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A REPORT ON THE COKING COAL POTENTIAL OF THE CARBON CREEK - WILLISTON RESERVOIR AREA, BRITISH COLUMBIA

1970

PR-Cck 70(1)A

Attn Mr James

February 12th, 1971

Re: Trend Exploration Limited
Coal Licences
Nos. 1648 - 1790 inclusive

Department of Mines and Minerals
Parliament Building
VICTORIA, B.C.

Attention: Mr. R. McCrimmon

Dear Sirs:

Enclosed please find a report and maps covering the captioned coal licences.

Trend geologists undertook several months of regional studies, air photo interpretation, and carried our surface mapping during the late summer and early fall and have compiled the results in the report and accompanying maps.

We trust this material will be of interest to the Department.

Yours very truly

TREND EXPLORATION LIMITED

R. R. Baekeland, P.Eng.
Vice President

RRB/bw
Encl:

COAL PROSPECTS

CARBON CREEK - WILLISTON RESERVOIR

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GEOLOGY

Trend recognized that the Gething coals at Carbon Creek should be excellent for coking, and chose the licenced areas for exploration largely for two reasons: (1) The Carbon Creek, Adams, and Dunlevy synclines offer relatively simple structural conditions with large areas of low dips, and (2) the area between the Peace and the Pine Rivers lies on the axis of deposition of the coal bearing Gething Formation. The simple structural elements are probably the result of the thick Lower Cretaceous units.

Trend geologists mapped the Gething and Cadomin Formations in the Williston Reservoir area on aerial photographs (Encl. 3 and 4). The important regional and local geological interpretations were derived from the study of facts recorded in the excellent work of the Canadian Geological Survey (Stott, Irish) and the B.C. Dept. of Mines and Petroleum Resources (Hughes, Mathews).

STRUCTURE

The foothills structural belt between Smoky River, Alberta, and the Peace River, British Columbia, is characterized by synclines, anticlines, and major west dipping thrust faults. These contemporaneous structural elements were caused by compression during the post Cretaceous orogeny. The density of the deformation, the direction of the linear elements, and the wave lengths of the folding all change in response to the amount of exerted force, and the competency and thickness of the folded stratigraphic "packages".

Geologists have long recognized that the Peace River structures are less complex than structures to the south and north. Hughes (1967), Irish (1968), and Fitzgerald (1968) discuss the Peace River structural style. These and other geologists have discussed the possibility that the thick Cretaceous section could have caused the broad synclines and narrow, closely folded, anticlines. Hughes documents the broad flat synclines of the Peace-Pine River area (Figure 1) and mentions that minor folding and faulting can occur in the axial portion of the structures. The anticlines in the foothills belt are closely related to fault systems, (Encl. 4) and these faulted anticlinal systems form many of the topographic ridges.

Carbon, Adams, and Dunlevy synclines have steep east flanks and fairly gentle west flanks. Large areas in each of the synclines are underlain by strata with dips less than 15°. Adams and Dunlevy synclines, including the Mt. Gething area, are covered with timber and alluvium. Drilling will find some small faulting and folding, but major structural complexities, so prevalent on the local anticlinal ridges and in the tightly folded areas to the north and south, should be absent in the Carbon, Adams, Dunlevy and Mt. Gething areas.

