Pt. 1 of 2

Gen-B.C. 74(10) A

PRELIMINARY REPORT ON THE LESS DEVELOPED THERMAL COAL DEPOSITS OF BRITISH COLUMBIA

R.S. ADAMSON
P.I. STREET
D.D. CAMPBELL

JAN. 31st 1974

DOLMAGE CAMPBELL & ASSOCIATES LTD.
CONSULTING GEOLOGICAL & MINING ENGINEERS
1000 GUINNESS TOWER
VANCOUVER 1, B.C.

British Columbia
Hydro and Power Authority

Report on the LESS DEVELOPED THERMAL COAL DEPOSITS of BRITISH COLUMBIA

PRELIMINARY

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R. S. Adamson
P. J. Street
D. D. Campbell

Consultants

Vancouver, Canada.

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SUMMARY

This report briefly reviews all of the coal occurrences in British Columbia except those at Hat Creek, Comox, Sukunka-Peace River and East Kootenay, which are discussed in separate, detailed reports. The purpose of this review has been to determine which of the known coal occurrences have the best potential for thermal plant feed now or in the near future.

Four coal deposits or districts listed in this report suggest reasonable potential as sources for thermal coal and thus warrant more detailed investigation. These are:

Princeton-Tulameen
Telkwa
Cowgitz (Queen Charlotte Islands)
Suquash (Vancouver Island)

All but Suquash have potential for open-cast mining. (Separate reports are now in preparation for each of the above.)

One other deposit, at Bowron River, has more immediate production potential but will require underground mining. A summary separate report is being prepared for this deposit since coal from it would be well located to possibly supplement production from Sukunka.

With the exception of the above-listed deposits all of the deposits discussed in this report do not have the potential to be immediate sources for thermal coal, although in some cases extensive exploration could indicate more encouraging conditions. For this reason the final report on most of these properties will probably be unchanged from that given here.

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INTRODUCTION

Dolmage Campbell & Associates Ltd. have been requested to undertake a determination of the extent, quality, and availability of thermal coal resources in British Columbia by B.C. Hydro and Power Authority.

PRESENT REPORT:

The present report contains a summation of all known coal occurrences in the province of British Columbia, however meagre the available information. A thorough search of the available literature has provided the basis for the study embodied in this report. The major coalfields of Sukunka, Peace River, Hat Creek, Comox, and East Kootenay are not discussed in this report because each is the subject of a separate study and report. The approach for this study has been to group the various occurrences, deposits, and fields on a geographical basis, regardless of coal age, rank, productive history or whatever. Accordingly, the province has been subdivided in eleven quadrangles, as shown on Figure 1.

QUADRANGLES:

Each quadrangle encompasses an area 3° (latitude) by 6° (longitude). A series of eleven quadrangle maps have been developed on a scale of 1:1,000,000. On each map are shown the coal basins, differentiated with respect to age, in which coal is known to occur, and geologically-related basins in which coal could occur; that is, coal-bearing and coal prospective basins. The location of known coal occurrences, deposits, and mines are shown. The basis transportation network and existing power grid are also shown on these quadrangle maps.

COAL DEPOSITS:

In the report 44 deposits, excluding those in the above-mentioned five major districts, are reviewed as well as those miscellaneous and obscure occurrences that have been extracted from the literature as the study progresses. Emphasis is placed upon the area of the basin containing coal, the number and thickness of seams in the basin, and the quality and nature of samples taken.

Those deposits of obviously-relevant potentially-economic significance have received more detailed assessment. Tonnage estimates have been calculated wherever adequate data permits. Mining methods and costs, capital costs, and transportation costs have been determined where warranted.

QUADRANGLE 1

Four occurrences have been reported from the extreme northwest corner of the province. Little is presently known about them, other than that they apparently lie within Lower Cretaceous rocks equivalent to the Tantalus Formation from which coal is produced in the Yukon Territory.

GRAHAM INLET (No. 1):

(An assessment of the Graham Inlet occurrence has yet to be made. Investigation of its nature is in progress.)

SLOKO RIVER (No. 2):

(No assessment of the Sloko River occurrence has been made as yet. Investigation is in progress.)

INKLIN RIVER (No. 3):

(Investigation of the nature of the Inklin River deposit remains in progress.)

TAKU RIVER (No. 4):

(The Taku River occurrence remains to be assessed. Investigation is in progress.)

QUADRANGLE 2

On the basis of the presently available information the Groundhog coalfield represents the most important coal resource in Quadrangle 2; the remaining occurrences apparently are relatively restricted in areal extent.

DEASE RIVER: (No. 5)

(Investigation of the Dease River deposit is in progress.)

HYLAND RIVER: (No. 6)

(An assessment of the Hyland River deposit remains to be done. Investigation is in progress.)

COAL RIVER: (No. 7)

(The Coal River deposit remains to be assessed and is presently being investigated.)

RAPID RIVER: (No. 8)

(An assessment of the Rapid River occurrence is in progress.)

STIKINE RIVER: (No. 9)

(The Stikine River (Tuya) deposit is under investigation. The deposit is presently covered by ten coal licenses (6400 acres) belonging to W.E. Kleinhout.)

GROUNDHOG: (No. 10)

The extent and structure of the Groundhog coalfield is presently little understood because of its remote location, its very limited exploration by previous owners, its structural complexity and its relatively-thick forest cover. The field would probably have received more detailed exploration had it contained seams with adequate coking characteristics. The most recent work, done in 1968, established that;

a) no significant coal of coking quality was found.
b) the coal is impure, has a high ash content, and a low volatile content. It has been metamorphosed to anthracite grade.
c) the coal occurs in many thin beds; five to ten seams are indicated averaging four feet in thickness, including two 10 and 12 feet thick.
d) the geological setting is structurally complex resulting in a lack of continuity of seams and many steeply-dipping seams not amenable to open-pit mining.

e) Relatively-incompetent wall rocks bracket the coal seams should underground mining be considered.

(Further assessment of the Groundhog coalfield as a potential thermal coal resource will continue.)

QUADRANGLE 3

Two coal deposits of no readily-apparent economic importance occur in the northeastern corner of the province.

HALFWAY - SIKANNI CHIEF RIVERS (No. 11)

(The investigation of the Halfway-Sikanni Chief River occurrences is still in progress. No definitive assessment is yet available.)

MINAKER RIVER (No. 12)

(The Minaker River occurrences remains to be investigated.)

QUADRANGLE 4

Five deposits of Lower Cretaceous age and one of Tertiary age (Driftwood Creek) are under investigation in Quadrangle 4. These five deposits essentially comprise the Telkwa Coalfield and represent the larger of fourteen remnant outliers of Bowser Basin rocks that host the Groundhog coalfield 125 miles to the north.

KISPIOX RIVER: (No. 13)

Coal-bearing Upper Jurassic to Lower Cretaceous rocks of the Bowser Group are exposed on both the Kispiox and Skeena Rivers for 14 miles upstream from their confluence. At least five coal seams are known, ranging from 2 ft. to 5 ft. in thickness. However, the rocks are highly disturbed and are cut by numerous dykes; continuity of coal seams is therefore likely to be poor. The village of Kispiox itself is said to be underlain by relatively undisturbed strata of the same formation, but there is no report that these have ever been drilled.

Very limited production, for local consumption, was obtained in 1911 from a property on the Kispiox River. Interest in these deposits waned when it was found that the coal was too badly crushed to meet commcercial specifications of that time. Little work has been done in the district since then. (A review of the available information on these occurrences is still in progress.)

In addition to the Kispiox occurrences, coal occurs in rocks of the same age at Seaton, on the Bulkley River 20 miles upstream from Hazelton. This is a small basin, approximately $4\frac{1}{2}$ miles by $1\frac{1}{2}$ miles, containing 12 seams that range in thickness from 1 ft. to 3 ft. 4 in., distributed throughout a 500-foot stratigraphic section. The coal has been described as yielding an "unusually dense" coke. Limited production was carried out around 1936, but was abandoned, despite good coking characteristics, because of the very high ash content of the coal, which ranged from 17% to 47% (the latter in a seam $2\frac{1}{2}$ feet thick, above average thickness for the coalfield). Average ash content of the Seaton coal was 35-37%.

Near Cedarvale, also, on the Skeena River about 25 miles downstream from Hazelton, numerous occurrences of anthracitic to graphitic material have been reported, but none is of commercial significance.

ZYMOETZ RIVER: (No. 14)

Seven coal licenses, totalling 4,480 acres, are held near the headwaters of the Zymoetz River near McDonell Lake, and are accessible by a gravel road from Smithers, about 25-30 miles to the east.

The coal is in Upper Jurassic to Lower Cretaceous Bowser Group rocks, and consists of at least two seams, 6 ft. and 6-10 ft. thick respectively. It was sampled in 1968, and is of high volatile bituminous rank, with a thermal rating of 13,400 to 13,970 BTU/lb. Three other seams have been intersected by drilling, but all are of less than mining width.

The deposit is not amenable to open-pit mining, and structural complexities are likely to add to the difficulties of underground mining.

(Further information on the property is presently being gathered.)

LAKE KATHLYN: (No. 15)

The coalfield lies on the eastern slopes of Hudson's Bay Mountain near Smithers, and is approximately 3 miles west of Lake Kathlyn. The coal formation is exposed on both walls of Glacier Gulch, which drains the major ice-filled cirque on the northeast face of the mountain.

Earlier reports, (1917, 1926), assigned the coal-bearing formation to the Hazelton group, of Jurassic age, but according to more recent mapping, the property is underlain by Upper Jurassic to Lower Cretaceous Bowser Group sedimentary rocks, close to a faulted contact with the volcanic rocks that form the main mass of Hudson's Bay Mountain.

Five seams are known, but the reported seam widths contain appreciable thicknesses of banded slate and graphite as well as coal. Because the sedimentary rocks are so close to the intrusive and volcanic core of Hudson's Bay Mountain, the shales and sandstones have been metamorphosed to slate and quartzite, and the coal to anthracite and graphite. The five seams are as follows, from higher to lower stratigraphically:

Forge seam:	5 ft.	mostly graphite, only minor coal
Ballard seam:	$3\frac{1}{2}$ - 4 ft.	coal, with 3" - 4" of bone
Ten-foot seam:		mixed bone and schistose coal; not considered worth sampling in 1926
Three Tunnels seam:	4 ft.	comprises $1\frac{1}{2}$ ft. of schistose coal, 2 ft. bone, 6 inches non-schistose coal
Frank seam: Total	7 ft. of coal	interbedded with slate; coal thicknesses are (individually) 2'2", 1', 1'10", 6".

The coal ranks as anthracite (with 55 - 79% fixed carbon), but has a moisture content (up to 15%) that is described as characteristic of lignite, and therefore anomalous in a coal with such high fixed carbon content. Samples from the Ballard seam yielded a thermal rating of 13,300 BTU/lb.

The coal seams strike approximately northwest, and dip 45° - 60° to the northeast. In 1933, a tunnel driven on the Ballard seam found the seam faulted off about 300 ft. from the portal. A 400-ft. crosscut, designed to intersect all the veins, driven 250 ft. in elevation below the Ballard tunnel, intersected one seam $2\frac{1}{2}$ feet wide and another narrower faulted seam. An estimate of reserves would require further exploration to determine the vertical extent and continuity of these steeply-dipping seams.

The licenses held by the original owners are no longer shown on the provincial government's coal license map; however, the area that they probably covered is now marked as a "Map Reserve".

The Lake Kathlyn Anthracite Coal Co. Ltd. operated the mine under a royalty agreement with the license owners, but there is no reference to the company later than 1933, and no record of commercial production. The B.C. Minister of Mines' Report for 1926 judged that a market would exist only for coal of appreciably higher quality, and concluded that "this property is a prospect, not a mine".

(Modern techniques of treatment and utilization may make this coalfield a more attractive prospect than it once was, and additional information is presently being sought.)

DRIFTWOOD CREEK (No. 16)

Coal showings on Driftwood Creek are situated about 7 miles northeast of Smithers, in a small basin of Tertiary rocks (possibly Oligocene in age) that may cover an area of about 4 miles by 2 miles. Its precise extent is obscured by thick glacial drift. The coal formation consists of interbedded conglomerate, sandstone and shale, and contains lignite where prospected. It is almost horizontally-lying, but elsewhere in the vicinity it has been highly folded and faulted. In places it has been burned, and the shale layers turned to a brick-like material.

The principal seam consists of:

carbonaceous shale and a little coal	5'0"
clean coal	1'10"
coal and shale	4'5"
shale and a little coal	3'7"....total 14'10"

Analysis of these coals gave the following results (basis not stated):

a) for the 1'10" seam of clean coal alone:

Moisture	7.9%
Volatiles	36.64
Fixed Carbon	42.06
Ash	13.40

b) for the combined 6'3" of clean coal and coal with shale:

Moisture	7.39
Volatiles	31.88
Fixed Carbon	28.07
Ash	32.66

No thermal rating has been reported.

In addition, a report of 1910 mentions the existence of "several small seams" from a few inches to one foot thick. The report concluded that "it is doubtful whether a workable thickness of coal clean enough for market purposes will be found here."

TELKWA RIVER: (No. 17)

Under this heading are included coal deposits on Telkwa River itself, (the former Aveling coal property), and Goathorn Creek, (Bulkley Valley Collieries Ltd. and its predecessors). Goathorn Creek enters the Telkwa River from the south, about four miles southwest of Telkwa. There are also showings on Pine Creek, which enters the Telkwa River from the north about four miles west of the mouth of Goathorn Creek.

A total of 20 coal licenses and three Crown-granted lots cover the properties on Goathorn Creek, which were in production as recently as 1970.

The coal-bearing rocks of the Bowser group, (Upper Jurassic to Lower Cretaceous), lie in several northwest-trending elongate bodies, about 11½ square miles in area, centred six miles southwest of Telkwa. Outcrops are relatively sparse, due to thick glacial overburden, but coal seams are exposed in the lower valley slopes of Telkwa River and Goathorn Creek. These rocks represent the eroded remnants of a larger basin that has been gently folded (present dips range from 5° to 30° on the coal seams) and broken by faulting, which limits the present remnant basin. Prospects of subsurface extensions of the coal formation are minimal due to the fault-limits of the basin.

The coal-bearing rocks comprise mudstone, sandstone and coal. The maximum known thickness of the coal measures is about 200 feet; coal is said to make up about 20% of this, and is generally interbedded with the mudstones. Drilling has intersected as many as seven seams, but they are lenticular and discontinuous. The earliest producing mine on Goathorn Creek, (the McNiel mine of Telkwa Collieries Ltd.), worked a 14-foot seam, and the three mines of Bulkley Valley Collieries Ltd., worked intermittently from 1930 to 1954, produced coal from seams 10 - 14 feet thick, all three of which were designated the "Betty" seam and were probably reliably correlated. Correlation is made more difficult by faulting that may have displaced the beds as much as 200 feet vertically.

Analyses of coals from the Telkwa River and Goathorn Creek properties gave the following results (basis not stated):

	Upper seam ("Major"?)	Betty seam	Lower seam
Moisture	1.92%	5.6%	2.1%
Volatiles	30.45	29.70	32.40
Fixed carbon	61.30	58.90	56.30
Ash	6.33	5.80	9.20
Sulphur			1.6
Thermal rating			13,570 BTU/lb.

Between 1930 and 1952, Bulkley Valley Collieries Ltd. operated the No. 1 and No. 3 mines, both underground, on the east bank of Goathorn Creek, and the No. 2 Mine (underground) and an open-pit mine on the west bank. After 1952, the open-pit mine was extended underground as the No. 4 Mine. Drilling results indicated that some coal seams are very close to the surface of bedrock, (e.g. 20-30 ft.), and would thus present problems of support in mining. Other seams, however, are overlain by 200 feet or more of bedrock. Drilling also intersected one seam 30 feet thick in the east bank of Goathorn Creek, about 100 feet in elevation above the creek and 200 - 250 feet below ground surface. However, this seam may lack continuity because of faulting. Mining does not appear to have come within 300 feet of the drill hole that intersected this seam.

Trenching on the west bank of the creek had exposed a 12-foot thickness of coal near the surface, and it appears that this showing was developed as the open-pit mine. However, there are distinct possibilities of developing a new open-pit mine if exploration confirms that this near-surface seam picks up again anywhere else in the same vicinity.

On the north shore of Telkwa River about two miles west of Goathorn Creek, the Aveling property produced coal from 1920 to 1942. Production came from the seam originally named the "Betty", with which those on Goathorn Creek were later supposedly identified. At this property the seam was nearly 18 feet thick, but this included three shale bands up to 8 inches, and a $3\frac{1}{2}$-foot width of "blacksmith coal" that was too friable to mine as lump coal. Moreover, 2 feet of coal was left for the roof, as the incompetent hanging-wall rocks required support, and a 4-foot coal bed was left in the floor. Thus only about 10 feet of coal, including the "blacksmith coal", was mined.

This seam was faulted off at a distance of 200 feet north from the portal. The seam is exposed "for a few hundred feet" along the bank of the river, but the two development tunnels were driven only a short distance apart. Estimation of reserves is therefore difficult on the information presently available.

A second seam, the "Major", is exposed about half a mile west of the "Betty" workings and approximately 150 feet higher up the valley slope. Thickness of coal in this seam totalled at least 7 feet, but included a $1\frac{1}{2}$-foot band of shale in the middle. There is no indication in the reports that development on this seam ever reached the production stage.

A rough estimation of the total reserves of the Telkwa basin could be made by assuming continuity of a 10-foot thickness in the "Betty" seam throughout the basin, as this seam has been mined to that thickness at least in several places. It would be a conservative estimate to the extent that it ignores the other seams intersected by drilling, which may or may not be mineable, and ignores also the "Major" seam that is known, but remains undeveloped, on the north bank of the Telkwa River. On the other hand, folding, faulting and differential erosion reduce the likelihood that even a 10-foot thickness is continuous throughout the basin.

The mapped areal extent of the Bowser Group rocks is approximately $11\frac{1}{2}$ square miles. Using a factor of approximately $1\frac{1}{4}$ million tons per square mile per foot of thickness, possible reserves are 143.75 million tons; using a factor of 1 million tons per square mile, etc., they are 115 million tons. However, these estimates include areas of Bowser group rocks in which, to date, there has been no positive evidence of the presence of coal, and ignores the aspect of mineability.

During the period 1918 - 1970, total production from the Telkwa coal-field was just over 477,000 tons.

On Pine Creek, 4700 feet of drilling was done in 1969, but no further information is available at present.

In conclusion, although the Telkwa coal basin is of restricted extent, there may still be significant reserves that have hitherto been left untouched either because of support problems in underground mines or because of the lack of a market. In particular, the deposits on the north shore of the Telkwa River appear to have been inadequately explored; and drilling financed by the Federal Government as an emergency measure during World War II intersected a seam as much as 30 feet thick on the Goathorn Creek property of Bulkley Valley Collieries Ltd., that was not reached in the course of mining operations. For these reasons, the search for further information on this coal basin is receiving high priority in the present study.

CLARK FORK: (No. 18)

Potentially coal-bearing Bowser Group rocks are exposed in three small areas on Thaultil and Denys Creeks, which flow into the Morice Lake and appear to be known jointly as the "Clark Fork" of the Morice River. These three areas probably total not more than 9 square miles.

At one time they were covered by a total of 23 coal licenses, of which 11, covering the most northerly areas, were held by Bethlehem Copper Corporation. All the licenses are now designated as "forfeited". Trenching, mapping, roadbuilding and almost 2,000 feet of drilling were carried out in 1968.

