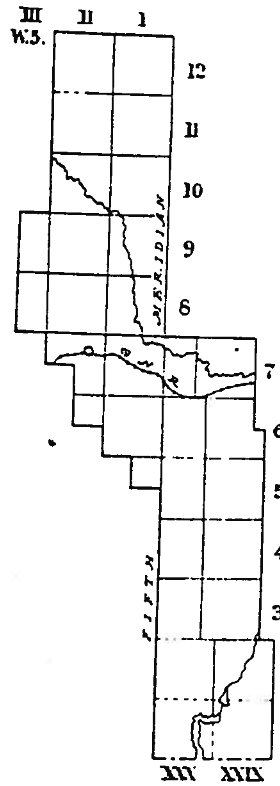
Map 63 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

Map 64 shows the location of the operating mine graded by output in 1943.

Because of wide differences in analyses of coals from separate points, the area has been subdivided into 2 districts wherein similar coals occur. The districts are given, by townships, below the maps.



MAP 63



MAP 64

ill. Z

Scale: 20 miles to 1 inch. For symbols see page 93.

District	Township	Range	Meridian
A	7-10	II	W 5
B	5	XXIX	W 4

DISTRICT A

The production now is from this district.
Canadian classification—High Volatile A Bituminous and High Volatile B Bituminous

Typical Analyses

Proximate		Ultimate (with 6.0% moisture)	
Moisture	% 6.0	Carbon	% 65.35
Ash	% 14.6	Hydrogen	% 5.25
Volatile matter	% 35.2	Sulphur	% 0.8
Fixed carbon	% 44.2	Nitrogen	% 1.7
		Oxygen	% 12.3
		Ash	% 14.6

Fuel ratio (FC/VM), 1.25.

Calorific value, gross, in B.t.u. per lb., 11,700.

The net calorific value of this coal is approximately 480 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	58.0 — 0.58(M+1.22A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	15,000 — 150(M+1.10A)

DISTRICT B

Canadian classification--High Volatile C Bituminous

Only one sample has been received from this district, with analysis as follows:

Proximate

Moisture	%	7.5
Ash	%	14.6
Volatile matter	%	33.8
Fixed carbon	%	44.1

Fuel ratio (FC/VM), 1.30.

Calorific value, gross, in B.t.u. per lb., 10,830.

PRAIRIE CREEK AREA

The mines are on the main line of the Canadian National Railway and the coal is sold for railway use. The coal is known as sub-bituminous; it is weather resistant. Two ranks of coal have been mined, according to Canadian classification, High Volatile B Bituminous and High Volatile C Bituminous. The seams occur in the Belly River horizon.

One mine was operated in 1943. The output for 1940 was 100,000 tons, and for 1943 was 1,900 tons.

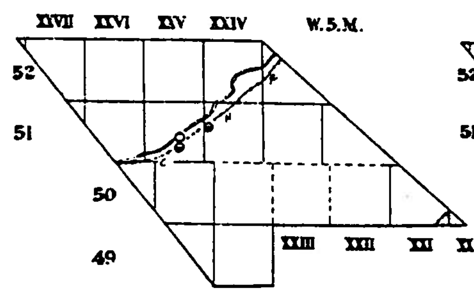
In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: storage (oxidation), pulverizability and grindability.

Map 65 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

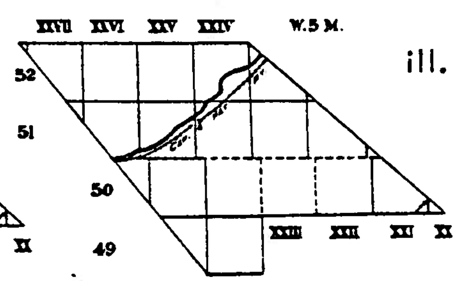
Map 66 shows the location of the operating mines graded by output in 1943.

Because of wide differences in analyses of coals from separate points, the area has been subdivided into 2 districts wherein similar coals occur. The districts are given, by townships, below the maps.

ill. AA



MAP 65



MAP 66

Scale: 20 miles to 1 inch. For symbols see page 93.

District	Township	Range
A	51	XXV
B	51	XXIV

DISTRICT A

This coal has coking tendencies

Canadian classification—High Volatile B Bituminous

Volume Weight Relation

Solid coal as in seam

Percentage of Ash	5	10	15
Specific gravity	1.31	1.35	1.39
Tons per hundred cubic feet	4.05	4.20	4.35
Tons per acre foot	1,780	1,820	1,880

Typical Analyses

Proximate		Ultimate (with 7.0% moisture)	
Moisture	% 7.0	Carbon	% 66.85
Ash	% 10.7	Hydrogen	% 5.35
Volatile matter	% 35.3	Sulphur	% 0.3
Fixed carbon	% 47.0	Nitrogen	% 1.3
		Oxygen	% 15.5
		Ash	% 10.7

Fuel ratio (FC, VM), 1.35.

Calorific value, gross, in B.t.u. per lb., 11,850.

The net calorific value of this coal is approximately 490 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon = $58.0 - 0.58(M + 1.12A)$

Volatile matter = $100 - (M + A + FC)$

Calorific value, B.t.u./lb. = $14,900 - 149(M + 1.26A)$

DISTRICT B

Canadian classification—High Volatile C Bituminous

Typical Analyses

Proximate		Ultimate (with 8.4% moisture)	
Moisture	% 8.4	Carbon	% 64.7
Ash	% 10.4	Hydrogen	% 5.2
Volatile matter	% 34.2	Sulphur	% 0.2
Fixed carbon	% 47.0	Nitrogen	% 0.8
		Oxygen	% 18.7
		Ash	% 10.4

Fuel ratio (FC, VM), 1.40.