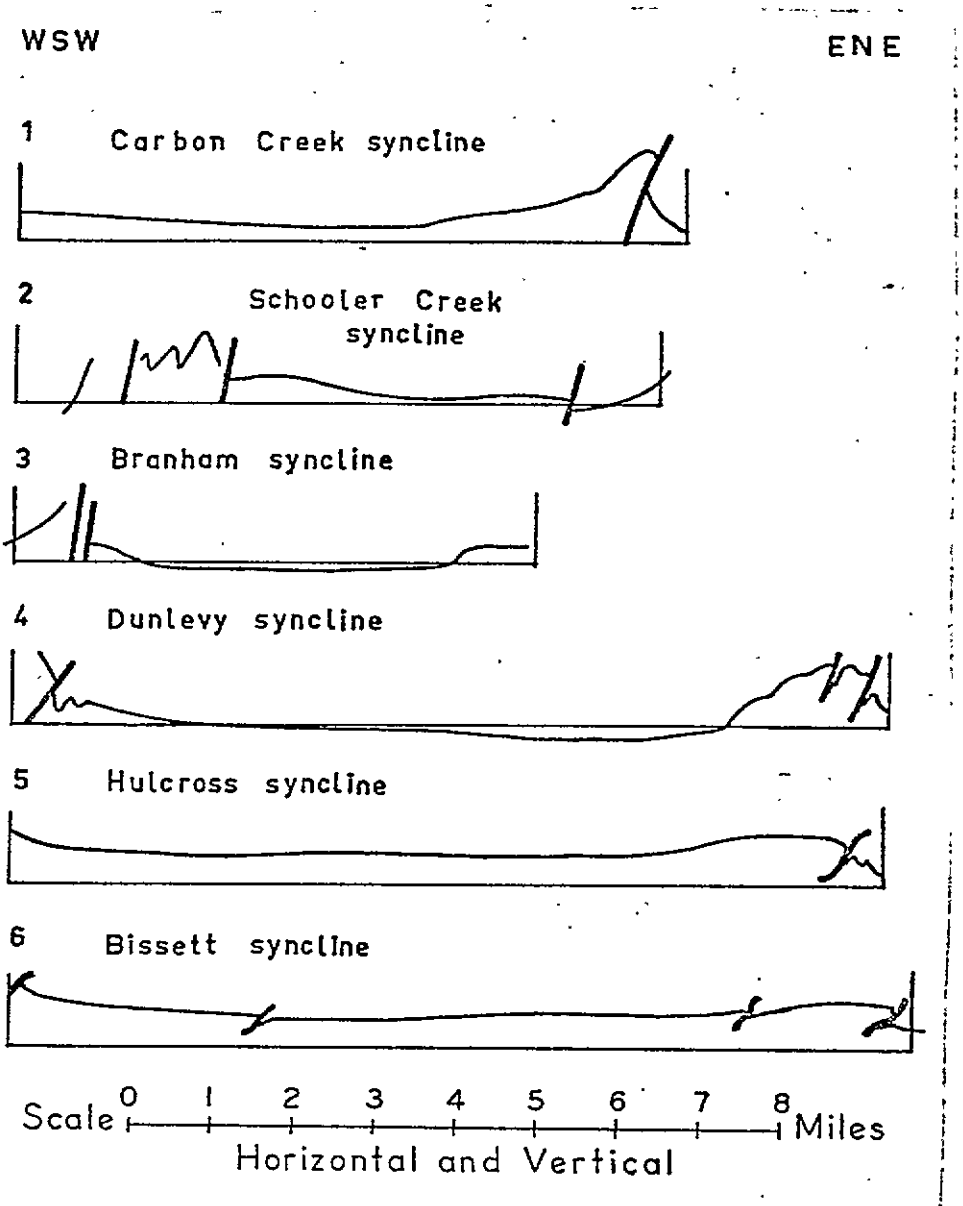

FIGURE 1

Comparison of synclines and anticlines
in Peace River Area (Hughes, 1967)

STRATIGRAPHY

The Gething and Cadomin Formations were deposited by and close to streams flowing from the west into a shallow early Cretaceous sea. The conglomerate and coarse, cross-bedded sandstones of the Cadomin were deposited in alluvial fans by high gradient streams near rapidly eroding mountains. Fine grained, "dirty", occasionally ripple-marked sandstones, coals and carbonaceous shales were laid down in the flood plain environment (low gradient streams and swamps) near the sea. The Gething Formation represents an early Cretaceous, rapidly subsiding deltaic complex.

In the Williston Reservoir area, the Gething Formation is largely covered by vegetation and thin Recent alluvium. This unit is well exposed at its type section along the Peace River, and partial sections have been measured along the Carbon Creek (Encl. 5). Shallow wells were drilled into the lower Gething before the construction of Bennett Dam. These logs have not been located, but John Hughes, the geologist who described the cuttings, confirmed the similarity of the stratigraphy at the dam to that exposed in the Canyon. The coal bearing nature of the Gething is well documented and it can be expected to contain coal in all of the outcrop areas in the Williston Reservoir area. The Gething is 1000 to 1400 feet thick at its type section. It exceeds 1000 feet in thickness at Noman Creek and is 800 to 1000 feet thick under the Trend coal licences in the southeast position of the Carbon Creek map. It is assumed that the Gething was originally 1000 to 2000 feet thick west of the Peace River Canyon because of the increase in isopach values from west to east (Encl. 6). This assumption was used in preparing the cross sections on Enclosures 3 and 4.

Some confusion has resulted from the various terminology used by previous geologists for the Gething, Cadomin and older formations, (Fig. 2). The purpose of Trend mapping in the Carbon Creek-Williston Reservoir areas was to delineate the boundaries of the coal bearing Gething which most of the previous geologists included in larger units. Trend geologists primarily retained the stratigraphic terminology presented in the most recent G.S.C. Publication. The Brenot Formation by Hughes, 1964, was retained, but set off by quotation marks to identify its controversial useage.

The main controversy concerns the mapping of the Cadomin formation. Mathews, in his Carbon Creek report, 1947, called the coal measures the Non-marine Part of the Bullhead Group and attributed a thickness greater than 4500 feet to the unit. This 4500 feet would include the Gething, Cadomin, and "Brenot" Formations of this report. Mathews reports conglomerates approximately 1100 to 1500 feet above the base of the coal measures, which would coincide with the Cadomin of this report. Note that Mathews also reports that "thick seams are most common in the upper part of the coal measures" (p.13, 1947).