The sedimentary rocks are similar to those of the Bowser Group in the Telkwa area, and consist of mudstones, siltstones and sandstones, folded into two parallel synclines with gently-dipping limbs(10° - 35° dips).

Reports in the early 1900's mentioned three seams, respectively 8 ft., $6\frac{1}{2}$ ft. and $3\frac{1}{2}$ ft. thick, and the report of the B.C. Minister of Mines for 1968 noted the presence of "several narrow coal seams". Other early assessments are available, but their reliability is prejudiced somewhat by the difficulty of equating the modern names of creeks, lakes, etc. with the old names that have fallen into disuse.

It may be possible to secure more useful data on this coalfield, but for the time being there isn't enough information on which to base a meaningful estimate of possible reserves.

CHISHOLM LAKE: (No. 19)

The Chisholm Lake coal showings lie within a belt of Bowser Group rocks to the east and northeast of Morice Lake, approximately 6 miles wide and 24 miles long. The Chisholm Lake rocks consist of mudstones, shales and sandstones with some coal, folded along structural axes that are parallel to those in the Clark Fork area. Dips range from 20° to 65°. There appears to be considerable glacial and alluvial overburden that obscures the full extent of the coal-bearing formation.

There are 22 current coal licenses in the area around Chisholm Lake itself, but 6 licenses covering the central part of the holdings are designated as "forfeited" in the provincial government's coal license map. The remaining licenses are held by Scurry-Rainbow Oil Co. Ltd. of Calgary, Alberta. The six central licenses were formerly held by Kaiser Resources Ltd., who carried out limited exploration work. No drilling was done, but two coal seams, 6 inches and 8 inches respectively, were found in outcrop.

No other information is presently available, but the considerable area of the basin, approximately 150 square miles, makes it a potentially attractive target for further exploration.

QUADRANGLE 5 (Sukunka)

PEACE RIVER - SUKUNKA BELT -(No. 20)

(This area forms the subject of a separate report.)

FRASER LAKE (No. 21)

In a railroad cut at the east end of Fraser Lake several narrow seams of coal are exposed in rocks of Tertiary age. The host rocks (Eocene or Oligocene) have an areal extent, as mapped by the Geological Survey of Canada, of less than 1 square mile. They lap onto much older granites, and are flanked by younger volcanics that may overlie more of the coal-bearing formation.

The coal is of lignite rank, is mixed with much shale, and slacks rapidly on exposure to air. The widest seam does not exceed 12 inches. A company was formed in 1921 to investigate the occurrence, but after a little exploratory work the project was abandoned, as the coal was unsuitable for commercial exploitation (ref. Geological Survey of Canada, Memoir 252, 1965).

QUADRANGLE 6 (Queen Charlottes)

SKONUN POINT: (No. 22)

Skonun Point lies on the north-east coast of Graham Island, about 4 miles east of the village of Masset. This area is largely drift-covered, with only scattered rock outcrops, and the Skonun formation, of Miocene to Pliocene age, is exposed only at Skonun Point and at Yakan Point, 10 miles further east. Otherwise the stratigraphy of the formation is known only from six wells drilled by Richfield Oil Company in 1958 and 1961.

The Skonun Formation consists of clays, shales, sandstones and conglomerates, with interbedded lignite coal. At Skonun Point, where it is exposed on the shore in the intertidal zone, it is folded into a moderately compressed anticline with an east-west axis, the limbdipping up to 60° to the south and 25° to the north respectively, and faulted parallel to the axis. The section at this locality is not more than 500 feet thick, but on the east coast of Graham Island it is almost 6,000 feet thick.

The lignite at Skonun Point is well exposed, being tough and woody and thus weathering into relief. There are 13 lignite beds, but none is more than 3 feet thick (although 6 feet was intersected in a drill hole nearby). The total thickness of lignite here is about 20 feet, out of a 200-foot shaly section, and the outcrops extend about half a mile along the beach. At and near the surface the lignite is brownish, but it becomes darker and more coaly with depth.

An analysis made in 1912 on air-dried samples from Skonun Point gave the following results:

Moisture	11.03%
Volatiles	49.75
Fixed Carbon	35.94
Ash	3.28

No thermal rating was given.

Earlier estimates of reserves, (1912, 1929), based on a thickness of 30 feet of coal over at least 2 square miles, were set at 60 million tons. However, later work has revised the known thickness, and further exploration would be needed to confirm the continuity and thickness of the seams away from Skonun Point itself.

Finally, even if appreciable reserves do exist at Skonun Point, the establishment there of a provincial park in early 1974 may have removed them altogether from the possibility of development.

(Investigation of this coalfield is continuing.)

COWGITZ: (No. 23)

The designation is used here collectively for the various showings in the southern half of Graham Island, between Masset Inlet and Skidegate Inlet. The name Cowgitz originally applied to an anthracite mine close to Slatechuck Creek, which enters Kagan Bay at the west end of Skidegate Inlet. Coal was discovered there in 1859, but mining proved so difficult that the project was abandoned in 1872. Further attempts were made in 1890 and again in 1912. By 1913 it had again been abandoned and the tunnel was described in the same year as already "too gassy to examine". The other occurrences of the area were formerly known by the names of camps established to explore or exploit them, namely: Camp Anthracite and Camp Robertson, on the headwaters of Brent Creek (east of Yakoun Lake); Camp Trilby, on Baddeck Creek (southeast of Yakoun Lake); and Camp Wilson, on Wilson Creek, a tributary of the Yakoun River (several miles north of Yakoun Lake).

All the coal-bearing rocks were thought at one time to be part of the Cretaceous Haida Formation, consisting of sandstone, shale and siltstone. On the basis of that assumption, "proven" reserves of about 7 million tons and probable reserves much larger were projected. More recent work has shown that the Jurassic Yakoun Formation also contains coal. As there has been no significant exploration since 1914, there is no possibility of producing realistic figures for reserves until a new and thorough exploration program is undertaken.

The coals sampled from these occurrences ranged in rank from low-volatile bituminous to sub-anthracitic. The quality has been summarized as good, but relatively high in ash. Examples are: Camp Wilson: 12 analyses ranged from 2.92% ash (59.36% FC), 37.10% ash (31.17% FC), and four others from 2.92 to 9.45% ash;

Cowgitz and Slatechuck: 11 samples ranged from 3.1% ash (90.80% FC) to 29.49% ash (57.23% FC);

Camp Robertson: average of 3 analyses gave 22.51% ash. Other analyses from Camp Robertson varied widely, but all were high in ash;

Camp Anthracite: 3 samples ranged from 9.72% ash (80.07% FC) to 44.38% ash (42.10% FC).

The basis of most of these analyses is not known; they are taken mostly from Mackenzie, 1913, Geological Survey of Canada Summary Report. Three of the Camp Wilson samples were analysed with "total moisture", four were air dried; but moisture content was low (between 1.3% and 2.65%) in all cases.

All the seams in this district except those at Camp Wilson are thin, or are aggregates of thin seams with much interbedded shale, and no seam is much more than 2 feet thick. At Camp Wilson, a lenticular seam varies from 4 to 18 feet thick within about 50 feet in the workings and probably pinches out entirely within a few hundred feet, (Sutherland-Brown, 1968, Geology of the Queen Charlotte Islands). At Cowgitz, the coal was badly crushed and the seams, which were vertical, could be followed only with difficulty; however, later development encountered seams that were strongly folded, but not so badly crushed.

Reports from the years 1906 to 1914 provide ample detail of the geology as it was understood at that time, but it would be inappropriate to include it in the present preliminary report. As noted above, much of it should be re-assessed in the light of recent geological mapping; and enough has been said to establish that 1) the coal seams are generally thin; 2) they tend to be strongly deformed and therefore likely to present mining problems; 3) the quality and rank are medium to high, with the exception of a generally high ash content; and 4) no realistic estimate of reserves can be attempted without a comprehensive exploration program.

At present it appears that much of the prospective coal district is covered either by "alienated" land title or by crown coal rights. Efforts are currently being made to determine the status of these lands.

QUADRANGLE 7 (Bella Coola)

NECHAKO RIVER: (No. 24)

In the banks of the Nechako River, immediately west of Mount Greer and about 10 miles south of Fort Fraser, a 4-foot seam of lignite was observed by G.M. Dawson in 1878. The Mount Greer area is underlain by rocks of the Endako Group, of Miocene age or younger, that comprise mostly volcanics, but also include conglomerates, greywackes and some lignite.

In the course of recent mapping, the outcrop noted by Dawson was not found again, and it may no longer be exposed. Large blocks of lignite are said to be strewn along the bed of the Nechako River north of Kenney Dam. The source of these blocks has not been found, but must be relatively close.

Surveys in connection with the raising of Kenney Dam may have involved some examination of local mineral and fuel resources, and such sources of information will be followed up.

Tipper, (Nechako River map-area, 1963), remarks "lignite float has been noted at many places in the map-area but as it is Tertiary lignite, occurring with soft Tertiary sediments, no good exposures were seen".

Access to the Nechako River map area from main highways and the Canadian National railway is good, and between one quarter and one third of the map area is underlain by Endako Group rocks that contain lignite in places. But the paucity of coal exposures is in marked contrast to the considerable extent of potentially coal-bearing rocks, and the area thus rates very low in priority for future exploration.

BLACKWATER RIVER: (No. 25)

Tertiary sedimentary rocks, some of them containing lignite, are found along the Blackwater River intermittently for 15-20 miles upstream from its confluence with the Fraser River. They are one of several small Tertiary sedimentary basins in the Prince George - Quesnel area, all of which are confined to river channels, at elevations of less than 2,600 feet. They therefore offer only limited prospects of finding commercially significant deposits of thermal coal.

Little information on the Blackwater River occurrences has come to light so far, and in fact they are not even mentioned or marked on the current Geological Survey of Canada map of the area (Tipper, 1960). Sediments of the same age also occupy the valley of the Fraser River between Hixon and the mouth of the Blackwater, but there is no reference to the presence of coal. However, it is found in a similar geological setting on the Cottonwood River (q.v.) near Quesnel. (Further information on these localities is being sought.)

DEAN RIVER: (No. 26)

BELLA COOLA RIVER: (No. 27)

(Information on these two reported occurrences of Tertiary coals is presently being gathered. In the geological context of the Coast Range belt of intrusive rocks, any deposits of coal are likely to be in sedimentary basins of very restricted extent, and are likely also to be of low rank. Moreover, both occurrences appear to fall within the boundaries of Tweedsmuir Provincial Park.)

QUADRANGLE 8 (Cariboo)

FORT GEORGE: (No. 28)

Tertiary rocks, possibly of Miocene age, are exposed for about two miles along the east bank of the Fraser River apposite the city of Prince George, and it is reported that they contain coal.

The thickness, rank, etc. of these coals are not known at present, but information on them is being sought. This is one of a number of very small sedimentary basins that are confined to existing river channels, and in this respect, resembles the Blackwater River occurrence (No. 25, above). Another short narrow belt of the same rocks is exposed near the mouth of the Chilako River, a tributary of the Nechako, about 8 miles southwest of Prince George. No coal has been reported from that area.

Coal in this location would be ideally situated with regard to transportation and future markets, but mining it on the steep wooded east bank of the Fraser, so close to Prince George, would be an environmentally delicate proposition.

BOWRON RIVER: (No. 29)

Coal was discovered on the Bowron River in 1871, and some exploratory work was done during the years 1910 to 1914. However, until 1946 no further attempt was made to exploit these deposits, due partly to the difficulty of access and partly to the lack of markets during those years. Until a tractor road was put through in 1947, and an improved road in 1948, the only access was by pack-trail. The property is now only five miles from Highway 16, (the Yellowhead Highway), and is about 50 miles by road from Prince George.

Three coal licenses covering the central area of the deposits remain in good standing, and are held by Northern Coal Mines Ltd. Nineteen other contiguous licenses adjoining these three have been forfeited.

Drilling, underground development and trenching were carried on intermittently between 1946 and 1971, together with improvement of access roads during the earlier years. A total of 1,200 feet of underground workings was developed (from two adits), but was abandoned in 1971. A total of 42 drill holes had been put down on the property between 1946 and 1970, and in 1971 Bethlehem Copper Corporation drilled five more holes and carried out other exploration work under option from Northern Coal Mines Ltd. This option was dropped at the end of the 1971 season's work.

The coal is found in the basal 250 feet of a sequence of sedimentary rocks that is as much as 2,200 feet thick, occupying an elongate basin that trends northwestward and is about $2\frac{1}{2}$ miles wide and 10 miles long. Structurally the basin is a graben, i.e. a block bounded on either side by fault zones and down-dropped with respect to the adjacent blocks. Although this Bowron River graben is about 10 miles long, drilling has confirmed the continuity of the coal measures for only about $2\frac{1}{2}$ miles of this strike length. The beds strike parallel to the trend of the basin, and dips range from 20° to 60° to the northeast, with a predominant dip of about 45°.

Most of the area is covered by overburden, but coal is seen in outcrops along the Bowron River and in a few creek beds. Two main seams, almost contiguous, are known in outcrop and in underground workings; they are 11 feet and 8 feet thick respectively. Drilling has also intersected three other seams in the deeper part of the basin, as for example at a depth of about 1,400 feet in the southern portion of the property. All reports emphasize, however, that continuity of coal seams is poor and correlation extremely difficult. As noted above, the coal measures have been shown to extend about $2\frac{1}{2}$ miles along strike, and the 1971 drilling confirmed their down-dip extension for 2,500 feet.

In 1970 a private report to Northern Coal Mines Ltd., (Dr. J.M. Black), calculated reserves of 20 to 25 million tons of "indicated and probable" coal. Bethlehem Copper Corporation's work in 1971 confirmed reserves of about 5 million tons, taking an average seam width of only 6 feet over 8,000 feet strike length and 2,500 feet extension down-dip. Another private report to Northern Coal Mines Ltd. in 1973 (L.S. Trenholme) adopted a total of 18 feet thickness on two seams, and estimated 99 million tons over the "known and probable extent" of the coal measures, with another 90 million tons potential in adjacent untested areas "possibly underlain by the coal measures". In the light of this wide divergence of estimates it is impossible at this stage to propose a figure for reserves with any degree of reliability, other than to suggest that the most conservative figure is at least a minimum estimate.

The coal is of high volatile "B" bituminous rank. It is described as hard, and resistant to weathering. Visual observation indicated that some of the coal contained up to 8% resin, half of it a dark soluble "Refined Resin" and the other half an insoluble "Amber Resin". The refined resin was found to be comparable in quality with commercially-valuable resins from other parts of the world.

An analysis of coal from the 11-foot seam in the workings (made on unoxidized material) gave the following results (1970: basis not stated):-

"Inherent" moisture	4.92%
Volatiles	36.50

Fixed carbon	55.80
Ash	2.77
Sulphur	0.85

Thermal rating was 12,550 BTU/lb., and free swelling index 2.5.

Analyses made on drill hole cores taken by Bethlehem in 1971 gave the following results (average of 11 samples, basis not known):-

Moisture	not included
Volatiles	37.15
Fixed carbon	43.22
Ash	19.63
Sulphur	1.63

Thermal rating:- 11,064 BTU/lb. (values ranged from 10,109 to 12,222 BTU).

The 1971 B.C. Minister of Mines' report notes "the mineral matter-free BTU ranges from 13,500 to 13,900", but does not specify the source of the samples. The same report remarks that "the coal is reported to have coking qualities but is non-swelling", which is borne out by the low free swelling index quoted above.

An average of 19 samples, (Bethlehem, reported by Trenholme), gave (air-dried basis): Ash 24.63%, with fixed carbon of 42%. It was suggested that the Bethlehem samples may have contained more shale than was reported, or that there may be an increase of shaly material towards the centre of the basin where, presumably, Bethlehem's holes were drilled. No swelling tests were made by Bethlehem.

The Trenholme report (1971) stresses the problems involved in mining steeply-dipping seams, and emphasizes that more exploratory drilling needs to be done to confirm sufficient continuity of coal seams to justify large-scale mining. It suggests that hydraulic mining be considered. It also concludes that small-scale mining could be undertaken at the present stage of development of the mine, without the massive capital investment required for large-scale mining.

COTTONWOOD: (No. 30)

The Cottonwood River enters the Fraser River from the east about 10 miles north of Quesnel. For the last 15 miles or so before it joins the Fraser, the Cottonwood has cut a deep steep-sided valley in which are exposed Tertiary rocks of the same age as those on the Blackwater (No. 25, above) and at Fort George (No. 28). They are known to contain coal, but no individual showing is marked on the current Geological Survey of Canada map.

QUESNEL:(No. 31)

Lignite deposits in the Quesnel district have been known for many years, but are of low grade with high ash content, and have never been considered worth exploiting commercially for any but a strictly local market.

The Quesnel coal-basin, like those at Cottonwood River, Blackwater River and Fort George, is of very restricted extent, being confined to existing river valleys and generally lying at elevationsof less than 2,500 feet. The coal formation is of Tertiary age, and comprises conglomerate, sandstone, shale and lignite, interbedded with minor tuffs, basalt and breccia.

The coal is said to be exposed on the Quesnel River one mile north of the town of Quesnel. There is a sub-horizontal seam of "very dirty" coal from 2 to 4 feet thick.

ALEXANDRIA: (No. 32)

Coal deposits at Alexandria are part of the Tertiary sedimentary basin described above, which extends along the valley of the Fraser River for about 20 miles south of Quesnel. Small exposures of lignite are seen in several places, but it is invariably of poor quality or is interbedded with numerous thin bands of clay.

Fifty-nine coal licenses were formerly held in this area by Master Explorations Ltd. of Calgary, Alberta, but are now forfeited. In 1971 to 1972, the company drilled 21 holes for a total of 4,825 feet. Little information is presently available, but the coal seams intersected were described as "generally thin".

An old report (Geological Survey, 1920) gave the following analysis of coal samples taken near Australia Creek, about four miles north of Alexandria Ferry:-

	As received	Dried
Moisture	11.5	-
Volatiles	30.6	34.6
Fixed carbon	28.5	32.2
Ash	29.5	33.2

No thermal rating was given.

Around 1923, a short adit was driven into this deposit by the owners of the ranch on which it is located. The purpose was to secure supplies for domestic use, but as the project was discontinued, it is likely that the coal proved unsatisfactory.

It may be possible to obtain more information on the results of the 1971-72 drilling, but as no coal licenses remain in good standing, the results probably did not encourage further attempts to exploit the deposits.

Other small showings have been reported, including a seam 15 feet thick at Alexandria Ferry itself (800 feet south of the ferry, on the east side of the Fraser). About 3½ feet of this seam consists of two bands of clay and shale, but even the top 6 feet consists of dirty coal with interbedded clay bands. The other two "benches" of coal are 4½ and 4 feet thick respectively. A sample taken across the 4½-foot bench in 1923 was analysed, and it is here compared with another sampling, stensibly of the same seam, reported in 1930 (both probably "as received"):-

	1923	1930
Moisture	5.1	16.6
Volatiles	38.2	27.0
Fixed carbon	38.5	50.9
Ash	18.2	5.5

It was suggested (1923) that the ash content could be reduced by sorting out clay bands, but the coal would be suitable only for small-scale exploitation for local domestic market.