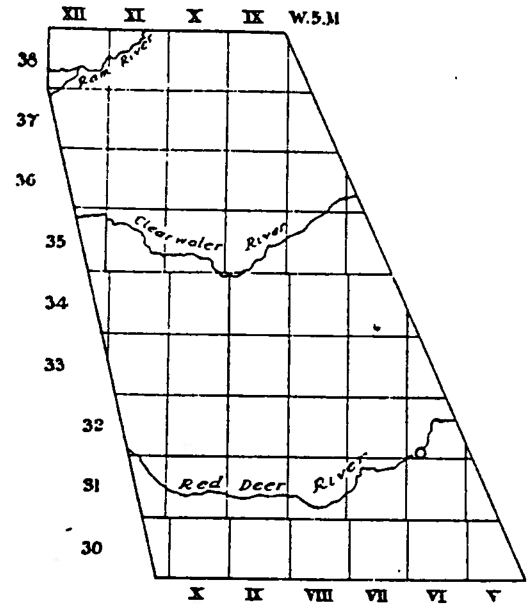
Calorific value, gross, in B.t.u. per lb., 11,200.

The net calorific value of this coal is approximately 470 B.t.u. per lb. lower than the gross value.

RED DEER AREA

Map 69 shows the location of the recorded mine opened. No samples have been obtained.

ill. BB



MAP 69

Scale: 20 miles to 1 inch. For symbols see page 93.

SAUNDERS AREA

The coal mined has been called subbituminous; it has been used principally for domestic heating. It is free burning, non-coking, weather resistant and slightly smoky. According to Canadian classification it is High Volatile C Bituminous. Several coal seams occur, all in the Belly River horizon.

The principal mines are on the Brazeau Branch of the Canadian National Railway. Two mines were operated in 1943 and the output was 65,000 tons.

Volume Weight Relation

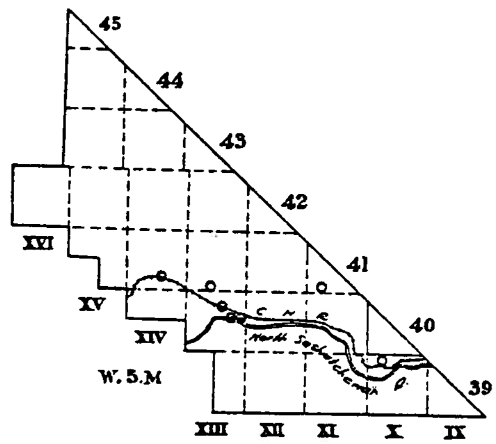
Solid coal as in seam

Percentage of Ash	5	10
Specific gravity	1.34	1.38
Tons per hundred cubic feet	4.15	4.30
Tons per acre foot	1,820	1,880

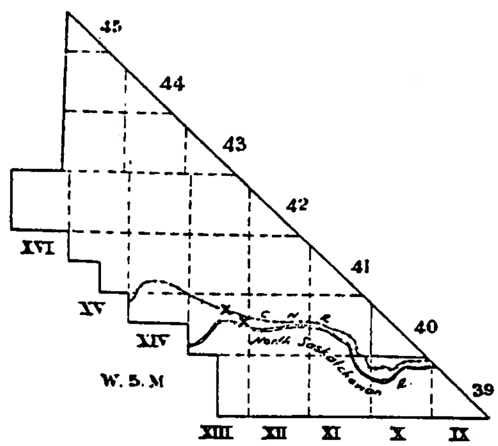
In addition to the typical and modified analyses given below reference has been made to coal from this area in the following sections of this report: storage (oxidation), pulverizability and grindability, fusibility of coal ash, solubility in organic solvents, solubility in alkalies, microstructure and spores, coal sizing, carbonization (L.T.C.) and smithy coal.

Map 71 shows the location of all recorded mines opened, and also indicates the mines from which samples have been obtained.

May 72 shows the location of operating mines graded by output in 1943.



MAP 71



MAP 72

ill. CC

Scale: 20 miles to 1 inch. For symbols see page 93.

Typical Analyses

Proximate

Moisture	%	9.7
Ash	%	6.8
Volatile matter	%	33.2
Fixed carbon	%	50.3

Ultimate (with 9.7% moisture)

Carbon	%	66.7
Hydrogen	%	5.3
Sulphur	%	0.4
Nitrogen	%	1.0
Oxygen	%	19.8
Ash	%	6.8

Fuel ratio (FC/VM), 1.50.

Calorific value, gross, in B.t.u. per lb., 11,550.

The net calorific value of this coal is approximately 480 B.t.u. per lb. lower than the gross value.

Modified Proximate Analysis

The following equations are provided to enable operators to tender on coals with moisture or ash differing from those of the typical analysis. See page 28 for method of use.

Fixed carbon	=	61.0 — 0.61(M+1.16A)
Volatile matter	=	100 — (M+A+FC)
Calorific value, B.t.u./lb.	=	14,200 — 142(M+1.32A)

SMOKY RIVER AREA

No operating mines have been recorded. The seams that have been prospected are of bituminous steam coals and occur in the Kootenay horizon.

A description of this area is given in "Smoky River Coal Field", James McEvoy, Geological Survey No. 2055, Department of Mines, Ottawa, 1922.

VII. FOOTHILLS MINES (CAMPBELL)

Following are extracted particulars of all mines for which analyses are given in Research Council of Alberta Report 65-5 (Campbell, 1966) with, as preface, the glossary.

7

GLOSSARY AND EXPLANATION OF ABBREVIATIONS

A. - ash; the noncombustible portion of a coal, expressed as percentage of total weight at capacity moisture.

bone or blackjack - miners' terms for silicified or calcified coal.

Bl - Blairmore Group or Formation and undivided stratigraphic equivalents; south of Tp. 30, barren of coal; north of Tp. 30 includes coal-bearing Luscar and Mountain Park Formations.

BR - Belly River Formation; north of Tp. 15 indistinguishable from overlying Edmonton Formation because of absence of intervening Bearpaw Formation and therefore grouped into the inclusive Wapiti Formation.

capacity moisture - the moisture content of a coal after equilibriation of coal in an atmosphere at 100 per cent relative humidity. (Capacity moisture does not include free surface moisture due, for example, to retention of rain or snow.)