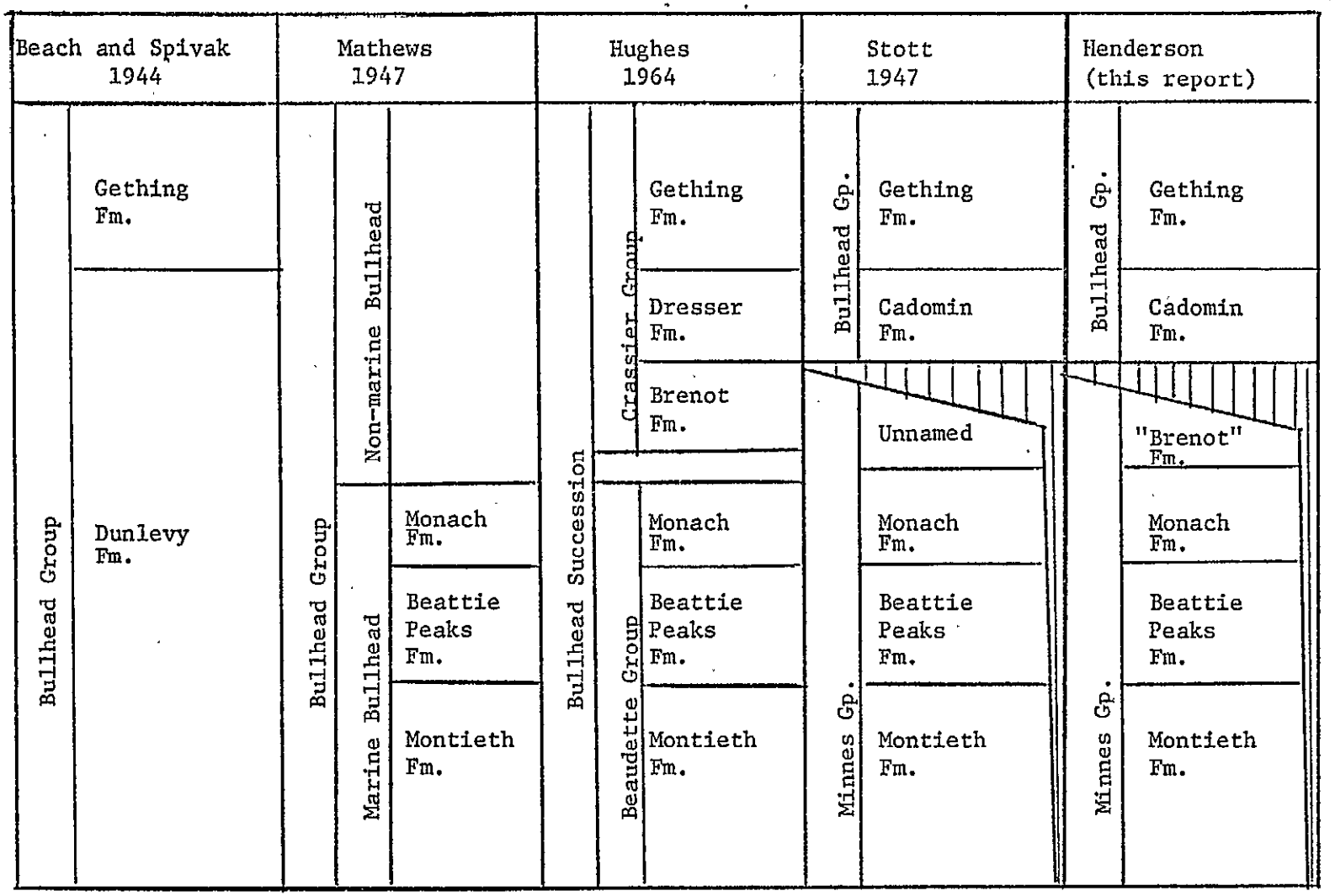

FIGURE 2

Nomenclature of Lower Cretaceous Rocks,
Williston Reservoir, British Columbia.

These seams are in the lower part of the Gething as mapped by Trend. This coincides with regional observations that thick seams occur in the lower Gething.

Stott (1963) recognized that the Cadomin conglomerates and sandstones constituted a mappable genetic unit in the Peace River foothills, and he showed the approximate Cadomin distribution on several published maps (1967, 1968). The Cadomin is important in coal exploration because it marks the base of the economically important Gething coal measures. Potentially commercial Gething coal seams occur near the Cadomin conglomerates at Quintette Mtn., Peace River, and Noman Creek (Encl. 6).

The Cadomin was mapped in the Carbon Creek basin by (1) observing chert-pebble conglomerates on The Monach and on the ridge above McAllister Creek, (2) finding massive and cross-bedded coarse-grained, sandstones near Mt. Rochfort, and (3) tracing the covered, resistant, correlative units around the basin. The Cadomin is rather easily mapped on air photos in the Adams syncline, Mt. Gething, and Dunlevy Creek areas because of the exposures of Cadomin at Rainbow Rocks, Mount Gething and in the Peace River Canyon.

The Cadomin varies in thickness regionally and locally because of its non-uniform alluvial environment of deposition. Stott (1968) notes the intertonguing relationship of the Cadomin and the Gething, and reports thicknesses for the Cadomin of 340 feet in the Peace River Canyon to over 660 feet at Butler Ridge. The Cadomin is shown to be over 1000 feet thick on the enclosed cross-sections because it is assumed that the Cadomin will increase in thickness rapidly to the west toward a local source (Encl. 6).

The case of the Cadomin is shown to be an unconformity on all of the enclosed sections. The Cadomin contact with older rocks is mostly covered in the area of interest, but the unconformity best explains (1) the apparent angular relationships observed between the "Brenot" and the Cadomin at The Monach and at the flat area east of McAllister Creek (2) the variation in mapped thickness of the "Brenot" in the Carbon Creek basin, and (3) the regional relationships of Cadomin resting on beds of different ages (Figure 3).