CHU CHUA: (No. 33)

The village of Chu Chua is in the North Thompson valley about 45 miles north of Kamloops, and has given its name to a formation of sedimentary rocks, of Eocene age, that appears to be of very limited areal extent but is known to contain coal. The formation is mapped in several places in this section of the North Thompson, but the only coal showings appear to be on Newhykulston Creek about three miles south of Chu Chua. Coal appears in the upper part of the Chu Chua formation, associated with sandy shale and arkosic sandstone, and different seams are separated by as much as 600 feet of stratigraphic section. The formation may be up to 2,500 feet thick.

According to a 1913 report, three seams on Newhykulston Creek are respectively 6 inches, 9 inches and 18 inches thick; in the early 1900's, the 18-inch seam had been mined to provide coal for a river steamer. Analysis of material from the 18-inch seam gave: Moisture: 2.22%; Volatiles: 32.05%; Fixed carbon: 52.81%; Ash: 12.92%. It is likely that these seams were later found to be among the "minor" seams as described below.

Further development along Newhykulston Creek was carried on in 1921-22, with the opening up of two small mines with a maximum production of 40 tons per day. Three main seams and up to nine minor seams have been mapped. The principal producing seam has up to 5 feet of coal, but also has up to 9-10 feet of shale and sandstone in the middle of it. Another seam has up to $2\frac{1}{2}$ feet of coal, but again is divided by a shale and sandstone band.

Analyses of coals from the producing seams gave the following results ("as received" = R; "air-dried" = D):-

	#1		#2		#3		#4	
	R	D	R	D	R	D	R	D
Moisture	4.0	-	3.7	-	3.6	-	4.0	-
Volatiles	36.1	37.6	29.4	30.5	37.9	39.3	37.9	39.5
Fixed carbon	35.9	37.4	29.6	30.7	44.7	46.4	36.0	37.5
Ash	24.0	25.0	37.3	38.8	13.8	14.3	22.1	23.0
BTU	10,290	10,700	8,230	8,550	12,040	12,490	10,780	11,230

The coal can thus be classed as low grade, low rank bituminous, or as low grade, high rank sub-bituminous.

No estimate of reserves has been found so far, but the remnants of the Chu Chua formation are of such restricted extent that important reserves may be scant.

QUADRANGLE 9 - Vancouver Island

SUQUASH: (No. 34)

The Suquash coal deposits, on the northeast coast of Vancouver Island, were first recognized in 1835, and mining on a limited scale was carried on by the Hudson's Bay Company from 1849 to 1853. Ten thousand tons were mined, all from outcrop. The workings were abandoned after the deposits at Nanaimo were discovered.

Further development was carried on between 1908 and 1922, with production of about 12,000 tons of coal up to 1914, but apparently none later than that date despite appreciable investment for large-scale production.

Three main seams of coal are known, of which the uppermost is $2\frac{1}{2}$ feet thick, and crops out at the shoreline and elsewhere. No. 2 seam is at a depth of 173 feet below surface; a shaft was sunk to this seam in 1908 and 10,000 feet of workings developed. This seam ranges from 4 feet to 8 feet in thickness. A third seam was intersected by drilling at a depth of 445 feet and is estimated to be 4 feet thick. The structure is very regular, with a dip of up to 10° to the northeast. The coal basin is of late Cretaceous age.

An analysis of Suquash coal gave the following results: (source of sample and basis of analysis not known):-

Moisture	5.03%
Volatiles	41.51%
Fixed carbon	46.52%
Ash	6.44%

Early reports tended to emphasize that although the coal was of good quality, it contained a good many shaly and sandy partings.

Recent studies, based on a principal seam thickness of 6 feet, suggest reserves are sufficient for a production of 500,000 tons per year for 45 years.

The property is covered by two current coal licenses, held by Cobre Exploration Ltd. of Vancouver, B.C.

This coal formation has been mapped for approximately 14 miles along the coast from Port McNeill northwest to Fort Rupert, and might repay systematic exploration with up-to-date techniques. Although road access is not particularly good, as the deposit is situated right on tidewater it is very favourably placed for transportation by barge. Mining of it will be by underground methods.

CAMPBELL RIVER: (No. 35)

Campbell River lies at the northwest end of a 75-mile long broad belt of sedimentary rocks, the Nanaimo group of Late Cretaceous age, that include the important coal measures of the Comox and Nanaimo basins further to the southeast.

(Information is still being gathered on the reserve potential of the Campbell River coalfield.)

COMOX: (No. 36)

(This coalfield forms the subject of a separate report.)

LANG BAY: (No. 37)

Lang Bay is on the mainland shore of the Strait of Georgia, about 14 miles southeast of the town of Powell River. A total of 136 mineral claims were held, (as of 1959), by Taiga Mines Ltd. of Vancouver, with a view to recovering germanium from a small basin of Tertiary sediments underlain by granodiorite and volcanic rocks. The germanium is associated with lignite and other carbonaceous material that occurs as threads, stringers and small isolated masses in the sediments (B.C. Min. of Mines' Report, 1959).

Carbonaceous material enclosing coal stringers has been found in trenches and drill holes, but the distribution is erratic, and "seams" of carbonaceous material are nowhere more than $5\frac{1}{2}$ feet thick. Very little of this is coal; the thickest coal stringer is only 2 inches wide.

Other than noting the occurrence, this location does not warrant further attention.

ALBERNI: (No. 38)

Lying parallel to the main Nanaimo-Comox belt of Late Cretaceous coal-bearing sedimentary rocks, (the Nanaimo group), is a narrower belt about 30 miles long and up to 5 miles wide. The towns of Alberni and Port Alberni are situated near the southeast end of this belt.

Abortive attempts were made to explore coal prospects in this area, first in 1877-78 and again in 1911-12. A seam of coal, that may have been about 3 feet thick, was discovered about a quarter of a mile south of Port Alberni; a drill-hole about half a mile to the southeast intersected, within the uppermost 31 feet, several seams of mixed coal and shale, from 1 foot to 3 feet thick, in addition to two very narrow coal seams, 1 inch and 2 inches respectively at a greater depth.

In 1911 a short adit was driven on the same 3-foot seam, but there is no reliable information on the results of this work. A dump at the mouth of the caved adit, sampled 11 years later, contained a mixture of carbonaceous shale and "lenses" of hard bright coal that had resisted weathering. Analysis of the latter showed that this coal was of anthracite rank, with a fixed carbon content of about 72% and ash content ranging from 14.3 to 22.1%.

J.D. Mackenzie, reporting on the Alberni basin for the Geological Survey of Canada in 1922, concluded that the scanty evidence of coal in the old showings offered no encouragement that the rest of the basin might contain coal in commercial quantities. Moreover, the shales and sandstones in the Alberni area probably correlated with basal members of the Nanaimo group further east, i.e. below the well-known coal measures of the Comox and Nanaimo basins, where drilling had confirmed the absence of significant coal seams at depth.

Although the prospects for coal exploration in the Alberni basin seem poor, it may be premature to write it off as a low-priority area, especially in the light of modern techniques of exploration. Further information on the area is being sought.

NANAIMO: (No. 39) and COWICHAN: (No. 40)

Both these coalfields, in Southern Vancouver Island, are well documented as a result of many years of development and production. The Nanaimo field in particular was the foundation of the early coal-mining industry in British Columbia.

(A review of both these areas is presently in progress.)

QUADRANGLE 10 - Dry Belt

HAT CREEK: (No. 41)

The Hat Creek coalfield, near Cache Creek and Ashcroft, forms the subject of a separate report. A study of production methods, costs etc. is currently in progress.

KAMLOOPS: (No. 42)

There is a report in 1924 of limited development work on two coal prospects close to the city of Kamloops, but as far as is known, they never amounted to a commercial proposition.

Coal near Kamloops is known in the Tranquille Formation, of Miocene age, in sedimentary rocks that are underlain and overlain by volcanics. The occurrence has been known since the late 1800's. One locality is on the slopes of Dufferin Hill about $2\frac{1}{2}$ miles southwest of the city, another is on the north side of the Thompson River about a mile west of Kamloops, and traces of coal are reported also just north of Stump Lake, which is several miles south of Kamloops on the Nicola-Merritt road.

The total thickness of coal found in 50 feet of the formation is $30\frac{1}{2}$ inches, of which the largest seam is only 12 inches thick. Because these showings were not representative of the total section of the Tranquille Formation, said to be up to 1,000 feet thick elsewhere in the vicinity of Kamloops, the B.C. Minister of Mines' Report for 1924 urged that the possibility of finding coal in commercial quantities should not be discounted, but that drilling should be carried out in places where a thicker section of the Tranquille beds remained. The present distribution of this formation represents a small erosional remnant of an appreciably larger sedimentary basin.

The local coal was described in the 1924 report as "as true coal, burning well and producing a coherent coke". No records of analyses are available.

Proximity to the city of Kamloops would make open-pit mining difficult, even if reserves close to the surface were proved up, and it is unlikely that enough coal exists in the basin to warrant an underground mining operation.

MERRITT: (No. 43); QUILCHENA: (No. 44)

The coal deposits of the Merritt-Nicola area have been known since at least 1877, and for years the local ranchers mined it for their own domestic use. Commercial production started in 1906, and a total of almost 2,700,000 tons of coal was mined from the Merritt coalfield between 1906 and 1945. The principal producer, (80% of the

total), was Middlesboro Collieries Ltd., which ceased production in 1944. Coldwater Collieries Ltd. has since been mining coal by recovering pillars etc. left in the old Middlesboro workings. Their production declined from a high of 1,259 tons in 1955 to 60 tons in 1963, the last year in which there is a note of their activities in the Report of the B.C. Minister of Mines.

The coal was mined from the "Coldwater beds", Miocene or earlier, that are probably correlative in age with the coal deposits of the Hat Creek area near Ashcroft. However, the Merritt basin probably does not exceed about 3 miles in width and 8 in length, oriented northeastward along the south side of the Nicola River. An extension of the same rocks is mapped for about 7 miles northwest of Nicola, but there is no report of coal-bearing beds in them. The Coldwater beds comprise conglomerate, sandstone, shale and coal, with numerous bony partings in the coal. The stratigraphy is still not well known, and correlation has been described as difficult, even between drill holes that are relatively close together. At least 6 coal seams are present in the area immediately south of Merritt, (Coal Gully Hill and Coldwater Hill), and possibly as many as 15, in coal-bearing strata that may be up to 750 feet thick. Many of the old mine records are missing. Surviving diamond-drill logs note compound seams from 2 to 3 up to 18 feet thick, in which coal alternates with shale, bony shale and bone partings. Individual coal beds, presumably of clean coal, range up to $6\frac{1}{2}$ feet thick. During the period 1952-1963, Coldwater Collieries Ltd. was recovering coal from pillars in a seam 4 to 5 feet thick with minor bone and shale. The seam dipped south at about 12°.

Examples of analyses of Merritt coals are as follows (basis not stated):

	Middlesboro Collieries #5 (1926)	Coldwater #5 (1954)
Moisture	4.9	5.6
Volatiles	31.3	35.4
Fixed carbon	56.8	47.6
Ash	4.0	11.4
Sulphur	0.7	0.7
Thermal rating (BTU/lb.)	12,555	12,060

The Coldwater No. 5 mine produced from the same seam as the old Middlesboro No. 5, by recovering pillars between the latter mine and the surface. Coking qualities were described (1926) as fair; coal rank was noted (1954) as high volatile "B" bituminous.

It is not possible at this stage to make a reliable estimate of remaining reserves, and to judge by the efforts made by Coldwater Collieries to extract the last possible ton from a mine abandoned by a larger producer (the Middlesboro No. 5),

there is little encouragement to think that production could be resumed in the same area. However, the same geological formation extends northeast to Nicola and northwestwards from Nicola, and exploration has probably not been thorough enough to date to warrant dismissing these areas entirely.

Another small basin of "Coldwater beds" lies along Quilchena Creek, about 12 miles east of Merritt. It is roughly 6 miles long by 3 miles wide, and trends slightly east of north. Four coal licenses formerly covered some of this ground, but they are now forfeited. There has been no reference to coal on Quilchena Creek since the report of the B.C. Minister of Mines for 1915.

There are small isolated occurrences of the same rock formation on Guichon Creek (near Craigmont Mine), close to Highway 5 nine miles southeast of Merritt, and in the hills between Merritt and Quilchena Creek. So far as is known, no coal has been discovered in these localities.

TULAMEEN: (No. 45)

The purpose of the present notes is to review briefly the essential features of the Tulameen coalfield, as it will be dealt with in greater detail in a subsequent report.

The Tulameen coalfield lies about 10 miles west and slightly north of Princeton, and covers about 6 square miles immediately south of the village of Tulameen and the Tulameen River. Metamorphosed volcanics of Late Triassic age are overlain by slightly more than 2,700 feet of Tertiary sedimentary rocks, and these in turn are overlain by younger volcanics. Near the base of the sedimentary sequence is a unit approximately 300 feet thick, of shale, bentonite and sandstone with several intercalated coal seams. The basin is warped into a shallow open syncline, trending northwest, with shallower southwest limb and steeper northeast limb.

Coal is exposed along the northeast margin of the basin in several creeks and exploratory adits, but all the commercial development has taken place in the south and southwestern sectors. Between 1919 and 1940, Coalmont Collieries Ltd. produced approximately 2,365,000 tons of coal from five mines, (but for practical purposes, Nos. 1-3 were one mine, with interconnected workings). The main seam of the No. 3 mine varied from $7\frac{1}{2}$-12 feet in thickness, and was underlain and overlain by varying thicknesses of interbedded dirty coal, shale and clay. The main seam in the No. 4 mine averaged about 12 feet in thickness and was probably equivalent to that in the No. 3 mine. The same seam was developed in the No. 5 mine, adjacent to the No. 4. Squeezing along clay layers limited development of Nos. 3 and 4 mines, and

No. 5 was abandoned when the main seam gave way to dirty coal. Only one seam was mined extensively during this period.

On the northeastern margin of the basin at least one seam 10-12 feet thick was developed by prospect tunnels, but the coal proved to be so badly crushed that there was no market for it at that time. It was acknowledged that changing techniques of coal utilization might in time make the crushed coal marketable.

The eastern margin of the basin was explored by adits and trenching, spanning about 400 feet of potential coal-measure strata, but without significant success. However, it is possible that the full stratigraphic thickness of the coal-bearing member was not exposed by these operations.

W.S. Shaw, reporting for the Geological Survey of Canada in 1952, concluded that correlation of coal seams over the whole basin was not possible, although the main seam mined by Coalmont Collieries in the south and southwest sectors showed fair continuity of thickness and quality. He saw no reason why the dirty coal encountered in No. 5 mine should not give way laterally to more of the clean coal, and noted that no attempt had been made up to that time to test the seam further to the northwest. In addition, a 12-foot seam was said to lie "several hundred feet" below, but this had not been adequately tested. The most severe limitation on production potential was the squeezing effect set up by bentonitic clays in the coal measure, and the generally poor support characteristics.

In 1954 the Mullins Strip Mine Ltd. developed an open pit in the surface pillar adjacent to the old No. 3 mine. The seam here was said to be 80 feet thick (B.C. Minister of Mines' Report, 1954). Subsequently, a series of trenches has also defined the outcrop of the (main?) coal seam for a further 7,500 feet northwest of the old No. 5 mine. Beds of coal and coal mixed with shale total up to 120 feet, including one coal bed 70 feet thick (report by Wright Engineers Ltd., 1970).

An analysis of coal from the open pit (1954) gave the following results (basis not stated):

Moisture	5.7%
Volatiles	31.3
Fixed carbon	46.3
Ash	16.7
Sulphur	0.4
BTU/lb	11,030

The coal was classified as high volatile "B" bituminous.

By comparison, the 1970 report quoted above ranked the coal as high

volatile "C" bituminous, and gave a thermal rating for coal from the Mullins Strip Mine as 9,000 BTU/lb. The source of these figures was not stated.

In 1970, Wright Engineers Ltd. estimated "proven" reserves at 6,642,000 short tons, based on a seam width of 70 feet, strike length, as shown by trenching and existing development, of 15,000 feet, average depth (into the seam) of 150 feet, a recovery factor of 60%, and S.G. of coal 1.45. By extending the strike length another 14,000 feet, "probable" reserves of 6,200,000 short tons can be added to the above; and a mining depth of 200 feet instead of 150 would provide another 4,300,000 short tons, for a total of 17,142,000. However, part of this total strike length appears to include workings that have already been abandoned because of squeezing, and therefore could not be mined to a further depth of 150 feet.

Production from the Mullins Strip Mine during the years 1954-1957 totalled 163,438 tons, but the only market for the coal was a generating plant owned by Granby Consolidated Mining Co., and when this ceased operations in 1957 the Mullins coal mine also closed down.

(Investigation of the Tulameen deposits is continuing.)

PRINCETON: (No. 46)

The Princeton coalfield is an elongate, roughly oval basin, covering an area of about 45 square miles, centred on the town of Princeton at the junction of the Tulameen and Similkameen Rivers. It is approximately 15 miles long, with a maximum width of about 5 miles, oriented North 30° East. The southern half of the basin, including Princeton itself, has most of the known reserves of coal.

The coal is in the Allenby Formation of Tertiary age, interbedded with shale, sandstone and conglomerate. A distinctive feature of the Allenby Formation at Princeton is the presence of numerous bands of bentonite, in places up to 11 feet thick. Because of its capacity to absorb water and swell, thus exerting great pressure, the bentonite contitutes one of the major obstacles to economic exploitation of the coal reserves, and has contributed to the relatively early closure of several operating mines in the coalfield.

The Allenby Formation is the middle of three rock units, all of Tertiary age, that make up the Princeton Group, which overlies metamorphosed Nicola volcanics of Late Triassic age. Both the lower and upper units of the Princeton Group are volcanics. Structurally the southern half of the coalfield is an elongate bowl, or closed syncline, with its axis roughly east-west. Thus in most places around the basin, the rocks dip

towards the centre at angles that range from 15-70°. Three anticlinal noses project inward from the periphery of the basin, introducing local changes of direction of dip. In the northern half of the coalfield the rocks are poorly exposed and the structure is not well known, but most exposures suggest a consistent dip towards the east, steepening towards the eastern margin.

Though correlation throughout the basin is uncertain, there appear to be four main coal zones, each of which has been exploited in different parts of the coalfield. They are, from top to bottom, the Golden Glow seam (approximately 10 feet thick), the Gem-Bromley Vale seam (20 feet), Pleasant Valley-Jackson seam (10 to 60 feet), and Princeton-Black seam (65 to 135 feet thick). Several individual seams, 5 to 20 feet thick, do not correlate from one place to another. The four main zones are distributed through a stratigraphic interval of about 1,700 feet.

All coal seams in the Princeton field are to some extent interbanded with shale, clay, bentonite and some bone. The thickest zone, the Princeton-Black seam, has eleven beds of clean coal ranging from $2\frac{1}{2}$ feet up to 10 feet thick, but also has "dirty coal" up to 30 feet thick, and nine bentonite layers from 1 to 3 feet thick. The last operating mine in the district, the Blue Flame No. 2, at the southern end of the basin, was mining coal from a seam that varied from 6 to 7 feet thick and dipped to the north at 14°. However, the whole of this coal-bearing zone is said to have been over 30 feet thick. Even this 7-foot seam contained several thin bands of sandstone and shale, and its stratigraphic position with respect to the four zones noted above is not known.

The coal ranges in rank from lignite to sub-bituminous "A". It slacks readily upon exposure to air because of its high moisture content, and has generally poor storage qualities, with a tendency to spontaneous combustion when stock-piled in large volumes.