C. Co. - coal company.

C. M. Co. - coal mining company.

** Coke - nature of coke; a tentative assessment of coking properties usually based on visual examination of the residue left from the volatile matter test; in this catalogue, 0 = non-coking, 1 = weakly coking, 2 = strongly coking.

F.C. - fixed carbon; the nonvolatile but combustible portion of a coal expressed as percentage of total weight at capacity moisture.

G.BTU - gross calorific value; the heat content of a coal (including the latent heat of condensation of the water produced by combustion) expressed in British Thermal Units per pound of coal at capacity moisture.

H_2O - moisture content of a coal expressed as percentage of total weight at capacity moisture.

Koot - Kootenay Formation; coal-bearing south of Tp. 30; north of Tp. 30 grading into barren Nikanassin Formation.

** NB.
The coke ratings given in the following catalogue (Campbell, 1966) are NOT Free Swelling Indices.

Lsd. - legal subdivision in the Land Survey system.

Mer. - principal meridian in the Land Survey system.

Prod. Fm. - rock unit from which coal is extracted.

proximate analysis - a system of coal analysis, including determinations of moisture, ash, volatile matter and fixed carbon, all of which are empirical evaluations not representing actual specific constituents of the coal. Proximate analysis does, however, give a valid measure of the quality of a coal.

R. - range in the Land Survey system.

s - strip mine.

Sec. - section, a parcel of land one mile square, in the Land Survey system.

SMR - St. Mary River Formation; south of Tp. 15 only, where divided from underlying Belly River Formation by intervening Bearpaw Formation.

ss - sandstone.

Tp. - township in the Land Survey system.

u/g - underground mine.

V.M. - volatile matter, that portion of a coal, other than moisture, which is lost from the coal on heating to 950°C. (1742°F.) in the absence of air.

Wti - Wapiti Group or Formation and undivided stratigraphic equivalents; here used to include all Upper Cretaceous and Paleocene continental strata north of Tp. 15; stratigraphy obsure since markers and breaks are unreliable; includes Brazeau Formation (lower part; equivalent to Belly River Formation and part of Edmonton Formation), Saunders Formation (middle and upper parts; equivalent to Edmonton and Porcupine Hills Formation), Coalspur beds (upper part; equivalent to Paskapoo Formation).

GEOGRAPHICAL LISTING, COAL MINES, ROCKY MOUNTAINS AND FOOTHILLS, ALBERTA

Lsd. or 1/4	Location Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Last Operator	Coal Area	Seam (feet)	Dip(degrees direction)	Prod. Fm.	Logs(feet); Analyses; Notes
10	3	6	2	5	199	u/g	1909-64	Beaver Mines C. Co.	Crowsnest	7		Koot	- Coal .7; splint .7; coal 3.7; clay .6; coal 2.7. H_2O 2.1; A. 16.9; V.M. 28.7; F.C. 52.3; G.BTU 12,030. 11
1,2,7, 8,10,11	9	6	2	5	1731	u/g	1953-60	Castle C. Co.	Crowsnest	7		Koot	- Coal .7; splint .7; coal 3.7; clay .6; coal 2.7. H_2O 2.1; A. 12.9; V.M. 29.4; F.C. 55.6; G.BTU 12,870; Coke-1. See also Sec. 10-6-2-5.
	30	6	3	5	71	s	1902-06	West Can. Coll. Ltd.	Crowsnest			Koot	- H_2O 2.1; A. 9.8; V.M. 30.4; F.C. 57.7; G.BTU 13,420; Coke-1. See also Sec. 17-6-3-5; Sec. 19-6-3-5; Sec. 20-6-3-5; Sec. 29-6-3-5; Sec. 31-6-3-5; Sec. 32-6-3-5; SE 1/4 6-7-3-5. 12
2,3,6,7, 10,11,14	31	6	3	5	1584	u/g	1942-62	Senycz Coll. Ltd.	Crowsnest			Koot	- H_2O 1.8; A. 12.6; V.M. 24.7; F.C. 60.9; G.BTU 13,060; Coke-1. See also Sec. 30-6-3-5.
	31	6	3	5	71	s	1902-06	West Can. Coll. Ltd.	Crowsnest			Koot	- H_2O 1.8; A. 25.9; V.M. 23; F.C. 49.3; G.BTU 10,580; Coke-1. See also Sec. 17-6-3-5; Sec. 19-6-3-5; Sec. 20-6-3-5; Sec. 29-6-3-5; Sec. 30-6-3-5; Sec. 32-6-3-5; SE 1/4 6-7-3-5.
10	26	7	2	5	1440	u/g	1933-54	Rhodes M. Co.	Pincher			BR	- Coal 4-5; rock 4-10; coal 4-10. H_2O 5.7; A. 15.7; V.M. 33.8; F.C. 45; G.BTU 11,610; Coke-2. Badly faulting.
3,4,5,6,9, 10,11,13, 14,15,16	28	7	3	5	133	u/g	1907-52	Hillcrest Mohawk Coll. Ltd.	Crowsnest			Koot	- H_2O 1.3; A. 20.2; V.M. 26.2; F.C. 52.3; G.BTU 11,770; Coke-4. See also Sec. 6-7-3-5; Sec. 7-7-3-5; Sec. 16-7-3-5; Sec. 21-7-3-5; Sec. 33-7-3-5.
13	12	7	6	5	1695	s	1949 ---	Coleman Coll. Ltd.	Crowsnest			Koot	- H_2O 4; A. 21.7; V.M. 23; F. C. 52.3; G.BTU 10,530; Coke-0. See also Sec. 11-7-6-5; Sec. 13-7-6-5; Sec. 14-7-6-5; Sec. 23-7-6-5; Sec. 24-7-6-5.
3,6,11,14	2	8	4	5	396	u/g;s	1913-65	Greenhill Mine	Crowsnest	10.5	40°W	Koot	- Rock 3.8; coal 3; dirty coal 2; coal 10; rock 34. H_2O 1.8; A. 15.4; V.M. 24.6; F.C. 58.2; G.BTU 12,600; Coke-1. See also Sec. 11-8-4-5; Sec. 14-8-4-5; Sec. 23-8-4-5; Sec. 24-8-4-5; Sec. 25-8-4-5; Sec. 36-8-4-5.
2,3,4,5, 6,7,10,11, 12,13,14,15	8	8	4	5	88	u/g	1903-54	Coleman Coll. Ltd.	Crowsnest	4.5-4.8		Koot	- H_2O 1.5; A. 8.6; V.M. 25.1; F.C. 64.8; G.BTU 13,790; Coke-3. See also Sec. 28-7-4-5; Sec. 29-7-4-5; Sec. 32-7-4-5; Sec. 33-7-4-5; Sec. 5-8-4-5.