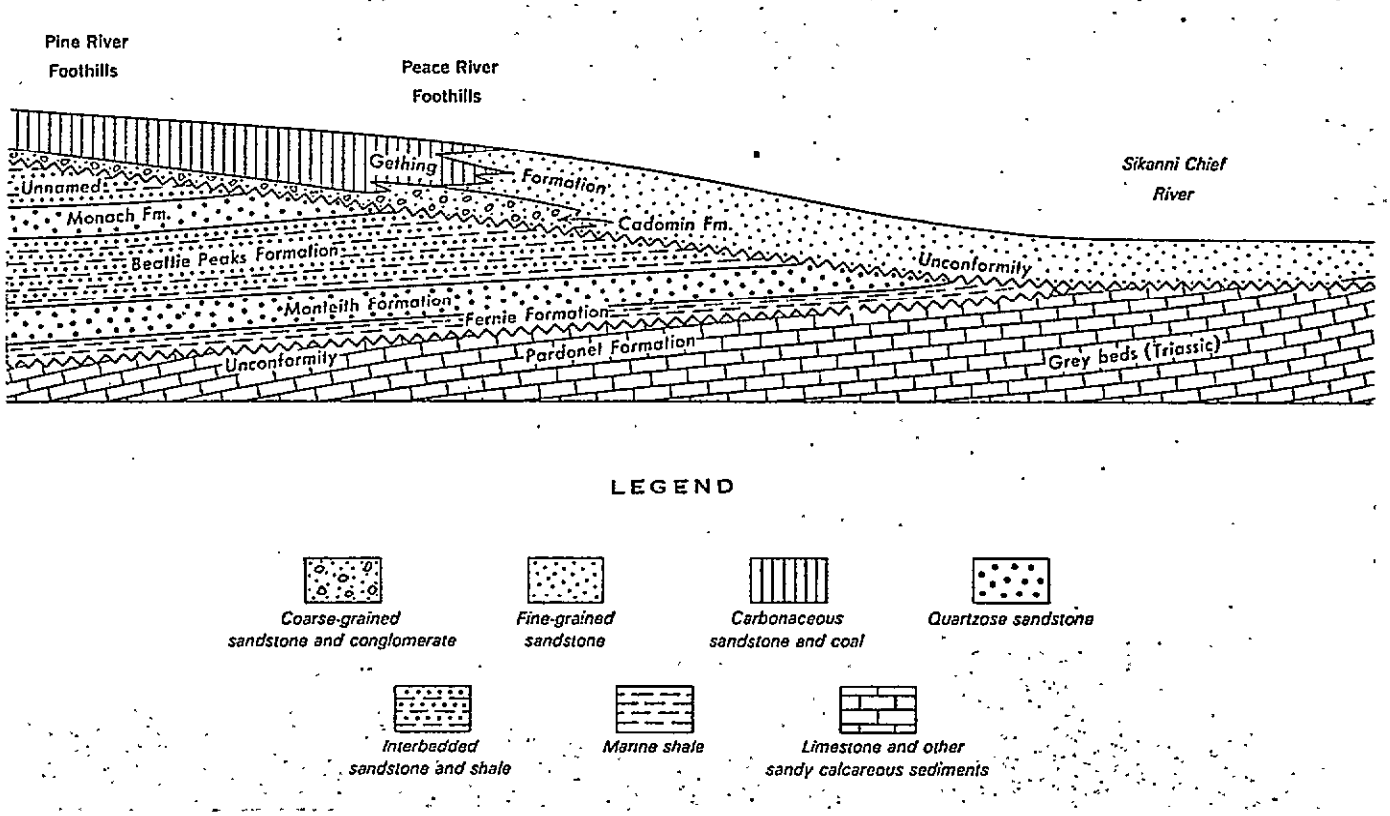

FIGURE 3

Basal Cadomin Unconformity
Pine to Sikanni Chief Rivers (Stott, 1967)

COAL

The Gething coals were first noted by Alexander Mackenzie in 1793 when he explored the Peace River. Coal leases were acquired by Neil Gething in 1908 near the Peace River Canyon and by Cowpert Rochfort in 1911 on Carbon Creek. For over 30 years, numerous attempts were made to raise capital for working the coal fields. Most of the activity was in response to reports of a railroad to be built along the Peace River. All four mines near the Peace River Canyon were operated in the 1940's to supply fuel for domestic uses. The Gething mine was operated sporadically until it closed in 1965 because of the lack of markets.

PEACE RIVER CANYON

The Gething formation is over 1000 feet thick and contains about 30 coal seams in excellent exposures in the Peace River Canyon. At least five seams are over 4 feet in thickness; and three seams, the Trojan, 115 to 130 feet below the Moosebar formation, and the Murray and Grant, at the base of the Gething, occur with thicknesses of 5½ to 8 feet.

Some of the important characteristics of the coal taken from the old mines are shown in Appendix 1. The tests were performed on near-surface oxidized samples before the Free Swelling Index test was common practice. The coal varies from low to medium volatile bituminous and shows high B.T.U. values, generally 13,000 to 14,000. The seam at the Grant mine should be noted for its thickness, over 5 feet, and low ash content, 2 to 6%. The Murray seam at the Peace River Mine (now covered by Bennett Dam) is 7 feet thick and has a very favorable low sulphur content (0.4%).

CARBON CREEK

The Burns Foundation of Calgary, Alberta, owns 10 square miles along Carbon Creek. Senator Pat Burns and his heirs, working with the coal discoverer Cowpert Rochfort, financed engineering work on the property for many summers from 1928 until 1950. The engineers established at least 10 "workings", mapped and surveyed the Carbon Creek basin, and sampled the coal for analyses. Numerous unpublished reports are available through the Burns Foundation.