In 1947 samples were taken for analysis by the B.C. Department of Mines from two operating coal mines, (whose names were not stated). Five samples were taken from each mine, and the average results from each group of five are given below, (Mine A and Mine B). The third column gives the results from an analysis made in 1906 on coal from the Princeton-Black zone (basis for Mines A and B not stated; 1906 analysis "by fast coking"):-

	Mine A	Mine B	1906
Moisture	13.26	15.72	16.17
Volatiles	28.50	28.56	37.58
Fixed carbon	45.02	42.64	41.67
Ash	13.22	12.80	4.58
Thermal rating	9,118	8,371	not given

The range of thermal ratings for these two mines was from 7,400 to 10,360 BTU/lb. Thermal ratings for the same two mines from samples taken in 1926 were:

Mine A: 10,540 Mine B: 10,307

Further analyses are given in the table below, which is taken from Rice, 1947, Geological Survey of Canada Memoir 243, Princeton map-area. The bases of the analyses are not stated:-

	1	2	3	4	5	6	7
Moisture	16.17	11.97	16.97			18.0	16.6
Volatiles	37.58	30.49	56.37	56.44	56.50	32.7	33.0
Fixed Carbon	41.67	49.21	21.76	39.71	39.73	42.8	43.0
Ash	4.58	8.33	4.90	3.85	3.77	6.5	8.4
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Thermal rating			12,630	12,200	12,100	9,850	9,850
Sulphur			0.65	0.34	0.44	0.60	0.60

1) Sample from 18-foot seam at Princeton, assayed by Geological Survey, Dowling, 1915, p. 261.
2) Sample from 8-foot seam at Princeton, Ann. Rept., Minister of Mines, B.C., 1902.
3) Sample from Tulameen Collieries. Idem., 1931.
4) As above. Idem., 1930.
5) As above. Idem., 1930.
6) From No. 1 mine, Princeton Coal and Land Co. Idem., 1923.
7) From No. 2 mine, Princeton Coal and Land Co. Idem., 1923.

In 1947, it was noted "of the seams so far worked, or prospected, none has been entirely free from included bands of clay, shale, "bone", or rock. . . in addition, a clay or shale capping of varying thickness often falls as the coal is mined and adversely affects the value of the product".

It should be noted that in spite of the apparently low thermal rating of the coal in this district, it was used successfully for seven years at the Granby Consolidated Mining Co.'s 17,500 kw steam generating plant at Princeton.

None of the references consulted so far makes any attempt to estimate the total reserves of the Princeton coal basin. However, if the southern half alone is considered, and its area taken as 20 square miles, the following reserves may be roughly indicated for each of the major coal zones:-

	thickness	total seam	% 'clean' coal	mineable reserves
Golden Glow	10 ft.	200 m. tons	50% ?	100 m. tons
Gem-Bromley Vale	20	400	50% ?	200
Pleasant Valley-Jackson	ave. 35	700	30% ?	210
Princeton-Black	ave. 100	2,000	50%	1,000
		Total		1,510 m. tons

Up to the end of 1951, a grand total of 2,025,460 tons had been produced from the entire coalfield, and from 1951-1961 an additional 40,000 tons was produced from the Blue Flame Mine, the only one remaining in operation. This total production of only just over 2 million tons clearly makes insignificant inroads into a reserve of over 1,500 million tons.

In 1947, the B.C. Department of Mines concluded that "the coal already mined comprises less than 1% of the probable reserves", and that "the coal reserves of the district remain almost intact".

Offsetting this favourable picture are the factors that are jointly responsible for the complete shut-down of the coal-mining district since 1961. To quote the Geological Survey of Canada's report of 1952 (Shaw, Paper 52-12), the district has always been "characterized by short-lived operations that ended when difficulties were encountered at depth, due to squeezing and crumbling of the roof and pavement, factors largely attributable to the relatively low strength of the partly consolidated sediments and the presence of bentonite beds near and within the coal seams . . . which expands . . . . and commonly results in disruption of the enclosing strata". Thus the major problem is that of developing mining techniques to cope with the conditions of poor support and movement induced by swelling of bentonite when wet.

The latter problem in turn calls for constant de-watering of the mines in order to reduce swelling of bentonite to the minimum, and this in the past has involved the operators in year-round expense, while their market was generally only seasonal.

Other problems included high incidence of gas at depth, (the near-surface Blue Flame Mine, by contrast, was very free of gas), and the tendency to spontaneous combustion of stockpiled coal. The latter characteristic necessitated as short a storage time as possible, and this in turn required the existence of a market that could keep up with mine production. A new thermal power generation project on the scale contemplated by the Power Authority of this province would supply the kind of steady market that the coalfield requires.

WHITE LAKE: (No. 47)

The White Lake basin, in the southern Okanagan valley between Kaleden and Oliver, is a small but geologically complex area of Tertiary volcanic and sedimentary rocks, which has been found to contain small amounts of coal.

Prior to 1912 a 35-foot shaft was sunk and two narrow seams discovered, 14 inches and 20 inches thick respectively, and about 1,000 tons of coal was mined to be used for blacksmithing purposes at the nearby Fairview gold mines. The coal was bituminous, with a fixed carbon content ranging from 41.3 to 57.3%. However, ash content ranged from 11.0 to 29.1%. It appears that volcanic activity in the White Lake district has up-graded the local coals from lignite to bituminous rank.

Further exploration was done in 1933, when a 4-foot seam was opened up by sinking a 90-foot winze from an old tunnel. It is not clear at what depth below surface this new seam was found. A "considerable amount" of coal from this seam was sold locally, and proved satisfactory. During the years 1926, 1927 and 1933 a total of 1,232 tons of coal was produced, i.e. making a total of 2,232 tons including the pre-1912 production.

Although at least seven seams have been discovered in all, (ranging from less than a foot thick up to 55 inches including rock partings), the White Lake basin is still only 2 square miles in extent, which does not give it a sufficiently attractive potential to make further exploration worthwhile under the present terms of reference.

CONCLUSIONS

Four major coalfields comprising the Peace River- Sukunka (No. 20), the Comox (No. 36), the Hat Creek (No. 41), and the East Kootenay (No. 48) deposits are receiving detailed study as separate discrete assignments. Of the remaining forty-four coalfields, deposits, and occurrences presently known in British Columbia, it is evident that many are of insignificant economic interest at this time.

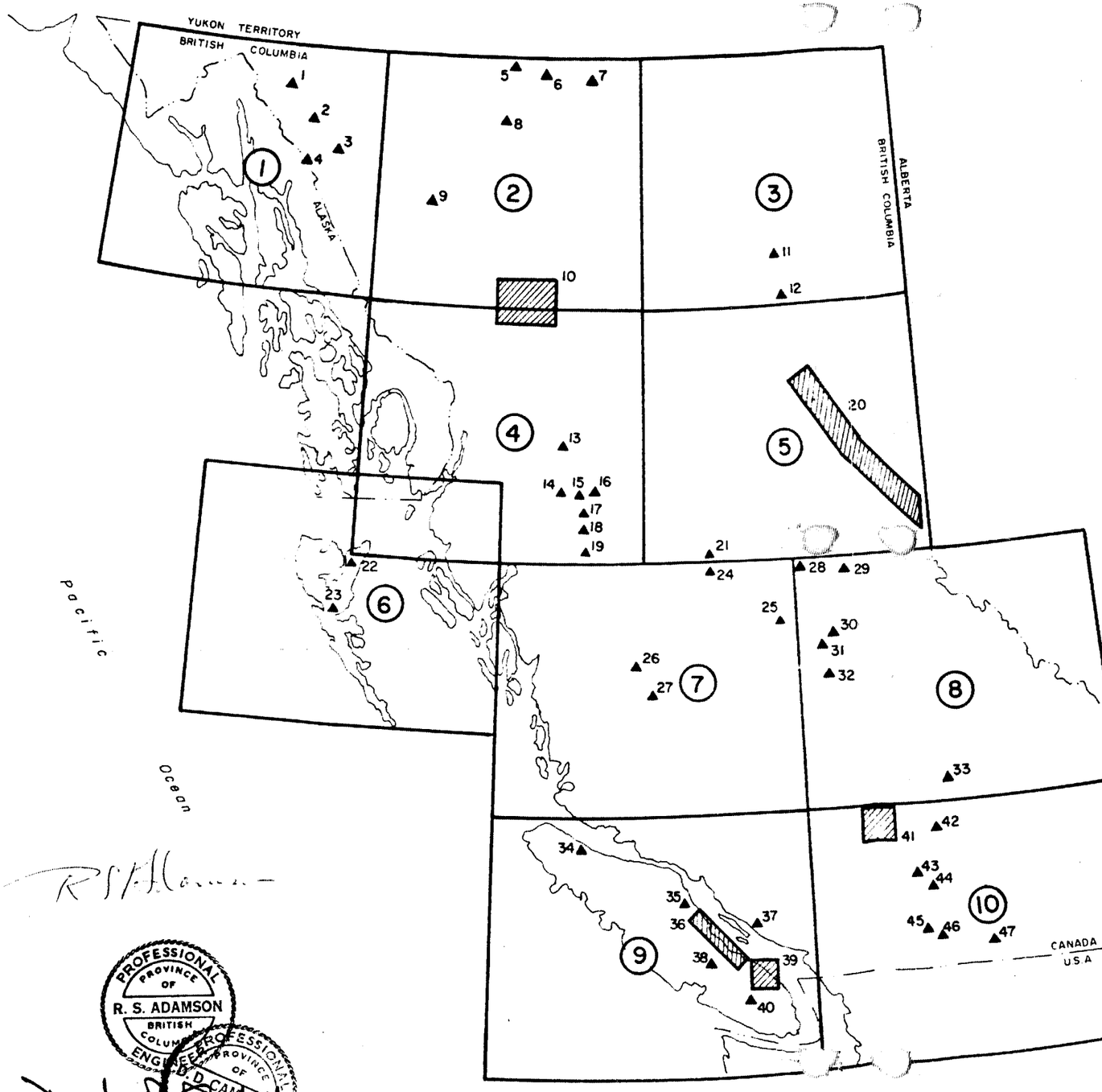
The following eleven deposits warrant more in-depth investigation than the remaining thirty-three; there, study is continuing on them for the final reports:

Groundhog	(No. 10)
Telkwa	(No. 17)
Skonun Point	(No. 22)
Cowgitz	(No. 23)
Bowron River	(No. 29)
Suquash	(No. 34)
Campbell River	(No. 35)
Nanaimo	(No. 39)
Cowichan	(No. 40)
Tulameen	(No. 45)
Princeton	(No. 46)

The Groundhog coalfield, although little of a definitive nature is known about these deposits, will be further reviewed because of its proximity to the B.C. Railway extension and because of its relatively wide areal extent.

The Telkwa, Bowron River, Princeton and Tulameen deposits lie near the existing power grid and major transportation routes. The present information suggests substantial reserve tonnages could be available. Conceivably therefore, these deposits might eventually support a locally-based thermal plant or alternatively provide supplementary feed to a more distant one.

The Cowgitz, Suquash, Campbell River, Nanaimo and Cowichan coalfields will be viewed principally as possible supplemental feed to a thermal plant to be established in the Comox area. In all cases there is reason to believe that appreciable reserve tonnages of coal similar in character to the Comox coals can be outlined.



COALFIELDS

QUADRANGLE 1

1 Graham Inlet
2 Sloco River
3 Inklin River
4 Taku River

QUADRANGLE 2

5 Dease River
6 Hyland River
7 Coal River
8 Rapid River
9 Stikine River
10 Groundhog

QUADRANGLE 3

11 Halfway - Sikanni Chief Rivers
12 Minaker River

QUADRANGLE 4

13 Kispiox River
14 Zymoetz River
15 Kathleen Lake
16 Driftwood Creek
17 Telkwa River
18 Clark Fork
19 Chisholm Lake

QUADRANGLE 5

20 Peace River
21 Fraser Lake

QUADRANGLE 6

22 Skonun Point
23 Cowgitz

QUADRANGLE 7

24 Nechako River
25 Blackwater River
26 Dean River
27 Bella Coola River

QUADRANGLE 8

28 Fort George
29 Bowron River
30 Cottonwood
31 Quesnel
32 Alexandria
33 Chu Chua

QUADRANGLE 9

34 Suquash
35 Campbell River
36 Comox
37 Long Bay
38 Alberni
39 Nanaimo
40 Cowichan

QUADRANGLE 10

41 Hat Creek
42 Kamloops
43 Merritt
44 Quilchena
45 Tulameen
46 Princeton
47 White Lake

QUADRANGLE 11

48 East Kootenay

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
R. S. ADAMSON

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
D. D. CAMPBELL

DOLMAGE CAMPBELL & ASSOCIATES LTD. CONSULTANTS
VANCOUVER, CANADA

B.C. HYDRO & POWER AUTHORITY
VANCOUVER, CANADA

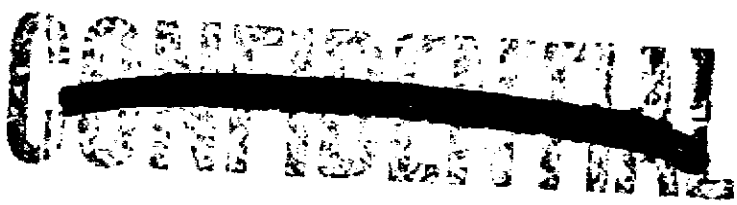
BRITISH COLUMBIA COALFIELDS

LOCATION MAP

SCALE: 1" = 100 miles | FEB., 1974 | FIG 1

DWG 8

GENERAL B.C. 74(4)BA



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The underground reserves in the Michel Area are said to be 45 000 000 sht (recoverable reserves). This tonnage calculates to 36 000 000 sht washed coal by using 80% yield factor.

4.1.1.2 COAL QUALITY

The washed coal quality of the Kaiser operation is said to be as follows:

Ash	9.5 - 9.7%
Volatile Matter	21 - 22%
Inherent Moisture	0.5 - 0.8%
Total Water	7.5% (at harbour)
Sulphur	0.3%
Free Swelling Index	6½ - 7
Dilatation	0
Contraction	19
Fluidity dd/m	40 - 45
Hardgrove Index	82 - 100

The cokability of this coal has be shown by a test performed in May 1970 by the Kaiser Steel Corporation - Steel Manufacturing Division, Fontana, California. The results are shown in the following Tab.15.

Coal Pulverisation	+ ¼"	10.8
	- 1/8"	75.2
Coal Moisture %		6.2
Bulk Density, Oven PIF		50.8
P. Max., Min DD/min		20
Final Coke Temp. °F		1970
Time to 1600°F., Hrs.		9:45
Coke Screen Test	+4"	4.1
	+2"	73.4
	+1 - 1½"	88.6
	-1	7.0
	-5/8"	5.7
Coke Shatter Test	+2"	61.2
	+1 - ½"	87.0
	-½"	2.2
Coke Tumbler Test	Stab.	56.9
	Hard.	66.3
Coke Porosity	A.S.G	0.98
	T.S.G	1.94
	% Cells.	49.5
Physical Fuel Value		58
Coke Physical Index		88

Tab. 15 : Coke Oven Test of 100% Kaiser's Balmer Coal

Tab.16:Proximate Analyses (as received), Seam No. 3, Hosmer-Wheeler Ridge Adit 26

	Sample 1 Wheeler Ridge Adit 26, Raw Coal	Sample 2 Wheeler Ridge Adit 26, Clean Coal at 1.50 S.G.
Moisture	0.84	1.79
Ash	12.92	4.27
Volatile Matter	31.68	33.50
Fixed Carbon	54.56	60.44
	100.00	100.00
Free-Swelling Index	9	more than 9
Calorific Value	12,773	14,150

Ruhr Dilatometer Test

	Sample 1	Sample 2
Softening Point θ_s °C	390	381
Contraction %C	20	25
Dilatation %	69	67
Temp. of Max. Dilatation °C	486	480
Temp. of Max. Contraction θ_c °C	445	440
Plasticity Index $\frac{C}{\theta_c - \theta_s}$	0.36	0.42

Microscopic Analysis

	Sample 1	Sample 2
Vitrinoid	62.9	60.0
Micrinoid	4.2	4.8
Exinoid	2.0	7.2
Fusinoid	5.2	9.6
Semifusinoid	18.9	16.0
Mineral Matter	6.8	2.4
	100.0	100.0
R_o (Reflectance in oil)	0.72	0.77
Reactives %	71.2	72.5
Inerts %	28.8	27.5

The outstanding result of this test is the low ash content in the washed product. Anyhow, the Fuel Research Centre comes to the following conclusions:

> The clean coal at 1.50 S.G from Adit 26, Wheeler Ridge, possesses exinoid, which is very unusual for western Canadian cretaceous type coal. Dilatometer tests and swelling index indicate that this coal is extremely fluid when heated to the plastic state (2300 dd/m). The rather large cavities tend to confirm the general observation that very fluid coals on carbonization alone tend to give weak cokes due to the rather thin cell walls caused by the large gas bubbles evolved during heating. However, this coal gives every indication of being excellent for blending with other western Canadian medium volatile coals of low fluidity. It is a coal which itself may

command a premium price as it is our understanding that the Japanese require fluid coals for blending.

The crushed vitrinoid may indicate that on washing there will be problems with fines of low specific gravity since as far as it is possible to see, there is little associated mineral matter with this type of vitrinoid. This is a marked contrast with some of the other coals of this region where the fine coal consists of semifusinoid and fusinoid laden with mineral matter.

A coke oven test (Tab.17) which was done in Ottawa, indicates very poor cokability of this seam as far as the ASTM-Tumbler-Test and the JIS + 15mm drum index are concerned.

Coke Oven Feed (db)	Adit 26
Ash %	8.95
Volatile Matter %	33.47
Fixed Carbon	57.58
Cal. Value (BTU/lb)	13700
Sulphur %	0.40
Hardgrove Index	87
FSI	8
Max. Fluidity dd/m	520
Contraction %	26
Dilatation %	48
Melting Range C^{o}	71
Carbonization Data	
Net Weight of Charge (wet) lb	526.8
Moisture in Charge %	3.8
ASTM Bulk Density (wet) lb/ft^3	48.5

Oven Bulk Density	51.0
Gross Coking Time hr : min	10:30
Maximum Wall Pressure lb/in^2	0.30
Coke Yield Actual %	71.7
Mean Coke Size in	2.00
Apparent Specific Gravity	0.890
Percentage - ½ inch (Breeze)	5.3
ASTM - Stability Factor	35.9
ASTM - Hardness Factor	63.5
JIS + 15mm Drum Index	85.3

Tab. 17 : Coke Oven Test, Seam No. 3, Wheeler Ridge, Adit No. 26

This computes to:

Possible reserves approx.	125.0 million tons
10% mining loss	12.5 million tons
	112.5 million tons in place

or 81 million tons clean coal applying 72% recovery. This calculation was done in Duesseldorf, Germany. Kaiser itself has the reserves in this area to 116 million tons in place and 73 million tons clean coal (Tab.19).

Including Seam No.'s 4, 5, 7 & 8, the total reserves calculate to 253 947 000 sht in place. It is not specified how many of the total reserves apply to the open cut mining method.

The overburden ratio is 5 : 1 (bcyd : 1 lgt raw coal) or 7.4 : 1 on a clean coal basis. A production of probably 3 million lgt/a could be maintained.