N.B. Coke Ratings are NOT Free Swelling Indices. (See p. 58, footnote.)

GEOGRAPHICAL LISTING, COAL MINES, ROCKY MOUNTAINS AND FOOTHILLS, ALBERTA

Lsd. or 1/4	Location Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Last Operator	Coal Area	Seam (feet)	Dip(degrees direction)	Prod. Fm.	Logs(feet); Analyses; Notes
2,3,4,5, 6,7,10,11, 12,13,14,15	20	8	4	5	204	u/g	1909-60	Coleman Coll. Ltd.	Crowsnest			Koot	- H_2O 1.6; A. 19.5; V.M. 22.2; F.C. 56.6; G.BTU 11,820; Coke-1. See also Sec. 17-8-4-5; Sec. 29-8-4-5; Sec. 30-8-4-5.
1,8,9,16	23	8	4	5	396	u/g;s	1913-65	Greenhill Mine	Crowsnest			Koot	- H_2O 2.1; A. 18.1; V.M. 22.6; F.C. 57.2; G.BTU 12,110; Coke-1. See also Sec. 2-8-4-5; Sec. 11-8-4-5; Sec. 14-8-4-5; Sec. 24-8-4-5; Sec. 25-8-4-5; Sec. 36-8-4-5. 17
16	19	9	4	5	1747	u/g	1957---	Coleman Coll. Ltd.	Crowsnest	30		Koot	- H_2O 1.9; A.8.8; V.M. 21.8; F.C. 67.5; G.BTU 13,850; Coke-1. See also Sec. 20-9-4-5; Sec. 29-9-4-5; Sec. 30-9-4-5; Sec. 31-9-4-5.
15	9	10	3	5	1733	s	1953-56	Willow Valley C. Co.	Oldman			Koot	- No production. H_2O 9.1; A. 22.8; V.M. 18.9; F.C. 49.2; G.BTU 8,620; Coke-0. See also Sec. 16-10-3-5.
	32	16	5	5	1625	u/g	1945-51	Ford Highwood Coll. Ltd.	Highwood	19		Koot	- H_2O 1.8; A. 17.4; V.M. 14.4; F.C. 66.4; G.BTU 12,200; Coke-0. See also Sec. 33-16-5-5; Sec. 32-17-5-5; Sec. 12-17-6-5; Sec. 14-19-7-5; Sec. 15-19-7-5.
	33	16	5	5	1625	u/g	1945-51	Ford Highwood Coll. Ltd.	Highwood			Koot	- H_2O 2.2; A. 26.1; V.M. 14.8; F.C. 56.9; G.BTU 10,880; Coke-1. See also Sec. 32-16-5-5; Sec. 32-17-5-5; Sec. 12-17-6-5; Sec. 14-19-7-5; Sec. 15-19-7-5.
	12	17	6	5	1625	u/g	1945-51	Ford Highwood Coll. Ltd.	Highwood			Koot	- H_2O 2.6; A. 20.1; V.M. 15.2; F.C. 62.1; G.BTU 11,760; Coke-1. See also Sec. 32-16-5-5; Sec. 33-16-5-5; Sec. 32-17-5-5; Sec. 14-19-7-5; Sec. 15-19-7-5.
7	24	19	6	5	1638	s	1945-51	Payne	Highwood			Koot	- H_2O 1.8; A. 7.2; V.M. 17.6; F.C. 73.4; G.BTU 14,150; Coke-2.
	15	19	7	5	1625	u/g	1945-51	Ford Highwood Coll. Ltd.	Highwood			Koot	- H_2O 2; A. 14.8; V.M. 11.8; F.C. 71.3; G.BTU 12,700; Coke-0. See also Sec. 32-16-5-5; Sec. 33-16-5-5; Sec. 32-17-5-5; Sec. 12-17-6-5; Sec. 14-19-7-5.
9,10,11,14,15	4	22	3	5	1516	u/g	1937-58	Davies	Pekisko	3.4		Wtl	- H_2O 5.7; A. 4.7; V.M. 38; F.C. 51.6; G.BTU 11,295; Coke-2. 20
15,16	3	23	9	5	1667	u/g	1947-56	Kananaskis Expl. & Dev't Co.	Cascade		34°NW	Koot	- H_2O 1.6; A. 6.2; V.M. 12.6; F.C. 79.6; G.BTU 14,320; Coke-0. See also Sec. 10-23-9-5.

N.B. Coke Ratings are NOT Free Swelling Indices.
(See p. 58, footnote.)