Representative analyses of the medium volatile bituminous coal Appendix 11, reveal the large number of low ash (2 to 6%), low sulphur (.5 to .7%) and the high B.T.U. (11,000 to 14,000) values. The samples were undoubtedly oxidized and no modern "coking" tests have been performed on the coals. J. Viseman, Head, Western Regional Laboratory, Canadian Dept. of Energy, Mines and Resources, and P.D.J. Vinkenborg, General Manager of Cyclone Engineering Sales Ltd., Edmonton, both reviewed copies of coal analyses from Burns Reports. In telephone discussion with Trend geologists, they both mentioned that none of the existing tests precluded the possibility that the coals will "coke", and although it is impossible to predict the outcome of coking tests, the Carbon Creek coals are of very high quality and some of them should be excellent coking coals. Note that the Gething coals are reported to have excellent coking properties at Noman Creek and Bullmoose Mountain, the only two areas where the Gething has been extensively tested in recent years (Encl. 6).

Mathews (1947) reports that 10 seams more than 4 feet thick occur in the Carbon Creek basin. Mathews postulates that the seams could have total thickness of 38 to 50 feet in the measured 500 feet of coal bearing Gething. Correlations are difficult and tentative, but there are probably 15 to 20 different seams exposed in the Carbon Creek area. Trend geologists have verified the existence of the outcrops of coal seams of 6, 9, and 17 feet (possible faulted) in thickness on the Burns property adjacent to Trend licences. . . . . Numerous outcrops of coal 2 to 4 feet thick exist near the base of the Gething within the Trend land.

Drilling should find thick coal seams, 6 to 15 feet, on the Trend licenced area, especially in the south end of the Carbon Creek basin, because of (1) the proximity to the Noman Creek ("No.76", A_{vg}. 16 feet thick) and the Carbon Creek coal (6 to 17 feet thick), (2) the regional and local tendency for thick coal seams to be present in the lower portion of the Gething, (Encl. 5 and 6), and (3) coal seams should increase in number and thickness to the west toward the greatest Gething depositional thickness.

COAL ACT

The prospective coal area was within the Peace River Coal Reserve, a large area of Northeastern British Columbia set aside by the government. Coal within the reserve is subject to disposition by the Crown under the authority of the Lieutenant-Governor in Council, as prescribed in the Coal Act R.S. 1948, c.209, s.1.

Trend posted a $50,000 performance bond with the British Columbia government on August 21st, 1970. This was a requirement for the removal of 690,000 acres from the Reserve. Between September 21, and October 21, 1970, Trend selected the most prospective acreage for coal and staked 143 coal licences. Each licence was staked according to the regulations in the Coal Act. Rentals at 50 cents per acre were paid to the government.

These coal licences can be renewed yearly if the rentals are paid and the licencee has complied with the Coal Act. Coal licences are issued to cover production of coal up to 10,000 tons per year. If work is performed on the licences at a value of $7.50 per acre, the rentals are rebated.

When production has exceeded 10,000 tons per year, the operator can acquire a coal lease - primary term of 20 years. These leases are subject to a yearly rental of $1.00 per acre.

Crown royalty is 25 cents per ton. Income from coal production will be subject to a tax as outlined in the British Columbia Mining Tax Act, 15 percent of net income in excess of $10,000 from the production of mineral ores.

ACCESSIBILITY AND TRANSPORTATION

The Trend Coal Licences are located on the Williston Reservoir near Bennett Dam, in Northeastern British Columbia. Most of the licenced areas are covered by heavy stands of timber (spruce, fir, pine) at elevations from 2000 to 4000 feet above sea level.

Local access routes are shown on Enclosure 8. A paved road exists between Dunlevy Creek and Hudson Hope. The Carbon Creek, Mt. Gething, and Dunlevy areas can be reached by boat along the reservoir. A logging road-trail extends from the Hudson Hope - Moberly Lake highway west to the McAllister Peak area, to within about 18 miles from the Carbon Creek licences. The Forest Service and a petroleum company have proposed roads into the Carbon Creek area. The Forest Service-Carbon Creek F.D.R. offers a haulage route from Carbon Creek (35 miles) to the P.G. and E. railroad at LeMoray in the Pine Pass.

At the moment, reconnaissance trips into the Carbon Creek and Adams areas are best performed by boat and helicopter. The dense timber and undergrowth are prohibitive for rapid travel by ground vehicle, horseback, or foot. Charter boat service through Mr. Ernie Krebs is available at Hudson Hope. Alpine Helicopter has three-passenger ships in Mackenzie, and Okanagan has three and four-passenger helicopters in Fort St. John.

Trend believes that the transportation of coal from the Williston Reservoir area to port facilities on the West Coast presents no major problems. The total distance to port, combined with the flexibility of short haulages (either by rail, truck, or barge) to the nearby P.G. and E. railroad make this area more attractive than many of the existing coal mining areas (Encl. 1).

The P.G. and E. railroad will be able to handle unit trains to haul coal to the Vancouver area or possibly to Prince Rupert. Coal should be transported from the Carbon Creek area to the railroad within a relatively short time by

1. Truck for 35 miles over proposed Carbon Creek F.D.R. (Grades less than 6%) to the railroad at Le Moray.

2. barge for 110 miles to existing rail spur at Mackenzie.

3. barge for 30 miles to a proposed rail spur to Bennett Dam.

Barges can operate on Williston Reservoir for 6 to 9 months during the year. Coal could be stockpiled at Mackenzie or Bennett Dam for continuous year-round rail haulage.

The P.G. and E. is also very interested in discussing the feasibility of a spur line into the Carbon Creek area. They are currently investigating the possibility of a deep-water port at Squamish, north of Vancouver.