4.1.3.2 COAL QUALITY

Indication for the coal quality is given in the following tabulation:

		Seam No. 10	Seam No. 9
Volatile Matter	%	26.4 - 27.9	26.9 - 27.9
Total Moisture	%	6	6
Ash	%	6.0 - 6.3	9.0 - 9.3
Sulphur	%	0.56 - 0.7	0.27 - 0.39
FSI		8	5½
Yield	%	approx. 68 - 72	approx. 68 - 72

There are indications, that splitting the production by seams and separate storage of each seam product, 50% of the production might be prime coking coal. Both seams combined will certainly produce a good blending coal. The quality of the other seams can be seen in Tab.

If the law for this area is amended, a joint venture for the area might be suitable of 1/3 participation Canadian Provincial Government, 1/3 Canadian Company and 1/3 participation of our group.

4.1.4.2 COAL QUALITY

The results of washability tests and quality indications are shown in Tab.23.In general, four seams in the Marten Ridge Area contain low ash, exhibit high fluidities and produce high yields. Three other seams contain high ash in the raw state, but appear to clean up well. The fluidities, however, appear to be lower on these seams. The recoverable coal tonnage is low for the area due to the poor situation of the seams for open pit mining.

The coal can be ranked as high volatile bituminous and would therefore be best used in blends with coal having a low volatile matter content. Due to the high volatile matter content and the limited reserves, the coal is more or less not of great interest to our group. The reserve problem can be overcome by including the adjacent area Hosmer- Wheeler Ridge.

4.1.5 MARTEN CREEK DEPOSIT

The location of the Marten Creek area is shown in Fig. 4. Note that the Marten Creek is a different deposit than the Marten Ridge. The Marten Creek area lies on the eastern limb of the Fernie Coal Basis, in Kaiser's Crowsnest Coal Field, approximately 10 miles east of the town of Fernie. Both accesses are blocked by run off until late spring. The Canadian Pacific Railroad loop at McGillivray lies some 15 miles northwest of the Marten Creek drainage.

The Marten Creek area constitutes part of the eastern limb of the Fernie Coal Basin. The beds along Marten and Leach Ridges dip westerly between 10^{o} and 43^{o} on this side of the broad synclinorium. The Kootenay Formation outcrops on the east facing slopes of Marten and Leach Ridges between elevations of 4800 feet, at Marten Creek, and 6400 feet.

Table : - Proximate Analysis of Adit Samples, Mc.ken Ridge

ADIT SAMPLES

Adit	Seam	Thick-ness		Ash	V.M.	F.C.	S	FSI	DDM
10	2	11.0	raw	9.1	34.4	56.5	0.38	6	125.0
			clean	5.4	37.2	57.4	0.42	6	218.0
9	3	18.0	raw	10.0	35.0	55.0	0.29	6	112.0
			clean	3.9	36.4	59.7	0.38	6½	97.0
8	3	abandoned - seam displaced by fault							
12	5U	19.5	raw	23.1	28.5	48.4	0.53	3	16.0
			clean	7.5	33.5	59.0	0.55	3	18.0
	5L	9.3	raw	18.3	34.2	47.5	0.42	2	24.0
			clean	6.7	33.9	59.4	0.46	4½	17.5
	5Comp	32.7	raw	28.7	28.2	43.1	0.42	1	18.0
			clean	5.5	34.4	60.1	0.50	5½	44.0
7	5U	9.5	raw	14.2	31.0	54.8	0.56	3	14.5
			clean	7.2	32.4	60.4	0.58	3½	3.8
	5L	10.4	raw	25.8	25.4	48.8	0.32	1	NA
			clean	7.9	29.6	62.5	0.41	2½	3.6
11	7	19.1	raw	14.3	32.6	53.1	0.38	7	81.0
			clean	5.0	34.6	60.4	0.42	7	97.0
4	80	22.7	raw	8.5	31.4	60.1	0.95	7	54.0
			clean	7.3	31.6	61.1	0.97	7	68.0
6	8L	29.5	raw	29.9	26.3	43.8	0.50	3	16.0
			clean	10.3	30.7	59.0	0.49	3½	6.0
5	9U	8.0	raw	30.7	25.8	43.5	0.48	1	3.0
			clean	8.5	29.6	61.9	0.50	1½	1.6
	9L	17.6	raw	28.2	26.2	45.6	0.32	1	2.1
			clean	10.0	29.3	60.7	0.38	1½	5.1

Name of Seam	B-Seam		No. 5 Seam		No. 7 Seam	
Proximate Analysis	Raw	Clean	Raw	Clean	Raw	Clean
Ash %	19.0	7.9	40.7	14.4	22.7	7.2
Volatile Matter %	33.7	38.6	22.3	33.0	28.5	32.2
Fixed Carbon %	47.3	53.5	37.5	52.6	48.8	60.6
Free Swelling Index	6.5	7.0	1.0	5.0	6.5	7.5
Sulphur %	0.66	0.71	0.37	0.78	0.54	0.62
Melting Range ^{o}C			57.0	49.0	62	55
Maximum Fluidity dd/m	2830	2350	74	11.5	295	175

Tab. 25: Coal Quality of Seams B, No. 5 and No. 7 at Marten Creek Area

Tab. 25 also shows, that the coal quality of Seam No. 5 is inferior to the other two seams. The clean coal products of Seams B and No. 7 have high volatile matter content, which is not very desirable, but Seam B has a good fluidity and might be suitable for blends with low volatile matter coals.

Tab. 26 gives an indication of the good washability of Seam B. The 1.55 S.G. float already yields 80.8% of an 7.1% ash clean coal product. P_2O_5 in ash indicates high phosphorous content.

Basis: Gravity Separation of -4" + 100 M fraction and froth flotation of -100 M x 0 fraction.

-4" + 100M (92.2%) 100M x 0 (7.8) Composite
84.5% YIELD @ 9.4 ASH

S.G.	CUM WT.%	YIELD WT.% x .922	ASH %	YIELD 7.8 x 84.5	ASH%	YIELD	ASH%
		a		b		a + b	
1.30	59.4	54.8	4.0	6.6	9.4	61.4	4.6
1.35	67.4	62.1	4.6	6.6	9.4	68.7	5.1
1.40	72.4	66.8	5.2	6.6	9.4	73.4	5.6
1.45	76.9	70.9	6.0	6.6	9.4	77.5	6.3
1.50	79.2	73.0	6.5	6.6	9.4	79.6	6.7
1.55	80.5	74.2	6.9	6.6	9.4	80.8	7.1
1.60	81.6	75.2	7.2	6.6	9.4	81.8	7.4
1.70	83.2	76.7	7.9	6.6	9.4	83.3	8.0
1.80	84.7	78.1	8.6	6.6	9.4	84.7	8.7
TOTAL	100.0	92.2	18.5	7.8	17.3	100.0	18.4

Tab. 26: B-Seam, Yield Versus Ash Content, Marten Creek

	Adit No.1 Seam 1 (17.2 ft)		Adit No.1 Seam 1 (31.8 ft)		Adit No.2 Seam 6		Adit No.3 Seam 7		Adit No.4 Seam Upper		Adit No.4 Seam Lower	
	Raw Coal	Clean Coal	Raw Coal	Clean Coal	Raw Coal	Clean Coal	Raw Coal	Clean Coal	Raw Coal	Clean Coal	Raw Coal	Clean Coal
Volatile Matter %	19.1	22.0	19.1	20.6	24.5	25.4	20.7	27.5	20.7	23.3	21.1	23.2
Ash %	16.3	9.4	19.3	9.4	9.3	4.9	33.1	8.0	19.3	6.3	13.7	6.8
Fixed Carbon %	63.1	66.0	59.2	67.1	68.2	69.7	46.2	64.5	60.0	70.4	65.2	70.0
Sulphur %		0.42*			0.56	0.60	0.70	0.72	0.48	0.53	0.41	0.43
Melting Range °C		23*			Oxidized		66	76	Non Coking		23	18
Max. Fluidity dd/m		1.8*			Oxidized		173	445	Non Coking		1.8	1.6
Dilatation		-20										
Contraction		20										
ASTM-Stability		47.2						54.2				
ASTM-Hardness		63.1						63.3				
JIS + 15mm		90.3						94.5				
Total Reactive Components		63.1										
Total Inert Components		36.1										
Mean Reflectance		1.34										
	Burnt Ridge Extension 1st Cross Cut		Burnt Ridge Extension 2nd Cross Cut	Elk Valley	Elk Valley							

* From Coke Oven Test

Tab. 28 : Quality Testing Results, Burnt Ridge and Burnt Ridge Extension.

TABLE 32 : SUMMARY OF TESTS RESULTS ON ADIT SAMPLES , FLATHEAD RIDGE

SAMPLE	SEAM NO.	SEAM THICKNESS	PROXIMATE ANALYSIS (db) ASH	VM	FC	S	FSI	WASHABILITY % YIELD	% ASH	S.G.	PLASTOMETER PLASTIC RANGE	MAXIMUM FLUIDITY
Adit # 1*	1	46.0 feet										
Raw Coal			26.1	15.7	58.2	0.63	#1				-	1.0 ddm
Clean Coal			11.3	17.7	71.0	0.69	#2½	58.2	@ 11.3 &	1.52	-	1.0 ddm
Adit # 2**	3	30.6 feet										
Raw Coal			22.5	17.8	59.7	0.52	#1				No Movement	
Clean Coal			10.4	18.0	71.6	0.77	#1	74.5	@ 10.4 &	1.70	No Movement	
Adit #3	4	22.6 feet										
Raw Coal			18.8	18.4	62.8	0.66	#4				20 C	1.6 ddm
Clean Coal			9.4	18.9	71.7	0.69	#5	79.1	@ 9.4 &	1.57	30 C	2.0 ddm
Adit #4	5	36.6 feet										
Raw Coal			13.4	20.8	65.8	0.22	#6					
Clean Coal			7.4	22.3	70.3	0.24	#6					
Adit #5	7	19.5 feet										
Raw Coal			5.3	22.4	72.3	0.42	#7½					
Clean Coal			3.7	21.5	74.8	0.45	#7½					
Adit #6	6	9.7 feet										
Raw Coal			17.1	19.1	63.8	0.58	#7					
Clean Coal			6.5	21.0	72.5	0.62	#7½					

TAB.35: LCH ASH COAL RESERVES NATAL, SPARWOOD, RIDGES

SEAM NUMBER	ADIT NUMBER	SEAM THICKNESS FT.	RESERVE IN PLACE 000'S MT (ALL CATAGORIES)	COAL CHARACTERISTICS						
				RAW		WASHED @ 1.50 SP. G.				
				ASH	FSI	YIELD	VM	DSM	FSI	ASH
NATAL RIDGE										
D	6,3X	7.7	2,200	10.7	6.5	82.1	32.5	11,300	7.5	5.7
A	4,2	16	43,000	10.7	6.5	86.1	26.5	2	6.5	7.4
SPARWOOD RIDGE										
UC	TP	10	5,000	15.8	7	87.5	28.1	-	8.0	4.1
LC	TP	8.5	4,000	16.4	7	80.4	24.4	485	7.5	8.5
B	Trench 1/	6	7,000	6.0	7	76.3	26.0	0 1/	0 1/	4.1
A	76,A Strip	36	27,000	8.0	8	90.5	24.8	98	7.5	4.5
1 2/	34	10	70,000	13.2	8	87.2	24.4	284	9.0	5.4
2 2/	35	7	49,000	13.0	-	88.1	23.7	41	8.0	6.9
U5 2/	62 1/	8	24,000	11.1	2.5	88.7	21.3	1 1/	2.5 1/	7.5
M5 2/	62 1/	8	24,000	13.3	5	87.6	20.4	98	8.0	8.7
U7	33,75	7	31,000	17.8	5	78.9	21.1	19	6.5	7.5
			286,200							

1/ Did not reach unoxidized coal.
2/ Both seams may not be recoverable due to close proximity to each other.

The washery plant operates at 60% yield. 75% yield was planned, but due to higher raw coal ash in the plant feed (26% instead of 16% planned), the yield dropped to 60%. The following washed coal quality is produced:

Ash	8.5 - 9.0%
Volatile Matter	22.0 %
Inherent Moisture	0.5 %
Total Water	8.0% (The contract calls for 6%, but dryer does not work properly)
Sulphur	0.3%
Phosphor	0.05%
FSI	7 - 7½

4.3 CARDINAL RIVER COALS LTD.

Cardinal River Coals Ltd. operates the coking coal deposit Luscar and is a joint venture of 50% Luscar Ltd. and 50% Consolidation Coal Co. of Canada.

The railroad distance to the loading facilities in the harbour Neptune Terminal, are 630 miles away. Luscar was producing 1 million tons washed coal per year, but the company has received permission in late 1973 by the Japanese customers to increase production to 1.5 million tons per annum. This justified a price hike, because of an overall increment in the stripping ratio.

All the open pit reserves are committed by long term contracts to the Japanese customers, and therefore the deposit is not of great interest to us.

4.3.1 COAL RESERVES AND COAL QUALITY

The open pit coal reserves at Luscar can support a 1.5 million lgt per year over the lifetime of the deposit (15 years) with an overall stripping ratio of 9.5 : 1 bcyd per sht raw coal. 27 million sht clean coal are available for this production target. The open pit was planned for a layout of 1 million lgt per year, with a stripping ratio of 6.5 : 1 (bcyd : sht). The coal stems from one seam (Main Seam, which is intensely folded, (thickness 6 - 50 m, average 12 m). The tectonic deformation of the coal seam resulted in thickening of the seam by tectonic flow in anticlinal structures. The intensely folded structure splits the Luscar open pit into four separated units:

1. Pit A : The present coal winning operation is in one part of the pit, while the other part is presently prepared for production. This represents some difficulties, because part of the old underground mine in this area is burning.

2. Pit 50 B : One part of this pit is mined out and backfilled with waste, while the other part is mined out to the last three levels.

3. Pit 51 B : Production not yet commenced.

4. Pit C : Production not yet commenced.

The washing plant is yielding 70 - 75% clean coal with the following quality:

Ash	9.25 % (contract specification is 8.75% $\pm$ 0.5%, and because of no bonus for less ash, Cardinal River operates at the upper limit)
Volatile Matter	19.5 - 26% (average 22%)
Inherent Moisture	2.9%
Total Moisture	4.0% (adjustable)
Sulphur	0.23%
Phosphor	0.014% PO_4
FSI	6 - 8

The bottle neck of the washing plant is the existence of only one filter for the production.

4.4 MCINTYRE PORCUPINE MINES LTD. (SMOKY RIVER DEPOSIT)

McIntyre Porcupine Mines Limited is operating the Smoky River metallurgical coal deposit, located 12 miles from the new town of Grande Cache, in Alberta, near the British Columbia border. The original long term contract of January 1969 with the Japanese customers, was replaced late in 1972, by a 2 year contract effective April 1,1973 for 1.25 million long tons in the first year. The second year purchase is to be negotiated. McIntyre Porcupine is also free to sell coal elsewhere and negotiation with U.S. steel companies were proceeding in mid-1973. Initially, No. 2 and No. 5 underground mines were developed to supply Japanese contract and production started September 11, 1970. October 1971, No. 8 surface mine reached full production and No. 5 mine was closed January 31, 1973, due to mining difficulties.

The coal is shipped in 85-car unit trains, each car 100 ton capacity to Neptune Terminal, Vancouver. The total rail distance is 620 miles. No. 9 surface mine, located over the mountain from No. 2 mine, is being developed with production start expected in mid-1974.

4.5.1 COAL RESERVES AND COAL QUALITY

The following reserves, according to Coleman Collieries information, are left in the presently worked mines or apply as potential for the not yet thoroughly explored areas:

1. Tent Mountain

According to Coleman Collieries there are 12 million recoverable short tons raw coal at an overall ratio of 5.5 : 1 (bycd : raw coal) for strip mining. Applying a 70% washery yield factor this amounts to 8.4 million sht clean coal. Coleman is mining at present with a ratio of 2.5 : 1 (bycd : raw coal) from pit No. 2. Furthermore, according to Coleman Collieries information, the quality which could be produced from Tent Mountain can be approximately

9.0%	Ash
21 - 22%	Volatile
0.35%	Sulphur
7	FSI

This quality is not produced presently because the wash plant would need some alteration for it. The ash is higher (probably close to 11.5%) and the FSI down to probably 5-6.

In addition to the open pit reserves there are with 60-70^{0} dips approximately 35 million sht recoverable (applying 50% underground recovery) hydraulic underground reserves.

A bulk sample properly washed in the United States gave the following results of Vicary Creek:
Analysis as received

8.23% Ash
21.90% Volatile Matter
66.04% Fixed Carbon
0.43% Sulphur
0.081% Phosphor
FSI 7½

Due to the present layout of the Wash Plant these results are not achieved. The contract specifications are:

9.5% ± 0.5% Ash This ash content is also not achieved. Deliveries to Japan have 11.5 Ash

20-24% Volatile Matter

0.3-0.4% Sulphur, max. 0.6%

6 FSI

According to Coleman the coal of Vicary Creek could be washed to the quality of the bulk sample shipped to the United States if the old Coleman washery would be altered.

Mr. Blackmore said that the best coke to be produced from Coleman Coal should be blended as follows:

5% coke breeze
15% low volatile coal
20% Coleman coal
60% high volatile coal

This should produce a coke of indices 57 stability and 70 hardness according to the ASTM-Tumbler test.

3. The Gomyo mine site has an in place tonnage of 24.4 million sht. Applying the same recovery and yield factors as for Vicary Creek the washed coal tonnage is 10.126 million sht.

   The quality should be similar to the quality of Vicary Creek, only the seam is thinning towards the south.

4. A geological surface survey in the Dutch Creek Area has indicated 80 million sht of coal in place or 40 million sht of recovered underground raw coal. Applying 70% yield a total tonnage of 28 million sht washed coal is possible for hydraulic mining method. No drill holes are done so far.

5. The Isola Area has a potential of 200 million sht in place or more. The real coal potential is not known because the three existing drill holes did not perforate the coal bearing strata completely. During the visit one outcropping seam could be seen on a newly closed forestry road. It was 14 feet thick but not completely exposed, so that the true thickness is most likely more than 14 feet as also indicated in the bore holes.

   The geological structure for the Isola Area is favourable for hydraulic mining. The Kooteney formation forms a synclinal basin and the coal is dipping in the same direction as the dip of the surface slope. That means that the seam to be mined has less cover and a substantial tonnage should also appear above drainage level.