GEOGRAPHICAL LISTING, COAL MINES, ROCKY MOUNTAINS AND FOOTHILLS, ALBERTA

Lsd. or 1/4	Location Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Last Operator	Coal Area	Seam (feet)	Dip(degrees direction)	Prod. Fm.	Logs(feet); Analyses; Notes	
1,6,7,8,9, 10,11,12	11	24	10	5	2	u/g	1899---	Canmore Mines Ltd.	Cascade			Koot	- H_2O 2.1; A. 8.7; V.M. 12.2; F.C. 77; G.BTU 13,800; Coke-2. See also Sec. 1-24-10-5; Sec. 12-24-10-5; Sec. 15-24-10-5; Sec. 16-24-10-5; Sec. 20 24-10-5; Sec. 21-24-10-5; Sec. 22-24-10-5; Sec. 28-24-10-5; Sec. 29-24-10-5; Sec. 32-24-10-5.	
2,5,6,7,8	15	24	10	5	2	u/g	1899---	Canmore Mines Ltd.	Cascade			Koot	- H_2O 1.9; A. 6.1; V.M. 13.6; F.C. 78.4; G.BTU 14,290; Coke-0. #5 Seam. See also Sec. 1-24-10-5; Sec. 11-24-10-5; Sec. 12-24-10-5; Sec. 16-24-10-5; Sec. 20-24-10-5; Sec. 21-24-10-5; Sec. 22-24-10-5; Sec. 28-24-10-5; Sec. 29-24-10-5; Sec. 32-24-10-5.	21
9,10,13, 14,15,16	16	24	10	5	2	u/g	1899---	Canmore Mines Ltd.	Cascade			Koot	- H_2O 1.6; A. 12.4; V.M. 14.9; F.C. 71.1; G.BTU 13,360; Coke-1. See also Sec. 1-24-10-5; Sec. 11-24-10-5; Sec. 12-24-10-5; Sec. 15-24-10-5; Sec. 20-24-10-5; Sec. 21-24-10-5; Sec. 22-24-10-5; Sec. 28-24-10-5; Sec. 29-24-10-5; Sec. 32-24-10-5.	
16	5	26	11	5	1244	u/g	1926-54	Wheatley & Sons	Cascade			Koot	- H_2O 1.5; A. 8.8; V.M. 12.7; F.C. 77; G.BTU 13,900; Coke-0. See also Sec. 4-26-11-5; Sec. 8-26-11-5.	
	3	27	7	5	1619		1944-51	Ansley & Sons	Morley	6-10		Koot	- Morley Indian Reserve. H_2O 3.2; A. 11.8; V.M. 36.3; F.C. 48.7; G.BTU 12,770; Coke-1.	
13	5	32	6	5	1448	u/g	1933-37	Sundre Coal	Red Deer	2		Wti	- H_2O 8; A. 15.1; V.M. 34.6; F.C. 42.3; G.BTU 11,080; Coke-1.	
9,10,15,16	24	40	13	5	388	u/g	1913-54	Bighorn & Saunders Ck.	Saunders	4-6		Wti	- H_2O 9.7; A. 8.8; V.M. 33.5; F.C. 48; G.BTU 11,150; Coke-0. See also Sec. 19-40-12-5; Sec. 25-40-13-5.	
9,16	27	40	13	5	852	u/g	1920-55	Alexo C. Co.	Saunders	5	N56°E	Wti	- H_2O 9.1; A. 6.8; V.M. 34; F.C. 50.1; G.BTU 11,380; Coke-0. Shale & ss; clad 1.2; bone .5; coal 5; shale 3; coal 2; shale. See also Sec. 26-40-13-5; Sec. 34-40-13-5; Sec. 35-40-13-5.	24
1,2,3,4,5,6, 7,8,11,12,13	22	40	15	5	256	u/g;s	1910-56	Brazeau Coll. Ltd.	Nordegg			Bl	- H_2O 1.6; A. 12.1; V.M. 17.2; F.C. 69.1; G.BTU 13,360; Coke-1. See also Sec. 11-40-15-5; Sec. 14-40-15-5; Sec. 15-40-15-5; Sec. 21-40-15-5; Sec. 23-40-15-5; Sec. 28-40-15-5; Sec. 29-40-15-5.	
13	22	40	15	5	1585	u/g	1942-56	Brazeau Coll. Ltd.	Nordegg			Bl	- H_2O 1.9; A. 6.1; V.M. 15.4; F.C. 76.6; G.BTU 14,350; Coke-1.	

N.B. Coke Ratings are NOT Free Swelling Indices.
(See p. 58, footnote.)