MINING POTENTIAL

The problems of coal mining in the Western Canadian foothills are well publicized and were discussed in detail by Jack Crabb, (Expl.Manager, Crows Nest Ind.) in Vancouver at the recent Canadian Coal Conference (Oct.1970). Mr. Crabb mentions the nightmares of steep pitches, variable stratigraphy, incompetent roof support, residual stresses, and unexpected benefaction problems.

Unfortunately the very same geological forces that caused the attractive coal rank for metallurgical purposes also caused the structural complexities which plague the mining operation. Increase in dips above 15 degrees apparently causes (1) less mobility for modern underground machinery and (2) narrower benches and more spoilage for open-pit operation. Intensely deformed areas cause great residual ground stresses, unreliable fractured roof conditions, and deeper zones of oxidation. Recent publications concerning the huge Kaiser operation in southern British Columbia underscore the problems caused by an unexpected great amount of "fines".

Trend geologists have attempted to stake areas which have the potential to approach what Mr. Crabb calls the unattainable....the ideal coking coal prospect. Before the Trend areas was released from the Peace River Coal Reserve, consideration for mining purposes was given to

1. Coal quality. The available analyses of the Carbon Creek and Peace River coals show that the potential exists to find coal seams of superior quality, in terms of ash and sulphur content, in comparison with current Japanese contract specifications (Encl. 1).

2. Structural complexity. Realizing that the majority of physical mining problems result from intense deformation, Trend geologists ignored the greatly fractured and thrust faulted anticlinal ridges.

3. Low dips. Gently dipping flanks of relatively simple synclinal areas were chosen as primary targets. Recognizing the limitations of reconnaissance mapping, Trend attempted to licence large areas of Gething outcrops in and adjacent to the apparently flat areas.

4. Stripping ratios. Natural forces have already stripped portions of the Gething in the synclinal areas. Because of the lack of outcrops, accurate ratios cannot be estimated. Certainly the potential exists for acceptable stripping ratios if (1) gentle dip slopes are coincident with some of the possible 30 seams in 1000 feet of Gething or (2) if Mathews is correct in postulating that 38 to 50 feet of coal exists in 500 feet of Gething at Carbon Creek.

5. Recoverable volumes for 15 year contract.

Estimates for reserves of recoverable coal are premature before drilling and are dependent upon the mining considerations discussed above. Old engineering evaluations for the Burns Foundation list probable reserves of 145 million to over 2 billion tons of coal in the Carbon Creek basin. Sufficient coal is in place in the Trend area to satisfy a large number of 15 year contracts.

For a minimum estimate, it is reasonable to expect that at least 8 feet of coal will be minable over 1/10 of the licenced area. If 1 million tons per square mile foot and 50% recovery are assigned, then 14 square miles could yield over 50 million tons of coal for a 15 year contract. This situation would be comparable to what Brameda must have found on their Sukunka River property. If the geological predictions are correct, that a seam similar to the "No.76" seam at Noman Creek, average of 16 feet thick, will be found in the Carbon Creek basin in areas of gentle dip, then 10% of the Trend acreage could yield coal sufficient for two or three 15 year contracts.

6. Seam continuity. Existing outcrops are too few to allow accurate correlation of seams over large areas in the Williston Reservoir area. Individual seams can be correlated locally within the Peace River Canyon, in the Noman Creek area, and on 11-mile Creek in Carbon Creek basin. Gething coal seams can be expected to vary in thickness over large areas and to contain lenses of cannel coal, sandstone and shale, but this should not discourage exploration because

   a. the environment of deposition for the Gething is the same as for the Kootenay, the Luscar, and the Commotion Formations which contain the existing billions of tons of recoverable coking coal in Alberta and British Columbia.

b. Brameda has reported 60 million tons of recoverable coal in the Gething at Bullmoose Mountain in a seam which averages 8½ feet. Assuming a 50% recovery factor, the extractable portion of the seam must be present over 10 to 15 square miles.

c. The Gething seams were present in commercial thicknesses over the 10 square miles of coal licences at Noman Creek. Mining was prohibitive because of structural complexities which are not expected within the Trend area.

7. Unconsolidated overburden. Recent stream alluvium and Pleistocene glacial debris are present along Carbon and Dunlevy Creeks and in the Adams and Mt. Gething areas adjacent to the Williston Reservoir. Interpretations showing possible distribution of this material are given by Mathews (1947) and Ziegler (1960). This material was inspected at the Carbon and Dunlevy Creeks, and the volume appears to be too small to significantly affect mining operations.

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APPENDIX 1

ANALYSES OF COAL FROM MINES NEAR PEACE RIVER CANYON
(From McLearn and Kindle, 1950)

1. PEACE RIVER COAL MINE (Murray Seam)

—	Moisture	Ash	Volatile matter	Fixed carbon	Caking property	Colour ash	S	B.t.u.
As received	13·1	13·7	22·0	51·2	Non-agglom-erate	Light rose	0·4	9,750
Dry		15·8	25·3	58·9	Non-agglom-erate	Light rose	0·4	11,210