BORE HOLE	SAMPLE NO.	DEPTH OF SAMPLE FROM (ft)	TO	FLOAT AT	ASH %	VOLATILE MATTER %	SULPHUR %	YIELD %	FSI
1	2	480	482½	1.58	6.9	19.2	0.33	96.9	3
1	3	482½	484¼	1.58	3.0	23.1	0.38	99.6	9
1	4	484¼	486½	1.58	4.2	22.0	0.32	90.6	8
1	5	486½	489½	1.58	5.3	21.8	0.27	59.4	8
1	6	489½	494	1.58	6.6	24.3	0.27	80.5	9
		REST OF ANALYSIS MISSING							
2	1	1821½	1824½	1.60	9.1	19.4		73	4
2	2	1824½	1827	1.60	6.8	22.9		83	8
2	3	1827	1829	1.60	9.0	21.8		79	6½
2	4	1829	1831½	1.60	9.9	21.3		63	4½
2	6	1833	1835½	1.60	14.5	18.8		81	1
2	7	1835½	1838	1.60	14.5	23.2		79	1½
2	8	1838	1841	1.60	11.8	20.1		87	1½
2	9	1841	1843½	1.60	19.0	17.7		60	1
2	10	1843½	1846	1.60	7.2	21.9		93	9
2	11	1846	1848	1.60	6.3	22.3		89	9
2	12	1848	1850	1.60	5.2	23.1		93	9
3	1	293½	296	1.58	7.0	21.6	1.30	59.4	9
3	3	298	302¼	1.58	14.6	19.5	0.61	50.5	6
3	4	407	409	1.58	6.8	18.9	0.41	89.1	3
3	5	409	411	1.58	8.6	18.9	0.36	95.8	2
3	6	411	413	1.58	6.7	21.9	0.38	98.2	6½
3	7	413	415	1.58	8.9	20.9	0.33	70.2	6
3	8	415	417	1.58	12.7	19.4	0.28	88.4	2½
3	9	417	419	1.58	12.5	18.0	0.29	58.0	1
3	10	419	420 3/4	1.58	11.8	18.6	0.37	78.5	1
3	11	420 3/4	422	1.58	10.2	23.9	0.55	53.0	9
3	12	429	432¼	1.58	15.9	17.8	0.44	45.5	1
3	13	432¼	434¼	1.58	16.1	17.2	0.38	87.7	1
3	14	434¼	436¼	1.58	11.7	19.1	0.44	79.4	3
3	15	436¼	438¼	1.58	6.7	21.3	0.53	92.4	8½
3	16	443	445	1.58	3.8	21.8	0.66	92.0	9
3	17	445	446½	1.58	10.6	23.1	0.73	49.6	9

Tab. 37 : Coal Analyses of Three Drill Holes Isola Area

SURFACE MINE RESERVES

CLASSIFICATION OF RESERVES	LOCATION	DEPTH *	SHORT TONS IN PLACE	RATIO CY/ST	WASTE COAL OXIDATION COAL & PIT LOSS **	PLANT LOSS 25%	NET CLEAN COAL PRODUCT ST	NET CLEAN COAL PRODUCT LT
PROVEN	AREA A	To 400	109,172,000	4.88:1	17,457,000	22,929,000	68,786,000	61,416,000
		400-600	39,270,000	5.88:1	3,927,000	8,836,000	26,507,000	23,667,000
		Total	148,442,000	5.15:1	21,384,000	31,765,000	95,293,000	85,083,000
	AREA B	To 400	27,000,000	4.72:1	4,300,000	5,700,000	17,000,000	15,200,000
		400-600	27,000,000	7.16:1	2,700,000	6,100,000	18,200,000	16,300,000
		Total	54,000,000	5.94:1	7,000,000	11,800,000	35,200,000	31,500,000
	AREA C	To 400	21,000,000	6.22:1	3,400,000	4,400,000	13,200,000	11,800,000
		400-600	13,000,000	7.45:1	1,300,000	2,900,000	8,800,000	7,900,000
PARTLY		Total	34,000,000	6.69:1	4,700,000	7,300,000	22,000,000	19,700,000
PROVEN	AREA D	To 400	15,000,000	4.33:1	2,400,000	3,200,000	9,400,000	8,400,000
		400-600	13,000,000	6.53:1	1,300,000	2,900,000	8,800,000	7,900,000
		Total	28,000,000	5.36:1	3,700,000	6,100,000	18,200,000	16,300,000
	AREA E	To 400	54,000,000	9.39:1	8,600,000	11,400,000	34,000,000	30,400,000
		400-600	14,000,000	6.37:1	1,400,000	3,200,000	9,400,000	8,400,000
		Total	68,000,000	8.77:1	10,000,000	14,600,000	43,400,000	38,800,000
	TOTAL AREAS B,C,D,E	To 400	117,000,000	7.09:1	18,700,000	24,700,000	73,600,000	65,800,000
		400-600	67,000,000	6.93:1	6,700,000	15,100,000	45,200,000	40,500,000
		Total	184,000,000	7.04:1	25,400,000	39,800,000	118,800,000	106,300,000
PROVEN AND PARTLY PROVEN	AREAS A,B,C,D,E	To 400	226,172,000	6.02:1	36,157,000	47,629,000	142,386,000	127,216,000
		400-600	106,270,000	6.54:1	10,627,000	23,936,000	71,707,000	64,167,000
		Total	332,442,000	6.20:1	46,784,000	71,565,000	214,093,000	191,383,000
SURFACE MINE RESERVES-HYDRAULIC MINE RESERVES								
	AREA F	To 5200	123,000,000	7.41:1	19,700,000	25,800,000	77,500,000	69,200,000
INFERRED	AREA G	To 5200	39,000,000	7.62:1	6,200,000	8,200,000	24,600,000	22,000,000
	TOTAL		162,000,000	7.64:1	25,900,000	34,000,000	102,100,000	91,200,000
UNCERTAIN	AREA H	To 5200	25,000,000	7.62:1	4,000,000	5,300,000	15,700,000	14,000,000
TOTAL SURFACE MINE RESERVES			519,442,000	6.66:1	76,684,000	110,865,000	331,893,000	296,583,000
UNDERGROUND MINE RESERVES								
INFERRED	AREA J	To 3200	1205,000,000		843,500,000	90,400,000	271,100,000	242,100,000
UNCERTAIN	AREA K	To 3200	660,000,000		462,000,000	49,500,000	148,500,000	132,600,000
TOTAL UNDERGROUND MINE RESERVES			1865,000,000		1305,000,000	139,900,000	419,600,000	374,700,000
TOTAL OR ALL RESERVES			2384,442,000		1382,184,000	250,765,000	751,493,000	671,283,000

* The 400 ft. depth is measured from the dragline bench and not the existing ground.

** Calculated for Area A as indicated and assumed 16% for other areas except for the 400 to 600 foot cut where 10% was used.

Tab. 39 : Coal Reserve Summary , Elk River Deposit

In general terms, the calculation by Mr. Linhart proved and confirmed the calculation done by Morrison & Knudson, despite the fact, that Mr. Linhart has approximately 9 Mio sht more in Area A and B, reason being is that he extended the "Initial Study Area" by 2000 ft (1000 ft to the north and 1000 ft to the south) and used a higher spec. gravity for raw coal than Morrison & Knudson.

4.6.3 COAL QUALITY AND COKE OVEN TESTS

The coal quality of the Elk River deposit was subject to a thorough investigation by Montan Consulting GmbH on the basis of the data on quality and coke properties, provided in the final reports of Morrison & Knudson. A computation of quality data available is given in Tab.40. The results of the study by Montan Consulting are summarized as follows:

The coal seams in the Elk River Area are characterized by the following common properties:

- high ash contents
- low sulphur contents
- high phosphor contents

The maceral contents and volatile matter, as well as dilatometer results and the G-value investigations indicate that the Elk River coals can be separated into three different groups:

Group 1: Seams 3, 4, 6, 7, 8, 9 und 10. They consist of low volatile matter and have mediocre to insufficient coking properties.

Group 2: Seams 2, 12, 13, 14 and 15.
They have low to medium volatile matter and perform good coking properties.

Group 3: Seams 16, 17, 18, 19 and 20*.
They show high volatile matter and have coking properties in excess.

The cokability of the Elk River Coals in blends of the seam-groups 2 and 3 will always be sufficient, and a coke with good characteristics can be expected. The portion of the seam-group 1, which can be utilized in a blend with the seam-groups 2 and 3, is depending on the following premises:

1. If the analysed inert macerals behave like inert components during the coking process, as can be concluded from the dilatometer curve and the G-value evaluation, up to 30% of seam-group 1 may be utilized in a composite blend. Higher percentages should lead to significant decrease in coking properties.

2. On the basis of the carbonization and the results of coke oven tests, a certain cokability of seam-group 1 cannot be excluded. There is a possibility that the analysed inert macerals are still reacting and are not completely inert. This increases the possibility that a portion of up to 50% of these coals (seam-group 1) in a composite blend may still provide a good coking coal.

* Seam 20 is of no commercial value.

DATA FROM GEOLOGICAL INVESTIGATION							DATA FROM COKE OVEN TEST - STUDY													
Seam No.	Percentage of Seam in Production %	Inherent Moisture Ash Free Basis %	Volatile Matter % waf	Ash % wf	S % waf	FSI	V.M. % waf	$\bar{R}$ max	V.M. For R max %	Ash % wf	F.C % wf	FSI	Dilatation %	Contraction %	G Value	P %	Max. Fluidity dd/m	ASTM Stabil. Factor	ASTM Hardness Factor	JIS + 15 mm Factor
2	10.4	0.62	21.2	11.8	0.51	7	22.1	1.50	22.6	10.4	69.8	8	26	17	1.016	0.014	20	57.8	73.3	92.1
3	4.3	0.61	21.3	7.6	0.58	7	21.2	1.49	22.8	8.2	72.8	7	- 1	23	0.93	0.100	5.9	51.6	69.0	91.7
4+4A	17.0	0.68	19.5	10.0	0.44	5½	20.9	1.49	22.8	8.8	72.4	5	-26	29	0.46	0.041	3.5	50.3	68.1	92.8
6	2.0	0.42	19.2	9.0	0.79	3½	20.8	1.48	23.0	9.0	72.1	2½	-20	20	0	0.161	0.9	36.2	58.4	84.6
7	2.5	0.60	20.8	10.8	0.69	4	21.2	1.46	23.2	8.5	72.1	5½	-23	23	0	0.045	1.8	53.8	66.0	92.0
8+8A	8.9	0.48	20.5	6.7	0.56	6	21.7	1.45	23.3	6.8	73.0	5½	-31	31	0	0.065	2.9	53.0	68.8	92.3
9	6.8	0.46	20.9	6.9	0.54	4½	21.6	1.42	23.7	7.2	72.8	4½	-28	28	0	0.038	1.5	45.6	66.1	90.4
10	10.4	0.50	21.8	6.8	0.46	5½	23.4	1.32	26.0	6.3	71.8	7½	-24	26	0.361	0.022	1.9	52.1	67.0	92.0
11	2.6	0.40	22.8		0.69															
12	6.6	0.49	22.8	9.2	0.74	9	26.0	1.25	27.2	9.0	66.8	9	71	25	1.041	0.059	84	56.0	66.6	92.4
13	4.8	0.52	24.6	9.2	0.84	9	26.7	1.24	27.4	10.1	65.6	9	104	24	1.051	0.066	259	60.5	67.2	93.4
14	5.4	0.53	25.6	9.2	0.83	9	29.3	1.17	28.8	9.9	63.5	8½	186	27	1.075	0.056	1175	56.2	64.0	92.9
15	5.4	0.41	26.5	9.1	0.68	9	29.3	1.17	28.8	9.3	64.4	8	76	26	1.041	0.061	330	56.2	67.0	92.1
16	3.4	0.41	27.8		0.78	8½	31.4	1.09	30.9	9.6	62.0	8½	130	29	1.061	0.096	1260	51.7	62.2	92.2
17	4.1	0.31	28.4		0.83	8½	31.3	1.08	31.0	7.5	62.5	8½	140	27	1.067	0.046	1150	49.7	64.3	91.6
18	3.7	0.53	29.9		0.58	8½	35.0	1.02	32.5	10.6	58.1	8½	200	30	1.09	0.051	3125	45.6	62.2	90.7
19	1.7	0.43	27.9		0.70	7½	33.8	1.03	32.0	9.1	59.7	8½	208	27	1.085	0.064	5650	50.6	62.3	91.5
Weighted Average	100.0	0.53	22.64	8.89	0.60	6.8	24.56	1.34	25.59	8.5	68.95	6.9				0.051				

Tab. 40 : Quality data and coke-oven test results, compiled by Montan Consulting and Mr. Linhart, Elk River Deposit.

Year	Percent Ash	F.S.I.	Sulphur	V.M.	I.M.	Plant Factor	Clean Coal Long Tons
1	9.91	7.08	0.56	19.85	0.49	73.60	1,389,100
2	9.94	7.48	0.58	19.91	0.46	74.60	3,314,300
3	9.72	4.97	0.48	18.80	0.46	83.50	5,283,400
4	9.91	5.59	0.44	17.97	0.57	71.90	3,105,200
5	9.84	7.22	0.57	20.11	0.48	76.30	5,009,000
6	9.67	5.28	0.46	18.54	0.52	78.50	4,994,000
7	9.76	6.57	0.55	19.89	0.46	79.80	5,242,300
8	9.89	5.79	0.48	18.39	0.54	74.90	3,536,700
9	9.89	5.80	0.51	19.16	0.48	78.70	4,998,800
10	9.70	6.04	0.50	19.39	0.49	78.40	4,362,700
11	9.64	5.59	0.49	18.47	0.53	74.20	4,320,800
12	9.30	5.84	0.54	19.70	0.46	81.30	4,445,100
13	9.93	6.20	0.52	18.88	0.52	74.60	4,065,600
14	9.66	5.17	0.49	18.80	0.49	79.10	4,442,300
15	9.71	6.42	0.54	19.67	0.49	77.10	4,325,700
16(Part)	9.33	4.71	0.51	18.57	0.45	84.30	800,000
Totals and Averages for Contract Period	9.75	6.00	0.51	19.15	0.49	77.60	63,635,000

Tab. 41 : Anticipated quality of clean coal production over anticipated production period, computed by Morrison & Knudson, Elk River Deposit

For clarification of these quality problems and for testing the blendability and coking characteristics of Elk River coals with Ruhr coals, a cost estimate for an additional exploration program was worked out with expenditures totalling up to $1,000,000.

On the basis of the compilation by Montan Consulting GmbH and the percentage of each seam in production computed by Mr. Linhart, the following quality is to be expected (Tab.40). The wash-plant yield is theoretically in range of 74.5% to 78%, but for Mr. Linhart's calculation, a yield of 60% was anticipated, based on the experience of Fording River.

Morrison & Knudson did a quality calculation on the anticipated production period. The result is shown in Tab.41. Both tabulations differ considerably, reason being is that Morrison & Knudson took stratigraphically lower seams into consideration than did Mr. Linhart. Tab.40 shows the most likely quality to be expected, except for ash, because washability curves for all seams were not available. The ash in the washed product will be between 9.5 and 10.0%.

4.7 SAGE CREEK DEPOSIT

The Sage Creek Deposit belonged to Pan Ocean Oil Ltd., but this company has optioned off 60% of the property to Rio Algom Mines Limited (a member of the Rio Tinto Zinc Group of London, England). It is believed that Rio Algom will have exercised the 60% option by the end of 1973. A participation of our group in this project can be recommended, but to obtain equity will be rather difficult. Rio Algom will certainly keep 51% of its 60%, and let's say to obtain another 17% from Pan Ocean might be very expensive. But

4.7.2 COAL RESERVES

The Sage Creek deposit consists of 3 major seams. Seam No. 2 accumulates 12 ft average thickness. Seam No. 4 (divided into Seam 4 A and Seam 4 B) has a 45 ft average thickness and Seam No. 2 shows a 50 ft average thickness. The seams are dipping 30^{0} with a dip slope. The following Tab.42 summarizes the reserves per seam and the parameters used for the reserve calculations.

Seam	No. 5	No. 4	No. 2	Total
Coal in Place	56,536,000	90,550,000	18,158,000	165,244,000
Clean Coal	30,530,000	48,837,000	9,806,000	89,173,000
Spec. Gravity Raw Coal		22 cft/lgt as average of all seams		
Preparation yield		60% as average of all seams		
Mining Recovery		90% as average of all seams		
Stripping Ratio				
In bcyd : 1 lgt Raw Coal		North Hill 5.7 : 1; South Hill 4.9 : 1 Average 5.5 : 1		
Production Planned		3 Million lgt/year		

Tab. 42 :Open Pit Reserves and Parameters used for the Reserve Calculations, Sage Creek Deposit

The above mentioned reserves can be increased by approximately another 50 Million tons in place, which are situated in the west part of the south hill, butthis is not yet thoroughly explored.

Summarizing the most important results of a visit to the deposit, the Sage Creek deposit might be the easiest proposition in Western Canada as far as mining is concerned. The seams are located in a dip slope of two hills which are called South and North Hill. In front of these hills lies a very wide-open valley which gives unlimited space for waste dumping. Coal and waste haulage is undoubtedly always downhill and the 30° - 35° dipping strata will also give no slope problems within the open pit, because the dip of the strata will provide a natural slope. Two berms may be provided on the final high wall, caused by upthrowing faulting of the seams. Also the geological structure of the seams works in favor for Rio Algom, as upthrowing faulting has reduced the overburden ratio to an overall average of 5.5 : 1 (bcyd : lgt raw coal).

4.7.3 COAL QUALITY AND COKE OVEN TESTS

Despite the easy mining proposition, the coal quality will definitely give problems which are not satisfactorily solved as yet, and still are worked on. Seams No. 5 and No. 2 have good coking characteristics, but Seams No. 4 A and 4 B, which accumulate approximately 50% of the total reserves, show poor coking characteristics due to high inert components (42%). A composite sample of all seams by percentage (Seam No. 2 = 19.4%, Seam No. 5 = 26.2%, Seam No. 4 A = 32.7% and Seam No. 4 B = 21.7%), according to the reserves in each seam, shows approximately the coking quality of Seams No. 4 A and 4 B and in this respect is deteriorating the good coking quality of Seams No. 2 and No. 5. Rio Algom is aware of this problem, and is presently conducting a study for a blend of seams which will give the best coke quality. For example, recent washability tests on Seam No. 4 A by altering the S.G. to 1.40 and using only 0.4 lb/t Kerosene + 0.3 lb/t M.I.B.C have improved the quality of this seam to 6.9 ash, FSI 7 and a yield of 60%. Rio Algom is testing all coal again by using that altered flow sheet. The overall recovery (washing and mining) is expected to be in the range of 52%.

Seam	5	4A	4B	2	Comp. Blend
Components Coals in Charge %	100	100	100	100	2 = 19.4% 5=26.2% 4B=21.7% 4A=32.7%
Raw Coal (adb)					
Ash %	26.0	19.0	20.0	18.0	22.0
Washed Coal (adb)					
Weight %	50.0	64.0	58.0	70.0	65.0
Inherent Moisture %	1.0	1.0	1.4	1.1	
Ash %	10.4	7.6	9.4	7.5	9.5
Volatile Matter %	23.9	21.3	23.3	22.9	23.1
Fixed Carbon %	64.3	69.9	65.9	68.5	
Total Sulphur %	0.59	0.36	0.7	0.5	
S.G of Float	1.42	1.42	1.42	1.42	1.42
FSI	6	5½	4½	7½	4½
Cal. Value (BTU/LB)	13820	14300	14110	14410	
Melting Range °C	63	17	93	53	39
Max. Fluidity dd/m	80	1.4	4	29	6
Contraction %	21	26	23	27	23
Dilatation %	18	Nil	- 21	16	-21
Total Reactive Comp.%	69.5	58.0	58.0	62.0	59.0
Total Inert Comp. %	30.5	42.0	42.0	38.0	41.0
Mean Reflectance %	1.09	1.15	1.15	1.18	1.12
Coke-Oven Tests					
Coke Oven Charge					
Ash %	10.7	7.7	9.5	8.1	9.4
Vol. Matter %	24.0	21.8	23.8	25.7	24.2
Fixed Carbon %	65.3	70.5	66.4	66.2	66.4
Sulphur %	0.7	0.35	0.5	0.59	0.5
Resultant Coke					
Ash %	13.3	9.4	11.8	10.0	12.0
Vol. Matter %	0.6	0.7	0.6	0.7	0.4
Fixed Carbon %	86.1	89.9	87.6	89.3	87.4
Sulphur %	0.54	0.43	0.45	0.51	0.42
Carbonization Results					
Gross Coking Time hr: min	9:30	9:25	9:00	9:50	9:30
Max. Wall Pressure lb/in^2	0.39	0.35	0.33	0.46	0.31
Coal Yield Actual %	77.0	77.3	79.5	80.5	77.5
Mean Coke Size in	1.96	1.98	2.00	1.8	2.05
Apparent Spec.Gravity		0.95	0.97	0.96	1.96
Percentage of Breeze (-½")	3.3	5.9	3.9	3.4	3.5
ASTM-Tumbler Test					
Stability Factor	53.5	47.5	52.2	53.6	50.0
Hardness Factor	69.1	63.2	66.1	70.0	67.0
Japanese Tumbler Test (Cumulative Percentage Retained on)					
50 mm Sieve	13.9	24.2	16.5	11.5	21.0
25 mm Sieve	90.4	84.1	88.3	85.5	86.0
15 mm Sieve	92.4	90.5	92.8	92.6	92.5

Tab. 43: Coal Quality and Coke Oven Test Results, Sage Creek Deposit

A coke oven test with 30% reference coal (12.4% low volatile + 57.6% high volatile) and 70% component Sage Creek coal improved the coke considerably.