GEOGRAPHICAL LISTING, COAL MINES, ROCKY MOUNTAINS AND FOOTHILLS, ALBERTA

Lsd. or 1/4	Location Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Last Operator	Coal Area	Seam (feet)	Dip(degrees direction)	Prod. Fm.	Logs(feet); Analyses; Notes
1,2,3,4, 5,6,7,8, 10,11,12	32	46	23	5	693	u/g	1917-52	Cadomin C. Co.	Mtn. Park			Bl	- H_2O 2 ; A. 9.7; V.M. 28.7; F.C. 59.6; G.BTU 13,380; Coke-2. See also Sec. 31-46-23-5; Sec. 5-47-23-5; Sec. 6-47-23-5; Sec. 1-47-24-5; Sec. 11-47-24-5; Sec. 12-47-24-5.
9	7	47	19	5	771	u/g;s	1918-58	Con. Coll. Res. Ltd.	Coalspur			Wtl	- Coal 2.5; clay & bone .8; coal 2.7; ss 3.3; coal & clay 2.4; coal 1.4; coal & shale 1.6; coal 5.8; clay & bone 1.6; coal 3; coal ,bone & clay 1.8. H_2O 9.7; A. 8.9; V.M. 36.1; F.C. 45.3; G.BTU 10,970; Coke-0. See also Sec. 13-47-20-5; Sec. 23-47-20-5; Sec. 24-47-20-5; Sec. 25-47-20-5; Sec. 26-47-20-5. 27
1,2,3,5, 6,7,10,11, 12,13,14	24	47	20	5	771	u/g;s	1918-58	Con. Coll. Res. Ltd.	Coalspur			Wtl	- Coal 2.5; clay 1; coal 2.7; ss 3; coal & clay 2.5; clay 1.7; clay 1; coal 5.5; clay 1.1; coal 3.2. H_2O 8.4; A. 10; V.M. 32.1; F.C. 49.5; G.BTU 11,110; Coke-0. See also Sec. 7-47-19-5; Sec. 13-47-20-5; Sec. 23-47-20-5; Sec. 25-47-20-5; Sec. 26-47-20-5.
1,2,7,8	25	47	20	5	1002	s	1922-55	Sterling Valley C.M.	Coalspur			Wtl	- H_2O 11.3; A. 14.4; V.M. 29.9; F.C. 44.4; G.BTU 10,140; Coke-0. See also Sec. 26-47-20-5; Sec. 35-47-20-5; Sec. 36-47-20-5.
1	26	47	20	5	1749	u/g	1957-58	Con. Coll. Res. Ltd.	Coalspur			Wtl	- Coal 5.4; clay .5; bone .5; coal 3.2. H_2O 9.1; A. 9; V.M. 34.3; F.C. 47.6; G.BTU 10,970; Coke-0.
12,13	15	47	24	5	905	u/g;s	1921-56	Luscar C. Co.Ltd.	Mtn. Park	38-50		Bl	- H_2O 1.7; A. 11.1; V.M. 28.5; F.C. 58.7; G.BTU 13,240; Coke-2. See also Sec. 14-47-24-5; Sec. 16-47-24-5; Sec. 21-47-24-5; Sec. 23-47-24-5; Sec. 26-47-24-5; Sec. 27-47-24-5. 29
9,16	16	47	24	5	905	u/g;s	1921-56	Luscar C. Co.Ltd.	Mtn. Park			Bl	- H_2O 1.1; A. 10.7; V.M. 28.2; F.C. 60; G.BTU 13,690; Coke-2. See also Sec. 14-47-24-5; Sec. 15-47-24-5; Sec. 21-47-24-5; Sec. 23-47-24-5; Sec. 26-47-24-5; Sec. 27-47-24-5.
1,8,9, 10,11,12	23	47	24	5	905	u/g;s	1921-56	Luscar C. Co. Ltd.	Mtn. Park			Bl	- H_2O 2; A. 8.9; V.M. 26.4; F.C. 62.7; G.BTU 13,860; Coke-1. See also Sec. 14-47-24-5; Sec. 15-47-24-5; Sec. 16-47-24-5; Sec. 21-47-24-5; Sec. 26-47-24-5; Sec. 27-47-24-5.
2,3,4,5,12	26	47	24	5	905	u/g;s	1921-56	Luscar C. Co.Ltd.	Mtn. Park			Bl	- H_2O 1.4; A. 12.7; V.M. 21.4; F.C. 64.5; G.BTU 13,290; Coke-2. See also Sec. 14-47-24-5; Sec. 15-47-24-5; Sec. 16-47-24-5; Sec. 21-47-24-5; Sec. 23-47-24-5; Sec. 27-47-24-5.

N.B. Coke Ratings are NOT Free Swelling Indices. (See p. 58, footnote.)

GEOGRAPHICAL LISTING, COAL MINES, ROCKY MOUNTAINS AND FOOTHILLS, ALBERTA

Lsd. or 1/4	Location Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Last Operator	Coal Area	Seam (feet)	Dip(degrees direction)	Prod. Fm.	Logs(feet); Analyses; Notes
7,8,9,10	28	47	24	5	1392	u/g;s	1932-53	K.D. Coll. Co. Ltd.	Mtn. Park			Bl	- H_2O 1.3; A. 7.8; V.M. 21; F.C. 69.9; G.BTU 14,260; Coke-1. See also Sec. 21-47-24-5; Sec. 29-47-24-5.
1,2,3,5,6,7, 8,11,12,13	19	48	21	5	846	u/g	1920-65	Can. Coll. Ltd.	Coalspur			Wti	- H_2O 8.2; A. 7.2; V.M. 35.8; F.C. 48.5; G.BTU 11,540; Coke-0. See also Sec. 17-48-21-5; Sec. 18-48-21-5; Sec. 24-48-22-5; Sec. 25-48-22-5; Sec. 26-48-22-5; Sec. 27-48-22-5; Sec. 34-48-22-5.
7	33	48	21	5	1692	u/g	1949-54	Vitaly	Coalspur	9	S43°E	Wti	- H_2O 7.3; A. 5.9; V.M. 38; F.C. 48.8; G.BTU 11,980; Coke-1.
1,2,3, 4,5,12	25	48	22	5	846	u/g	1920-65	Can. Coll. Ltd.	Coalspur			Wti	- #1 Seam: coal roof; shale .2; coal 2.2; bone .2; coal .8; clay .4; coal 3. #2 Seam: coal 6.9; bone .8; coal 3.9. H_2O 7.3; A. 8.8; V.M. 35; F.C. 48.8; G.BTU 11,340; Coke-0. See also Sec. 17-48-21-5; Sec. 18-48-21-5; Sec. 19-48-21-5; Sec. 24-48-22-5; Sec. 26-48-22-5; Sec. 27-48-22-5; Sec. 34-48-22-5.
9,15,16	11	49	21	5	775	u/g	1918-57	Lakeside C. Ltd.	Coalspur			Wti	- #1 Seam: coal 2.7; clay .5; coal 2.8. #2 Seam: coal 4.1; clay & bone .6; coal 5.8. H_2O 11.2; A. 10.1; V.M. 31.3; F.C. 47.4;G.BTU 10,660; Coke-0. See also Sec. 12-49-21-5; Sec. 14-49-21-5; Sec. 15-49-21-5.
9	20	49	21	5	1157	u/g;s	1924-57	King C. Ltd.	Coalspur			Wti	- H_2O 10.2; A. 8.4; V.M. 33.7; F.C. 47.4; G.BTU 10,780; Coke-0. See also Sec. 15-49-21-5; Sec. 16-49-21-5; Sec. 21-49-21-5; Sec. 22-49-21-5.
1,2,12	21	49	21	5	1157	u/g;s	1924-57	King C. Ltd.	Coalspur			Wti	- Coal roof 2; coal 3; clay .5; coal 5. H_2O 10.3; A. 9.4; V.M. 35.2; F.C. 45.1 G.BTU 10,820; Coke-0. See also Sec. 15-49-21-5; Sec. 16-49-21-5; Sec. 20-49-21-5; Sec. 22-49-21-5.
W 1/2	14	50	24	5	1706	s	1949-50	Capostinsky & Woodley	Prairie Ck.	6-13		Wti	- H_2O 10; A. 7; V.M. 34.9; F.C. 45.1; G.BTU 11,160; Coke-0. See also Sec. 15-50-24-5.
4	29	50	25	5	1653	u/g	1945-53	C.M. Woodley & Partners	Prairie Ck.			Wti	- Ss; coal 1.9; caprock 5; coal 4.2; clay .3; rock .2; clay .8; coal 1.9; shale .1; coal 1.8; clay .2; coal 3.1; hard shale. H_2O 6.7; A. 13.9; V.M. 32.8; F.C. 46.6; G.BTU 11.090: Coke-0.
7	11	51	25	5	1714	u/g	1950-57	Yellowknife Hard Coal	Prairie Ck.	5.8		Wti	- H_2O 11.7; A. 13.7; V.M. 31.7; F.C. 42.9; G.BTU 10,200; Coke-0.