2. GRANT MINE (Grant Seam)

—	Moisture	Ash	Volatile matter	Fixed carbon	Caking property	Colour ash	S	B.t.u.	A.S.T.M. classification[1]
Cliff 300 feet west of W. crosscut. Bottom 9 inches	0·6	3·4	23·6	72·4	Good	Flesh			Med. vol. bitum.
Cliff 300 feet west of W. crosscut. Middle and top 5 feet	0·8	3·4	20·4	75·4	Poor	Flesh			Low vol. bitum.
Cliff entrance to W. crosscut. Bottom 11 inches	0·7	2·1	24·6	72·6	Good	Flesh			Med. vol. bitum.
Cliff entrance to W. crosscut. Middle and top 4 feet 6 inches	0·6	2·6	18·7	78·1	Non-agglom-erate	Flesh			Low vol. bitum.
Tunnel 35 feet from portal. Bottom 8 inches	0·7	6·5	22·0	70·8	Good	Cream	0·7	14,440	Med. vol. bitum.
Tunnel 35 feet from portal. Middle 1 foot 11 inches	0·6	2·9	19·5	77·0	Non-agglom-erate	Brown	0·7	14,940	Low vol. bitum.
Tunnel 35 feet from portal. Top 3 feet 2 inches	0·7	5·3	19·6	74·4	Non-agglom-erate	Brick	0·7	14,420	Low vol. bitum.
Tunnel at E. crosscut. Bottom 9 inches..	0·7	2·4	22·9	74·0	Good	Flesh	0·7	15,130	Med. vol. bitum.
Tunnel at E. crosscut. Middle 1 foot 9 inches	0·8	2·6	19·3	77·3	Agglomerate	Flesh	0·7	14,960	Low vol. bitum.
Tunnel at E. crosscut. Top 3 feet.....	0·7	6·1	18·7	74·5	Non-agglom-erate	Cream	0·6	14,300	Low vol. bitum.
Face tunnel Sept. 26, 1923. Bottom 9 inches	0·6	2·4	24·8	72·2	Good	Flesh			Med. vol. bitum.
Face tunnel Sept. 26, 1923. Middle 1 foot 10 inches	0·6	2·6	19·5	77·3	Non-agglom-erate	Cream			Low vol. bitum.
Face tunnel Sept. 26, 1923. Top 2 feet 8 inches	0·6	4·1	20·1	75·2	Non-agglom-erate	Grey			Low vol. bitum.

3. PACKWOOD MINE

	Upper level		Lower level	
Moisture condition	As rec'd	Dry	As rec'd	Dry
Proximate analysis				
Moisture....%	5·0		4·5	
Ash....%	6·1	6·4	4·7	4·9
Volatile matter....%	18·9	19·9	19·1	20·0
Fixed carbon (by difference)....%	70·0	73·7	71·7	75·1
Ultimate analysis				
Sulphur....%	0·6	0·6	0,6	0·6
Calorific value				
B.t.u. per lb. gross....	13,220	13,920	13,580	14,230
Caking properties....	Agglomerate		Agglomerate	
Colour of ash....	Very light pink		Very light pink	

"This is a low volatile bituminous coal.

4. KING GETHING MINE (King Seam)

	0·7-foot bench		1·6-foot bench		2·0-foot bench		0·6-foot bench	
	As rec'd	Dry	As rec'd	Dry	As rec'd	Dry	As rec'd	Dry
Moisture condition								
Proximate analysis								
Moisture....%	3·8		5·9		5·7		4·5	
Ash....%	10·5	10·9	16·1	17·1	3·3	3·4	1·3	1·4
Volatile matter....%	22·1	23·0	26·8	28·5	21·4	22·7	26·2	27·4
Fixed carbon (by difference)....%	63·6	66·1	51·2	54·4	69·1	73·9	68·0	71·2
Ultimate analysis								
Sulphur....%	1·8	1·8	0·8	0·9	0·8	0·9	0·9	0·9
Calorific value								
B.t.u. per lb. gross...	12,900	13,420	11,080	11,770	13,840	14,680	14,480	15,170
Caking properties	Agglomerate		Agglomerate		Agglomerate		Good	
Softening temperature of ash....	2,050°F.		2,300°F.		2,710°F.		2,680°F.	
Colour of ash....	Light mauve		Light brown		Very light pink		Light salmon-pink	

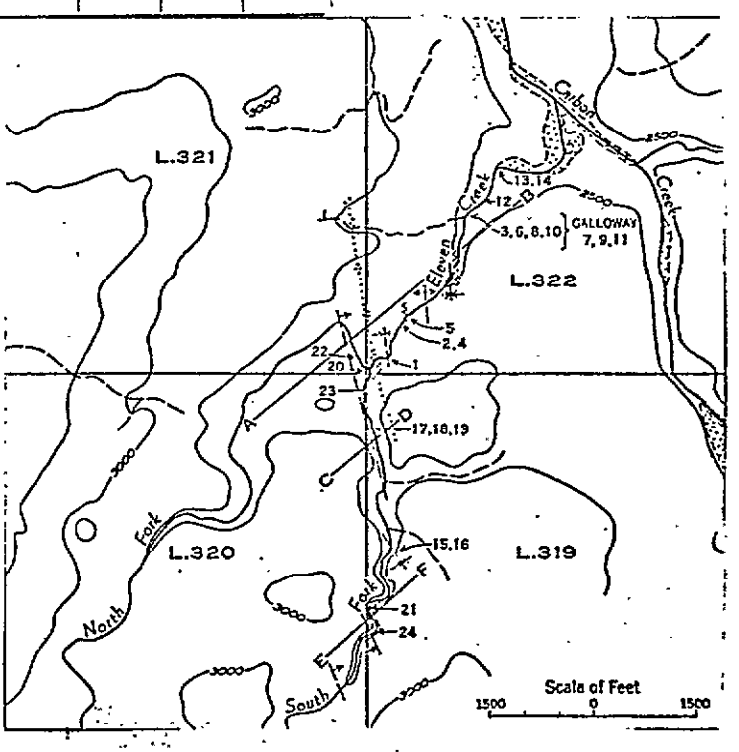
ANALYSES OF COAL FROM OUTCROP AND WORKINGS IN CARBON CREEK BASIN

(From Mathews, 1947)