ASTM - Stability	54.9
ASTM - Hardness	68.8
Breeze	2.5
JIS + 15mm drum index	94.1

All coke oven test results and quality figures are tabulated in Tab. 43. Bulk samples from the deposit have been ordered to Germany and Italy for testing.

4.8 LINE CREEK, HORSESHOE RIDGE AND EWIN PASS DEPOSIT

The Line Creek, Horseshoe Ridge and Ewin Pass deposits belong 100% to Crowsnest Industries Limited. Line Creek is the major deposit and the other two can only supplement reserves to the Line Creek deposit. The office of Crowsnest Industries Limited is located in Fernie, British Columbia.

It appears to be possible for our group to participate in this project by 50%, running the operation and contribute to the management. Despite these favorable facts, Crowsnest Industries may not offer a fair deal, a fact, why Rio Algom Mines Ltd. (Rio Tinto) did not acquire this property. On the other hand, the quality is not yet known sufficiently. Rumors exist, that 700 and 800 feet long adits were still in oxidized coal. Bulk samples are essential for testing the coals by our laboratories.

4.8.1 LOCATION AND ACCESS

The above mentioned coal deposits are situated in British Columbia and the center of the area is 12 miles north of the present large scale operation of Kaiser Resources' Balmer mine as the crow flies At the present time a well established forestry gravel road leads

to the deposit ready to allow for transporting heavy exploration equipment.

The closest towns are Sparwood and Elkford in equal distance from the deposit (approximately 15 miles as the crow flies). The nearest railway link is also located in Sparwood. The total distance to the harbour of Vancouver, Robertsbank, is approximately 700 miles.

4.8.2 COAL RESERVES

The coal reserves are listed in the following Tab. 44 according to seams and deposits. The bulk of the reserves are in Line Creek and other deposits as Horseshoe Ridge and Ewin Pass can just supplement the reserves of Line Creek.

There are rumors that two adits of the Line Creek deposits were 700 - 800 feet long and still in oxidized coal. For this reason the in Tab. 44 stated reserve figure should be approached carefully.

4.8.3 COAL QUALITY AND COKE OVEN TESTS

Tab. 45 indicates that the coals of the Line Creek deposit, Horseshoe Ridge and Ewin Pass show large variations in their quality figures. Therefore, the coal in all three areas, as far as the ASTM Tumbler Test is concerned, is only of medium to bad quality. A blend of Line Creek coals gave the following results (blend percentage : 15% Seam No. 10 A, 21% = Seam 10 B, 24% = Seam No. 9, 40% = Seam No. 8):

Deposit	Line Creek				Horseshoe Ridge			Ewin Pass				
Seam	No.8	No.9	No.10B	No.10A	No.6	No.7	No.8	No.4	No.5	No.6	No.7	No.8
Average Seam-thickness (m)	11.5	6.2	4.9	3.0	3.9	8.5	10.8	8.5	2.6	2.0	13.5	10.5
Preparation Yield (%)	72				72			72				
Underground Clean Coal (million t)	36.0 sht at 50% u/g recovery				unknown			unknown				
Open Pit Clean Coal (million t)	44.6 sht				13.5 sht			20.5				
Stripping Ratio	8.0:1(bcyd:lgt Raw Coal) 11.0:1(bcyd:lgt Clean Coal)				11.4:1(bcyd:lgt Raw Coal) 15.9:1(bcyd:lgt Clean Coal)			10.0:1(bcyd:lgt Raw Coal) 14.0:1(bcyd:lgt Clean Coal)				
Planned Production	1 or 2 million lgt/a justified				Production only in conjunction with Line Creek			Production only in conjunction with Line Creek				

Tab. 44 : Clean Coal Reserves Line Creek, Horseshoe Ridge and Ewin Pass, British Columbia

Deposit	Line Creek				Horseshoe Ridge		Ewin Pass				
Seam	No.8	No.9	No.10B	No.10A	No.6**	No.7	No.8	No.4	No.5*	No.6**	No.7	No.8
Ash %	7.9- 9.9	8.6- 9.0	7.5-10.2	9.6- 9.9		7.9-10.1	8.8-10.6		6.6			
Volatile Matter %	19.4-21.7	20.5-20.2	20.7-22.3	21.1-21.2		22.5-25.2	21.0-21.2		27.7			
Fixed Carbon %	68.4-70.9	70.5-71.2	68.6-70.2	68.9-69.3		65.0-69.9	68.2-70.2		65.7			
FSI	2 - 4½	3 - 4	7½ - 8	5 - 8		6½ - 8	3 - 3½		8			
Total Sulphur %	0.28-0.40	0.34-0.42	0.46-0.60	0.56-0.59		0.61-0.74	0.37-0.57		0.57			
Phosphor %												
Dilatation %	-23 to +14	-7 to -27	-2 to 34	-17 to 43		2 to 80	-30		+66			
Contraction %	8.5 to 23	7 to 27	20 to 79	20 to 26		26 to 36	30		28			
Max. Fluidity (dd/m)	0.9 - 5.4	1.0-5	5.4 to 36	54 to 128		5.2-6.1	0.8-1.9		83			
ASTM +25mm	36.1-52.4	49.2	58.2-62.2	52.0-55.3		40.9-56.7	42.8-46.6	48.6-54.8	44.5		48.6-51.2	54.8-56.6
ASTM + 6mm	60.6-72.9	71.8	69.9-71.3	63.8-69.4		61.9-66.7	55.3-57.8	62.3-67.9	56.5		62.3-63.0	66.2-67.7
JIS +15mm	86.7-92.0	91.8	93.3-93.7	92.7		89.4-91.4						

Tab. 45 : Coal and Coke Quality Line Creek, Horseshoe Ridge and Ewin Pass, British Columbia

* Coal Analysis exists only for Seam No.5

** No Analysis available

Ash	=	9.2%
Volatile Matter	=	21.1%
Fixed Carbon	=	69.7%
FSI	=	5½
Sulphur	=	0.40%
Phosphor	=	0.025% (Verbal information by Mr. J. Crab
Dilatation	=	- 25%
Contraction	=	28%
Max. Fluidity	=	2 dd/m
ASTM + 25mm	=	48.8
ASTM + 6mm	=	68.1
JIS + 15mm	=	91.0

Also the ASTM-Stability (+25mm) and the JIS + 15mm indicate only poor quality. In any case, the Line Creek Coal can only be regarded as a blending coal and nothing else.

The ASTM-quality figures improve considerably, if Line Creek coal is blended with 70% or 55% of American coals. The trend that Line Creek coals have positive influence on the coke quality in blends, has also been proven by a coke oven test performed by British Steel.

Unfortunately, the exact location of this sample sent to Great Britain is not known to us. The sample had the following analysis (adb):

Inherent Moisture	=	1.54 %
Ash	=	10.02 %
Volatile Matter	=	19.98 %
Sulphur	=	0.46 %
Fixed Carbon	=	78.62 %
Phosphor	=	0.026%
FSI	=	6½ %
Dilatation	=	- 21 %
Contraction	=	21 %

Max. Fluidity	=	None
Vitrinite	=	62
Inertinite	=	38
MICUM 40	=	73.5
MICUM 10	=	14.0

The evident negative data of this sample are high ash, negative dilatation and bad MICUM 10-value of 14.0. In blends with English volatile coals, the following results were obtained (Tab. 46):

Base Blend	% Addition	% VM (db) of blend	MICUM Indices M 40	M 10
Ravenscraig	NIL	33.5	60	12.0
	15	31.5	71	10.3
	30	29.5	73	9.8
Appleby-Frodingham	NIL	34.5	62	11.5
	30	30.2	78	10.2
Easington	NIL	36.3	58	12.7
	30	31.5	75	10.0

Tab. 46: Line Creek Coals in Blends with English High Volatile Coals.

Reviewing this result, it is obvious, that the coke resulting from the blends is always better than the quality of the single components. It is therefore advisable to test a reliable and representative sample of the Line Creek deposit in a blend with ATH coals.

1. Gething Coal Formation : contains no seams
2. Cadomin Conglomerate
3. Moosebar Shale
4. Basal Gates Sandstone : Marker Horizon
5. Gates Coal ~~Formation~~

The Gates Coal Formation has 3 seams developed, which are numbered from the footwall to the hanging wall Seam A, B, C, D and E. Most likely only three of them will only be mined, namely Seams A, B and C.

C$ 600,000.00 were spent so far for investigations on the deposit. The drillholes are inclined on the 35 - 50° dipping strata. The continuation of the Saxon Area is the Belcourt area, displaced by a fault. Belcourt also belongs to Denison Mines Ltd.

The total reserves mineable by underground method to 1500 ft depth compute to

250 million sht Raw Coal in Situ

Applying the worst possible recoveries (37.5% U/G recovery and 65% yield washery), there are 60 to 65 million sht clean coal obtainable, of which 20 million sht may be mineable at a ratio 7 : 1 (bcyd : sht raw coal) by open pit. 50% of the reserves appear likely above drainage level. The reserves may also be increased as the total area is not yet fully investigated.

4.9.1.3 COAL QUALITY AND COKE OVEN TESTS

In fact, the quality data of the Saxon coals are excellent. The washed coal and the coke oven charges show low to medium volatile matter with low ash contents. The FSI-values vary according to seams from 6½ to 8½. Especially the ASTM-Stability and Hardness values indicate strongly towards a prime coking coal. In blends

Tab.46: Analyses of Component Coals and Thermal Rheological Properties, Analyses of Coke Oven Charges and Resultant Cokes, Saxon Area of Denison Mines Ltd.

Seam	A	B	B
Washed Coal Data			
Weight	65 - 85	65	65 - 70
Inherent Moisture %	0.54-1.22	0.50-0.87	0.61-1.02
Ash %	6.92-8.79	6.71-9.89	6.96-app.7.5
Volatile Matter %	18.62-21.78	20.0-21.78	19.12-22.75
Fixed Carbon %	69.76-73.53	62.01-72.0	69.27-72.35
FSI	7 - 8½	8 - 8½	6½ - 7½
Total Sulphur %	0.23-0.34	0.27-0.45	0.42-0.47
Phosphor **	0.055	0.035	0.038

Coke Oven Charges

Seam	A,100%	B,100%	C,100%	Mapped as B but Prob.. C	30% Adit Saxon No.1 70% hv Ref. Coal	30% Adit Saxon No.2 70% hv Ref. Coal	30% Adit Saxon No.3 70% hv Ref. Coal	30% Adit Saxon No.4 70% hv Ref. Coal
Sample from	Adit Saxon No.1	Adit Saxon No.2	Adit Saxon No.3	Adit Saxon No.4				
Charge								
Proximate Analysis(db)								
Ash %	6.5	6.9	5.4	8.4	5.2	5.3	5.0	5.8
Volatile Matter %	22.2	21.8	22.7	22.2	32.1	31.4	32.0	31.0
Fixed Carbon %	71.3	71.3	71.9	69.5	62.6	63.3	63.0	63.2
Sulphur %	0.34	0.50	0.49	0.80	0.68	0.64	0.68	0.72
Resultant Coke								
Proximate Analysis (db)								
Ash %	8.9	8.6	7.3	10.2	7.6	7.7	6.9	8.1
Volatile Matter %	1.5	1.6	1.2	0.8	1.5	1.4	1.1	1.1
Fixed Carbon %	89.6	89.9	91.5	89.0	91.1	90.9	92.0	90.8
Sulphur %	0.30	0.45	0.43	0.77	0.47	0.52	0.54	0.65
Linear Expansion								
Bd. 52 lb/ft³ at 2% Moisture	NA	-6.1	-3.1	+2.8				
Gieseler Plasticity								
Start °C	442	443	439	457				
Fusion Temp. °C	457	457	454	477				
Max. Fluid Temp. °C	474	474	467	501				
Final Fluid Temp. °C	493	492	487	524				
Solidification Temp °C	498	498	491	530				
Melting Range °C	51	49	48	67				
Max. Fluidity dd/m	25	37	30	58				
Dilatation								
Softening Temp. °C	427	413	429	427				
Max. Contraction Temp. °C	461	454	467	469				
Max. Dilatation Tem °C	485	482	489	493				
Contraction %	29	26	30	26				
Dilatation %	10	29	18	28				
Free Swelling Index	6½	8	7	8½				
Carbonization Data								
Net Weight of Charge (Wet) lb	516.2	517.8	514.2	547.8	515.8	517.8	517.3	538.5
Moisture in Charge %	3.4	3.3	3.3	3.2	3.1	3.0	2.7	2.7
ASTM Bulk Density (Wet) lb/ft³	48.5	48.6	48.5	48.5	48.5	48.5	48.6	48.5
Oven Bulk Density (db) lb/ft³	50.7	50.6	50.3	50.8	50.5	50.6	50.8	50.9
Carbonization Results								
Gross Coking Time hr:min	9:55	9:07	8:50	9:30	8:18	8:40	8:46	9:10
Max. Wall Pressure lb/in²	0.50	3.02	0.75	0.00	0.25	0.23	0.27	0.27
Coke Yield Actual	79.3	77.81	78.2	77.9	72.8	71.6	71.6	73.0
Mean Coke Size in	1.96	2.01	1.89	2.32	1.97	1.92	1.99	1.90
Apparent Spec. Gravity	0.97	0.92	0.92	0.86	0.87	0.88	0.86	0.87
Percentage +¼" (Breeze)	3.8	3.9	3.4	2.5	3.9	3.7	3.9	3.8
Tumbler Test (ASTM)								
Stability Factor	69.5	65.0	66.8	57.4	58.4	52.2	58.6	54.3
Hardness Factor	73.7	71.7	73.6	69.6	66.6	67.8	64.2	69.9
Japanese Tumbler Test								
15mm Sieve	*	95.8	93.7	84.8	92.0	91.9	92.2	*

* Insufficient Sized Coke to Perform Test

** Analysis from Adit Samples

35.4 million sht/clean coal for conventional underground mining method or 28.9 million sht for hydraulic are available. These reserves include 9.6 million sht clean coal open pit reserves.

A comprehensive reserve tabulation can be seen in Tab. 49.

4.10.3 COAL QUALITY AND COKE OVEN TESTS (Tab. 50)

The quality of the seams in the Babcock area is good to very good. Especially the thick J-Seam has very good values for stability and hardness. This is most likely the reason that the Japanese steel industry is so much interested in hydraulic mining of this seam. The JIS + 15mm values confirm the ASTM values of Seam J.

In summary, the coking tests, petrographic investigations, and analyses to date clearly indicate that the coke prepared from Seams E, F and J will be high in quality and will perform in blends at least as well as and in some cases maybe better than other competitive Canadian coals. Seam D seems to perform also well in blends, however, its own stability (44 - 55) is definitely lower than those of other Babcock coals.

The ash content of the Babcock deposit can be kept at 7% with reasonable yield. The coal to be shipped will have a medium volatile matter content (21.4% - 23.4%) and a swell of 6 - 7. The sulphur content is low.

The quality of the coals in the Wolverine area differs in both Coal Formations. While the Gates Coal Formation has high FSI values (6½ - 8½) and medium volatile matter coals, the Gething Coal Formation has relatively low FSI values (1½ - 6) and low volatile matter coals. The coals have to be blended. The ash and sulphur contents are low in each Coal Formation. This blend should have volatiles in the order 20 - 22% ash between 5% and 6%, and a FSI of 6 or over.

Area	QUINTETTE BABCOCK															
Seam	D			E			F		G			I		J		Expected Shipment Specifications
Washed Coal Data	At 7% Ash	At 1.60 S.G		At 7% Ash	At 1.60 S.G		At 7% Ash	At 1.60 S.G	At 7% Ash	At 1.60 S.G	At 7% Ash	At 1.60 S.G		At 7% Ash	At 1.60 S.G	Weighed Average Range
Weight %	76.90	76.77		64.36	67.70		78.40	73.16	59.02	75.32	68.30	75.30		74.59	78.69	
Total Moisture %	5			5			5		5		5			$		6.0 (adjustable) -
Inherent Moisture%		0.82			0.84			0.89		0.78		0.98			0.85	
Ash %	7.07	7.22		7.06	7.68		6.80	5.02	7.74	10.97	7.04	9.06		6.80	7.66	7.03 6.6-7.6
Volatile Matter %	24.42	25.12		23.50	24.46		20.84	25.06	22.74	22.34	21.10	21.44		21.14	21.95	22.09 21.4-23.4
Fixed Carbon %	63.60	66.81		64.47	66.69		65.13	69.37	64.49	65.87	66.82	68.46		66.95	69.53	64.49 63.0-66.0
FSI	5½	5		7	7		7½	8	7½	6	7½	7½		7	7	6-6½ 6 - 7
Total Sulphur %	0.65	0.71		0.24	0.25		0.23	0.30	0.42	0.49	0.27	0.31		0.21	0.22	0.39 *0.31-0.51
Phosphor %	0.04			0.10			0.08							0.03		?0.05-0.06
Caking Properties	Range			Range			Range		Range					Upper J	Lower J	
Dilatation %	4-41			42			53-87		-5 to +13					35	76	
Contraction %	21-23			25			27-29		23-26					23	24	
Max. Fluidity (dd/m)	27-110			126			118-435		10-11.3					101	139	Over 100
etrograhy																
Total Reactives	62.6-65.9			66.7-68.0			68.4-71.4		65.7-70.7					65.0	67.9	
Total Inerts	34.1-37.4			33.3-32.0			28.6-32.6		29.3-34.3					35.0	32.1	
Coking Properties																
ASTM + 25mm	(35.3)*															
ASTM + 6mm	44.0-55.2			60.9			52.1-59.5		51.8-55.0					56.4	57.8	
	64.8 -70.4			73.1			69.0-74.9		69.3-73.0					74.1	73.1	
JIS - 15mm tested in Canada	*(91.3)91.3-93.1								94.0					94.1	94.2	
JIS - 15mm tested in Japan	91.4-94.4 (@ 92.8)						91.3-94.4 (@ 93.5)							91.6-94.9(@93.5)	91.1-94.8(@93.4)	

No Outcrop, No Adit

* oxidized sample, will be retested

Tab.50 : Coal Quality and Coke Oven Test Results, Quintette Area, Denison Mines Ltd.