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N.B. Coke Ratings are NOT Free Swelling Indices. (See p. 58, footnote.)

GEOGRAPHICAL LISTING, ALBERTA GOVERNMENT COAL LEASES,

ROCKY MOUNTAINS AND FOOTHILLS, ALBERTA

Lsd. or 1/4	Sec.	Tp.	R.	Mer.	Coal Area	Prod. Fm.	Lease Bearing; Logs(ft.); Analyses; Notes
8,9,16	19	9	4	5	Crowsnest	Koot	H_2O 1.8; A. 15.2; V.M. 21.2; F.C. 61.8; G.BTU 12,820; Coke - 2.
11	27	39	17	5	Nordegg	Bl	Freehold (no lease); dip 25° WSW. H_2O 2.3; A. 6.3; V.M. 22; F.C. 69.4; G.BTU 14,170; Coke - 2.
N1/2 & SE & 4,5	5	45	20	5	Mtn. Park	Bl	H_2O 3.1; A. 26; V.M. 17; F.C. 53.9; G.BTU 10,940.
S1/2 & NW	16	47	19	5	Coalspur	Wti	H_2O 8; A. 18.9; V.M. 31; F.C. 42.1; G.BTU 9,580; Coke - 0.
NE & 8,11,14	16	47	24	5	Mtn. Park	Bl	H_2O 1.9; A. 16.6; V.M. 24.6; F.C. 56.9; G.BTU 12,490; Coke - 2.
	19	57	8	6	Smoky River	Bl	Ss 3.3; shale .3; siltstone 3; coal 1; coal (hard) 7.7; coal (soft) 1.6; coal (bony) .2; coal (soft) .5; siltstone 1.7; siltstone .7; siltstone .6; siltstone 2. H_2O 2.5; A. 7; V.M. 19.2; F.C. 71.3; G.BTU 14,150; Coke - 2.
	9	58	9	6	Smoky River	Bl	H_2O 5.2; A. 8.3; V.M. 16.3; F.C. 70.2; G.BTU 12,760; Coke - 0.
	10	58	9	6	Smoky River	Bl	Ss 1; coal 1; coal 3.8; coal .5; coal 1.7; coal .3; coal 4.2; shale .1; coal .7; clay .1; shale .5; coal .7; siltstone .2; ss 2.7; shale 6; ss 1.5. H_2O 4.4; A. 5.4; V.M. 16.3; F.C. 73.9; G.BTU 13,600; Coke - 0.

N.B. Coke Ratings are NOT Free Swelling Indices.
(See p. 58, footnote.)

VIII. GEOLOGY

As can be seen in Figure 4, and in Map B, there are two distinct groups of coals, geologically speaking, in Alberta, although all are relatively young.

The older group, consisting of coals in the Kootenay Formation (youngest Jurassic to earliest Cretaceous in age) south of township 30, or in the Blairmore Group (early Cretaceous in age) north of township 30, are restricted to the inner Foothills belt where strata are strongly deformed, and topography is rough so that outcrops are relatively common. Unmodified seams range to 35 feet in thickness, while in the apices of synclinal folds, coal masses exceeding 200 feet in thickness have been encountered. Coal ranks range from High Volatile A Bituminous to Semi-Anthracite.

The younger group of coals, youngest Cretaceous or earliest Tertiary in age, are found in the outer Foothills belt (as well as in the Alberta plains). The coal measures here consist of an immense featureless and unfossiliferous sequence of strata (in places exceeding 13,000 feet in thickness) which, in the absence of reliable stratigraphic markers, is best considered for the present under the term Wapiti Group. In this region strata are generally less strongly deformed than in the inner Foothills belt and topography is less rough and consequently more heavily covered with drift, muskeg, and vegetation so that outcrops are uncommon. Probably most coal seams lie in the middle part of the sequence near the Cretaceous-Tertiary boundary; here single seams range to 15 feet in thickness, coaly zones (sequences of interbedded coal and coaly shale and siltstone) to 50 or 60 feet, and relatively solid masses of coal in the apices of a few overturned anticlinal folds to more than 300 feet. Coal ranks range from High Volatile C Bituminous to High Volatile A Bituminous.

IX. RECOMMENDATIONS

(a) Coal deposits in the Foothills belt of Alberta are difficult to discover since they are obscured by strong geological deformation, especially in the inner belt, or by drift, muskeg and vegetation cover, especially in the outer belt. They must be sought by careful examination of terrain either from the ground or from helicopter. Air photo interpretation has, to date, found only limited usefulness as an adjunct to more conventional methods while other "short cuts" grouped under the term "remote sensing" have found no application and seem to hold out little hope for the future. On the other hand a drill program is highly recommended even at an early stage. Plans should be made to include one or two holes with a portable rig even in a program of reconnaissance prospecting.