1. ELEVEN MILE CREEK

Interval between seams	No.	Thickness sampled	H₂O	Vol. comb.	Fixed carbon	Ash	Sulphur	B.t.u.
		Ft. Ins.						
120 feet	*1	3 6	3·4	30·4	52·7	13·5	0·56	11,830
	2	1 9	3·4	29·2	61·0	6·4	0·85	12,670
	3	1 8	4·5	29·8	60·3	5·4	0·73	12,730
	4	4 1	3·3	27·0	66·3	3·4	0·57	13,150
	5	4 3	1·9	27·2	68·6	2·3	0·77	13,980
10 feet	6	4 4	3·5	26·1	67·3	3·1	0·49	13,620
	7	5 0‡	4·6	25·2	66·6	3·6	....	.....
	8	1 4	2·7	24·9	56·8	15·6	0·70	12,000
15 feet	9	1 4‡	2·9	23·7	56·2	17·2	....	.....
	10	2 2	2·7	27·7	66·9	2·7	0·67	13,650
3 feet 6 inches	11	2 1‡	3·4	26·2	67·7	2·7	....	.....
45 feet (±)	12	4 9	....	....	....	....	....	.....
80 feet (±)	13	1 1	2·2	29·4	65·9	2·5	0·79	13,750
4 feet 9 inches	14	2 10	3·4	24·5	68·4	3.7	0·70	13,150
(?)	15	4 0§	3·0	19·5	46·1	31·4	0·44	9,140
25 feet	16	6 0	3·3	23·3	70·7	2·7	0·59	13,650
100 feet (?)	17	4 4‖	7·2	25·3	57·2	10·3	0·59	10,950
18 feet	18	4 5‖	9·6	20·5	54·9	15·0	0·47	10,360
25 feet	19	4 3‖	5·5	25·1	67·7	1·7	0·53	12,700
	20	17 0‖	2·2	25·1	58·1	14·6	0·62	11,840
125 feet	21	9 2¶	2·9	23·6	57·9	15·6	0·50	11,740
	22	6 0	2·6	25·5	69·2	2·7	0·61	13,970
15-20 feet	†23	6 3	7·2	25·6	64·0	3·2	0·48	12,230
	24	5 7	3·6	23·9	70·1	2·4	0·61	13,580

* Highest known seam.
† Lowest known mineable seam in Eleven Creek area.
‡ Sampled by J. D. Galloway.
§ Only upper 3 feet 4 inches sampled.
‖ Thickness may be abnormally great.
¶ Excluding 14-inch shale parting.



2. NORTHERN AREA

Analysis No.	Distance above base of coal-measures	Thickness sampled	H_2O	Vol. comb.	Fixed carbon	Ash	Sulphur	B.t.u.
	Feet	Ft. Ins.						
1	1,000	2 11	3·3	21·6	70·1	5·0	0·49	13,590
2	2,000	5 0	5·8	24·3	64·7	5·2	0·52	12,800
3	2,000	5 4	5·2	20·4	59·2	15·2	0·47	11,410
4	2,000	4 6†	2·1	22·0	69·4	6·5	....	.....
5	2,250	3 0	2·6	17·9	49·8	29·7	0·54	9,580
6	2,250	3 5	2·7	18·3	57·6	21·4	0·71	11,410
7	2,400	2 4	2·8	24·2	64·0	9·0	0·65	13,320
8	2,420	2 2	4·2	21·4	61·0	13·4	0·58	12,040
9	3,500	5 4‡	5·5	24·8	61·5	8·2	....	.....
10	3,500	4 10§	2·8	25·8	63·9	7·5	0·67	12,930

3. WESTERN AREA

11	1,000	2 7	5·0	19·5	72·1	3·4	0·46	13,320

4. SOUTHERN AREA

12	1,000	8 9‖	4·5	15·6	66·9	13·0	0·36	12,090
13	2,500	2 6	2·5	16·4	77·5	3·6	0·50	14,180
14	3,000	2 10	2·0	20·0	69·7	8·3	0·76	13,470

5. CENTRAL AREA, exclusive of Eleven Mile Creek

15	3,500—4,000	2 10	4·4	25·6	65·4	4·6	0·57	12,850
16	3,500—4,000	5 7	7·3	22	55·4	14·6	0·48	10,620
17	3,500—4,000	2 6¶	1·8	21·5	75·6	1·1	0·52	14,620
18	3,500—4,000	3 5	1·5	30·2	64·3	4·0	0·78	13,980

† Taken by J. D. Galloway—full width of seam, but excluding 5 inches of bone.
‡ Taken by J. D. Galloway—full width of seam, excluding 2 inches of shale parting.
§ Base of seam not accessible.
‖ Probably thickened locally at crest of a fold.
¶ Five- to six-foot seam, base not accessible.

Note: (a) Distance above base of coal measures refers to distance above top of Monach on enclosed maps.

(b) Location of seams for areas 2,3,4, and 5 are given in Mathews text (1947)