(b) Deposits of high-grade coking coal are to be sought in the inner Foothills belt in rocks of the Kootenay Formation south of township 30 or of the Blairmore Group (including the Luscar Formation) northwest of township 30. It might also be profitable to examine rocks of the Nikanassin Formation (see Figure 3) in the region west of the Smoky River although, to date, no seams of mineable thickness have been reported.

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Figure 4 Succession of Strata, Rocky Mountains and Foothills, Alberta.

		South of Tp. 15	Tp. 15-30	North of Tp. 30
PALEOCENE		Porcupine Hills and Willow Creek Fm.	Wapiti Gp. (Wti) ** and equivalents	Wapiti Gp. (Wti) ** and equivalents
CRETACEOUS	UPPER	St. Mary River Fm. (SMR) **	Wapiti Gp. (Wti) ** and equivalents	Wapiti Gp. (Wti) ** and equivalents
CRETACEOUS	UPPER	Bearpaw Fm.	Wapiti Gp. (Wti) ** and equivalents	Wapiti Gp. (Wti) ** and equivalents
CRETACEOUS	UPPER	Belly River Fm. (BR) **	Wapiti Gp. (Wti) ** and equivalents	Wapiti Gp. (Wti) ** and equivalents
CRETACEOUS	UPPER	Marine groups and formations*	Marine groups and formations*	Marine groups and formations*
CRETACEOUS	LOWER	Blairmore Fm.	Blairmore Fm.	Blairmore Gp. (Bl) ** and equivalents
CRETACEOUS	LOWER	Kootenay Fm. (Koot) **	Kootenay Fm. (Koot) **	Nikanassin Fm.
JURASSIC		Fernie Gp.	Fernie Gp.	Fernie Gp.

** Coal-bearing rock unit.

(c) The inner Foothills belt also contains considerable quantities of coal that is non-coking, usually because its rank is too high. Already some of this coal has found a foreign market as blending stock.

(d) Coal of the outer Foothills belt is all non-coking or at best marginally coking because its rank is too low. It seems likely that in the near future this coal will find markets both as blending stock and as economically exportable thermal fuel.

(e) It is recommended that definitive coking tests not be made on samples collected less than 50 feet in from the nearest rapidly eroding ground surface (e.g. a creek-cut) or less than 200 feet in from the nearest slowly eroding ground surface (e.g. a gentle hill slope), nor should they be collected by means of straight air drilling.

(f) Air drills, however, may be the most economical method of outlining with reasonable accuracy the stratigraphy, structure and extent of coal bodies. *

(g) Near-surface coal deposits suitable for strip-mining, in the inner Foothills belt are probably mostly taken up by now, and in the outer Foothills belt possibly largely so. However it is believed that world demand for good coking coal, for blending coal and even for economically transportable thermal power coal will increase markedly so that less favourably situated bodies, which will have to be mined by underground methods, will be attractive in the near future. Consequently it is recommended that prospecting programs be designed to detect the presence of more deeply buried coal deposits as well as those which are of immediately economical attraction.

X. ALBERTA LAND SURVEY SYSTEM

(3) Alberta Land Survey system. Townships (Tp.) are six miles square. They are numbered from the International Boundary northward. The 4th, 5th, and 6th Meridians (Mer.) are respectively, 110, 114, and 118 degrees of longitude west of Greenwich. Ranges (R.) are numbered westward from each meridian.

Sections (Sec.) are 1 mile square. Within each township they are numbered as shown:

31	32	33	34	35	36
30	29	28	27	26	25
19	20	21	22	23	24
18	17	16	15	14	13
7	8	9	10	11	12
6	5	4	3	2	1

Sections may be divided into 16 Legal Subdivisions (Lsd.) which are numbered as shown:

13	14	15	16
12	11	10	9
5	6	7	8
4	3	2	1

* Also, true coking quality of any coal is NEVER WORSE THAN the coke rating indicated by analysis of a sample obtained by air-drilling.

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WILLMORE
WILDERNESS
PARK
JASPER
NATIONAL
PARK
BANFF
NATIONAL
PARK
ROCKY
MOUNTAINS
FOREST
RESERVE
GLACIER
NATIONAL
PARK
LAND HOLDINGS
LEASES
EXPLORATION RESERVATIONS
FREEHOLD
MAP A
FOOTHILLS COAL AREAS
ALBERTA
OCT. 1 - 1970
SCALE: 12 MILES TO 1 INCH
MILES 10 0 10 20 30 40 50 MILES
KILOMETRES 10 0 10 20 30 40 50 60 70 KILOMETRES
1970-3 1/2

1/2 1970-3


LEGEND
R.C.A. COAL ANALYSES:
COKING
NON-COKING
SEMIANTHRACITE
LOW AND MED. VOL. BITUMINOUS
HIGH VOL. BITUMINOUS
APPROX 86% ISOCARB LINE
APPROX 69% ISOCARB LINE
COAL PROPERTY (MINE, LEASE, PERMIT)
WILLMORE
WILDERNESS
PARK
JASPER
NATIONAL
PARK
BANFF
NATIONAL
PARK
ROCKY
MOUNTAINS
FOREST
RESERVE
PLAINS
FOOTHILLS
OUTER FOOTHILLS
INNER FOOTHILLS
MT ROBSON
PROVINCIAL
PARK
WATERTON
GLACIER
NATIONAL
PARK
MAP B
LEGEND AT TOP
FOOTHILLS COAL AREAS
ALBERTA
DISTRIBUTION OF COAL PARAMETERS
SCALE 12 MILES TO 1 INCH
MILES 10 0 10 20 30 40 50 MILES
KILOMETRES 10 0 10 20 30 40 50 60 70 KILOMETRES
may 19 1970
2/2 1970-3
1970-3
2/2