QUINTETTE - WOLVERINE				
Gates (F):No.1	No.2	Gething CF.:	No.II(Skeeter)	No.III(Chamberlain)
75.8-89.0	71.5-92.0		64.9-96.9	89.0-98.0
5.0	5.0		5.0	5.0
6.21-6.86	6.49-7.97		6.06-6.83	5.44-6.50
20.68-23.60	21.57-25.29		17.01-20.58	17.07-18.45
64.83-67.78	63.21-66.33		70.87-72.60	71.49-74.60
6½-8½	6-8½		1½-6	4-5
0.21-0.31	0.22-0.41		0.26-0.70	0.28-0.49
.0.0026	0.0041		0.483	0.0066
			Not done	
			Not done	
			Not done	

QUINTETTE FIVE CABIN SYNCLINE				
Gates CF:	No.1	No.5	No.7	Gething CF.: No. II/III
	Upper 3', Lower 4.2'			
	63.33 N/A	82.0	61.0	98.00
	7.89 7.26	7.30	8.23	6.64
	29.65 28.55	27.24	28.92	20.06
	62.40 63.38	63.78	61.88	71.96
	8½ 7½	6½	8	3½
	0.73 0.31	0.27	0.31	0.15
		0.0092	0.0036	0.0084
			Not done	
			Not done	
			Not done	

It is most unlikely that all of these reserves are coking coal. A large unknown percentage is certainly only suitable for steam coal. The washability tests and coke oven tests are presently conducted in a laboratory in Chicago. The following quality is to be expected:

Volatile Matter	:	24 - 25%
Fixed Carbon	:	63 - 66%
Ash	:	Like Kaiser, about 9.5 to 10%
Sulphur	:	0.3%
BTU	:	13,000
FSI	:	varying 2½ - 4 or 6 - 8

The development of the coal quality has to be watched carefully by our side, because the deposit seems to be very interesting.

Tab. 51 : Coal Reserves As Per Seam, Sukunka Deposit, B.C.

MEASURED RESERVES

CATEGORY	Million lgt, in place			Million lgt, washed coal		
SEAM	Plate 1	Plate 2	Total	Plate 1	Plate 2	Total
CHAMBERLAIN	3.62	58.53	62.15	2.02	32.80	34.82
SKEETER	2.52	9.32	11.84	1.23	4.56	5.79
TOTALS	6.14	67.85	73.99	3.25	37.36	40.61

INDICATED RESERVES

CATEGORY	External to grid	Plate 3	Total	External to grid	Plate 3	Total
CHAMBERLAIN	22.0	6.51	28.51	12.0	3.65	15.65
SKEETER		2.59	2.59		1.23	1.22
TOTALS	22.0	9.10	31.10	12.0	4.87	16.87

COAL QUALITY AND COKE OVEN TESTS

The coal quality of the Chamberlain Seam and the Skeeter Seam is shown in Tab.52 . Quality of the coal in the Chamberlain Seam is remarkably high, having an ash content of between 3.9 and 5.3% and averaging 4.0% in Plate 2; these figures are based on analytical data of a washed product at S.G. 1.60. The FSI is predicted to be between 7 and 7½ and the volatile matter (daf) is between 20% and 26%.

The quality of the Skeeter Seam is for the most part similar to that of the Chamberlain Seam having on the basis of bore core analysis, averages only slightly higher for ash content (4.8% as against 4.0%) and slightly higher volatile content (24.9%, daf, as against approximately 22%). A FSI of 7½ is predicted for this seam.

WASHED COAL PRODUCT AT 1.60 SPEC. GRAVITY
(AIR DRY BASIS)

	CHAMBERLAIN SEAM RANGE (PLATE 2)	SKEETER SEAM PLATE 1	SKEETER SEAM PLATE 2
Moisture %	0.8 - 1.0	1.1	0.9
Volatile Matter %	19.2 - 22.2		
Volatile Matter % (daf)	20.6 - 26.2	21.4	20.1
Ash %	3.9 - 5.3	3.7	4.1
Fixed Carbon %	73.0 - 73.9	73.9	74.9
FSI	7 - 7½	5	6½
Calorific Value (BTU/LB)	14520 - 15030	15000	14670
Sulphur %	0.35 - 0.45	0.30	0.30
Phosphorous %	0.021 - 0.035		

Tab. 52 : Coal Quality of Chamberlain And Skeeter Seams, Sukunka Deposit

The proximate analysis of the Sukunka coal product is expected to be as follows:

Inherent Moisture	1.0%
Ash	4 - 4.5%
Volatile Matter	22.5%
Sulphur	0.6% maximum
Fixed Carbon	72.5%
Free Swelling Index	7 - 9
Hardgrove Index	98

Tab. 53 shows the coking properties of the Sukunka coal and in addition blending tests of Sukunka coal with 75 and 50 percent Polish coals. The tests show that the Sukunka coal on its own is a prime coking coal and does not improve in blending with high volatile Polish coals.

PERCENTAGE (WT %) IN BLEND					
Polish Coal ICF, 1 & 2			100	75	50
Sukunka	100*	100		25	50
COAL ANALYSIS					
Moisture as received %		5.0	6.0		
Volatile Matter, dry basis %	22.8	22.3	29.0	27.3	25.8
Fixed Carbon, dry basis %	72.6	73.0	64.9	66.9	68.7
Ash, dry basis %	4.6	4.7	6.1	5.8	5.5
Sulphur, dry basis %	0.46	0.56	0.58	0.56	0.57
Calorific Value, dry basis, BTU/LB		14936	14384		
FSI	7½	7½	7	6½	6½
Grindability	90		64		
Ash Softening Temperature °F		2088	2285		
GIESELER TEST					
Maximum Fluidity dd/m	204	54	175	83	68
Range °C	72	69	66	63	66
DILATOMETER TEST					
Maximum Dilatation	30	28	27	28	28
Maximum Contraction	48	26	20	16	18
MOVABLE-WALL OVEN TEST					
Moisture as charged %	0.4	not run		3.0	2.4
Pulverization - 1/8"%	87.0	not run		90.5	90.8
Bulk Density dry coal/CF %	50.2	not run		48.2	48.1
Maximum Wall Pressure lb/sqin	28	not run		less than 1	
Coke Yield Dry Basis %	78.6	not run		71.1	73.8
ASTM TUMBLER TEST					
Stability + 1" %	58.2	not run		51.3	57.2
Hardness + ¼" %	66.6	not run		62.7	67.0
MICUM TEST					
M 40	73.6	not run		74.6	73.6
M 10	7.0	not run		8.7	7.7
COKE ANALYSIS					
Ash Dry Basis %	6.1	not run		7.8	6.9
Sulphur Dry Basis %	0.51	not run		0.56	0.57

TAB. 53 : CARBON TESTS SUKUNKA COAL AND BLENDS WITH POLISH HIGH VOLATILE COALS

* For Reference

Plant feed (Raw Coal)	
Raw Coal million lgt	28.429
Ash %	20.1
Volatile Matter %	21.2
Clean Coal Product (dry basis)	
Clean Coal million lgt	22.5
Ash %	7.7
Volatile Matter %	24.2
Yield Washery	79.1

Due to calculation method, Manalta anticipates that the actual volatile matter content will be slightly lower and seems to be only 23.3%; also the ash content is not expected to be less than 8.5%.

Petrographic analyses indicate mean reflectance between 1.20 and 1.30. Fluidity tests indicate that for a volatile content of 26% the range would be 80 to 250 dd/m.

The depth of oxidation at the Gregg River deposit varies between 25 to 60 feet. 40 feet may be the average.

Reviewing the quality data of the bulk samples and coke oven tests (Tab. 54), the coal does not show equal quality. The volatile matter varies from medium volatile to high volatile matter, and Manalta has to blend by 70% medium and 30% high volatile matter. The dilatation differs between -12 to 112, but the low value may be effected by oxidation. The range of maximum fluidity is between 8 - 1700 dd/m and the melting range varies from 50 to 92° C.

The washery layout will be according to three grain fractions as follows, but the tests for optimum wash process are still running:

Fraction ½" - 1½" :	Heavy media separation, Spec. Gravity 1.60, 25% of this fraction size is expected here.
Fraction 100 MESH -¼":	Deister tables, 65% of this fraction size is expected here.
Fraction 0 - 100 MESH:	Flotation cells, 10% of this fraction size is expected here.

4.14 BRAZEAU DEPOSIT

The Brazeau deposit belongs to the Consolidation Coal Company of Canada. This company has not been contacted by our group, because the manager of Consol, Mr. Cholak, indicated during the 25th Coal Conference in Victoria, that his company will not accept partners for the development of a project.

The deposit is located near Nordegg. The main problem for this project is the long railway distance to a port of 1020 miles, and a new construction of 106 miles spur line.

4.14.1 COAL RESERVES AND COAL QUALITY

The brief reserve information stated here was obtained from a report of Consolidation in the office of Scurry Rainbow. This report states that 23 million sht tons clean coal are available in a multiple thin seam open pit operation. This calculation is based on a 6.5 : 1 (bcyd : sht clean coal) ratio, but representatives of Scurry Rainbow indicated that a ratio of 10 : 1 (bcyd : sht clean coal) is more appropriate.

The coal quality is of low volatile matter rank and the Tex Report (26.9.1973) states the following quality:

SEAM	No. 2	No. 3
Ash %	5.6	6.7
Volatile Matter %	17.2	17.2
Sulphur %	0.55	0.51
FSI	8	8

The more advanced report, which Scurry Rainbow has had, states much different figures:

SEAM	No.2	No. 3
Ash %	7.5	9.1
Volatile Matter %	18 - 20	18.0
Sulphur %	0.7	0.52
FSI	5 - 7	5.44
Yield Washplant	60%	
Recovery O/P	90%	

These figures seem to be more reliable.

4.15 ROCK LAKE DEPOSIT

The Rock Lake deposit belongs as well to Denison Mines Ltd. The property is situated in the Willmore Wilderness Park, and Denison acquired the deposit by competitive bid on the invitation of the Government of Alberta, on February 10, 1969. At that time, it was clearly the understanding of all parties presenting bids, that Article 7 of the Willmore Wilderness Park Act would allow successful bidders to proceed with exploration and mine development. Denison commenced some preliminary exploration, but approval for a more comprehensive development program was not forthcoming in 1972. In the meantime, Denison received the Wildhay properties

from the Government of Alberta without saying that this is in exchange for the Rock Lake Area. It is felt, that the Rock Lake Area is blocked as long as the exploration result in the Wildhay property is obvious. The Wildhay Area will be dealt with in the next chapter.

4.15.1 LOCATION AND ACCESS

The Rock Lake property is located in Alberta some 20 miles from the Alberta Resources Railway. The center of the property is some 35 miles as the crow flies west of Hinton on Highway No. 16. The ideal location for housing and accommodation the work force is obviously Hinton.

4.15.2 COAL RESERVES AND QUALITY INDICATIONS

Within the Rock Lake property, only one area, namely the one south of the Wildhay River, has been significantly explored. In this area, one major seam (Seam A), 30 to 40 feet thick. The major seam has been traced by adits and trenches for over two miles and it dips from 30 to 65 degrees to the south-west. There is no indication of any major fault or disruption of the seam over this distance. Much of the physical work was done in the days of steam coal, and therefore only raw ash analyses are available. Denison's 1969 work included complete proximate analyses plus sulphur and FSI determinations, but these were only done on one bulk sample from each seam. Unfortunately, Mitsui reported that this sample was oxidized, and therefore no definitive coking formation is available. The FSI button of the clean coal from the oxidized sample was only 2 to 3, and Mr. T. Ishihara has expressed his confidence that fresh samples will provide a product with an FSI of 5 or better.

On the basis of the limited analyses available, the expected product from Seam A should have the following characteristics (as received, 6% moisture):

Recovery (yield)	65 - 75 %
Ash	8 - 9 %
Volatiles	23 - 27 %
Fixed Carbon	60 - 64 %
Sulphur	0.3 - 0.5%
FSI	5 - 7 %

Assuming that Seam A is 30 feet thick and 2.5 miles long, approximately 31 million inferred tons of coal are estimated to be in place to a depth of 1,500 feet. If the seam averages 40 feet in thickness, this figure will increase to 42 million tons and a similar increase may be expected, if Seam B is found to be continuous and to average 10 feet thick. For hydraulic mining, it is assumed that approximately 70% of the coal will be extracted, resulting in 50% net clean coal from this one location.

In addition to this specific locale, the property also has the geological potential for the location of more than 200 million tons of coal in place, of which it is confidently expected that at least 10% will be available as clean coal product.

The first priority for the property is to prove the inferred reserves south-west of the Wildhay River. Deeper drilling has to be done first to obtain fresh samples, adits will then be driven into good cover and proper samples will be shipped for coke tests. The deposit must also be tested at depth for structural and stratigraphic continuity before definite reserve calculations are possible.

20% of the reserves may be above drainage level.

HIGHWOOD COAL FIELD
(FORD COAL PROPERTY)

Tab: 55 :

COAL RESERVES SUMMARY

N.C. - not calculated
blank - Not Applicable or Not Available

	TENTATIVE STRAT COLUMN						THICKNESS		DIP	% MOISTURE	% ASH	% VOL MATTER	% FIXED CARB	% SULPHUR	CALORIFIC VALUE	COKING PROP.	ASTM RANK	RESERVES IN PLACE (10⁶ long tons)				TOTAL		REMARKS
	LOUISENA BAND HIGHWOOD SECTION	NAME OF SEAM	CATFRIEK SECTION	NAME OF SEAM	PICKLEJAR SECTION	NAME OF SEAM	RANGE (ft)	USED (ft) SOUTH	USED (ft) NORTH	RANGE OR AVER. DIP (°)								TRENCHED AND CORRELATED SOUTH PORTION		TENTATIVELY CORRELATED & ASSUMED NORTH PORTION		BOTH PORTIONS		
EASTERN BAND							55																	ANALYSIS - from coal mining Dept. of Mines and Minerals inspection - also R.C.A. archive of drilled
							75	75	-	60	2.6	37.8	13.15	46.4	0.63	9045			3.3	2.1			3.3	2.1	
							5-7	6	-	40-60	2.2	26.1	14.8	56.9	0.86	10880		Lvb	3.7	2.0			5.8	4.1	Tentered, doubtful area in Cut 6 Area
								60	-	42									2.1	2.1					
							5-12	12	-	35-60	1.8	22.2	19.8	61.2	0.55	11460			10.7	6.4			20.4	12.3	Cut 1 to Cut 9 Area Col Creek Area. Eastern Band North
								5	-	50									2.2	1.8	7.5	4.1			
								-	8	55															
							16-20.5	16	8	50-55	2.6	20.1	15.2	62.1		11760			7.1	5.7	22.5	12.3	29.6	18.0	
							0	0		50									3.5	2.8			3.5	2.8	
							5-8	8	6.5	50-55									3.5	2.8	7.4	3.7	10.9	6.5	
							5-32	20		60-65	3.4	15.9	14.6	66.1	0.59	12480			8.9	3.6					Cut 1 Area Cut 6A Area
								5		40°									3.1	2.5					
								6	15	40-55									2.7	2.1	17.1	8.6	39.7	21.5	
								5.5		50-55									2.2	1.8	5.7	2.9			
	For correlation details See charts and discussion in each Band's chapter						Variable thicknesses used indicate central figure used for the particular Reserves Block											TOTALS :		53	35	60	32	113	67	
																		EASTERN BAND TOTAL:						113	
CENTRAL BAND							Th RANGE	SOUTH	NORTH	DIP	M.	ASH	V.M.	F.C.	S	Btu	coke	ASTM							
							10-48	25	-	60-65	2.3	20.4	17.7	59.6 (79.3)		11750		Lvb	4.5	2.2			4.5	2.2	Anal. by R.C.A.
							4	4	4	50-85									1.4	0.7	5.7	2.9	7.1	3.6	Southern half of NORTH PORTION
							11	11	10	50-83	2.5	11.3	17.4	68.8	N.A.	13260		Lvb	3.9	2.0	14.3	7.1	18.2	9.1	"
							30-39	35	30	50-85									12.5	6.2	42.8	21.4	55.3	27.6	"
							7-45		55	50-75											7.9	3.9	7.9	3.9	Northern half of NORTH PORTION
							5-11		8	50-75											11.4	5.7	11.4	5.7	"
							16-20		18	50-75											25.7	12.9	25.7	12.9	"
							8-5		6.5	-"-											9.3	4.6	9.3	4.6	"
							8-21		15	-"-											21.4	10.7	21.4	10.7	"
	For Correlation details See Charts and discussion in each Band's chapter																	TOTALS :		22	11	138	69	160	80	
																		CENTRAL BAND TOTAL:						160	
WESTERN BAND							Th RANGE	SOUTH	NORTH	DIP	M.	ASH	V.M.	F.C.	S	Btu	coke	ASTM							
							22	22		80-90									7.9	-					
							5	5	34	-"-									1.8	-	108	54	119.2	54.0	Consecutive total thickness was used for Eastern Coast Area portion - There is a good possibility of coal in the reserves
							7	7		-"- (North Pocket 90-90)									1.5	-					
	For Correlation details See Charts and discussion in each Bands chapter																	TOTALS :		11	-	108	54	119	54	
																		WESTERN BAND TOTAL:						119	

For the locations of reserves blocks - See Plate 1.

The above table indicates an existence of large reserves of low volatile bituminous coal, most of which is deposited in thick seams steeply inclined

Considerable strippable reserves do exist in the area - they are in order of 30 to 40 mil. long tons in place.

ALL BANDS	SOUTH PORTION	NORTH PORTION	BOTH PORTIONS (TOTAL AREA)
TO MAX DEPTH OF 2000 feet	86	306	392
ABOVE RIVER LEVEL (approximately) OF THAT	46	155	201

TOTAL COAL RESERVES	392

The ash content of the raw coal samples from Highwood Area varies from lows of around 10% up to about 50%. This large variation is a result not only of sampling different seams, but also from inclusion or exclusion within the sample of various partings in the seam. Some detailed washability studies were made by the Fuel Research Laboratories on Highwood coals in 1946, and it would seem reasonable to anticipate a product containing less than 10% ash while maintaining a yield of around 75% at the preparation plant.

The sulphur content of the coals varies from 0.35% to 0.8%. Such values are acceptable. Only one reference to phosphorous is known. This analysis was made by Laucks Laboratories Inc. of Seattle (1946) and it says "phosphorous - no trace".

The coking quality is unknown. Of the eleven analyses made by the Research Council of Alberta in 1946, ten report the coal to be of "coking quality".

This analyses made by the Fuel Research Laboratories did not use the ASTM Free Swelling Index. The scale of values reported ranges from negative values of -500 to positive values exceeding +1000. As far as can be ascertained, such values would indicate an FSI of 0 - 6. Most samples taken are believed to have been weathered (note moistures exceeding 1.0%), and it appears likely that most unweathered, washed samples of Highwood coals would be of coking quality.

Two statements by Swartzman of the Fuel Research Laboratories of the Federal Government are worthy of note. He describes the coals as volatile coals and further says "on washing, clean fractions may be prepared which exhibit high swelling characteristics".

It is worthy of note that Manalta - operators of the Alberta Coal property adjoining the Highwood area - report FSI's of 1 - 5½ with volatiles ranging from 9% to 18% for their property. The Savanna Creek area to the south has been explored by Bralorne over the last two to three years and is reported to have proven up a medium to low volatile coking coal deposit.

The deposit has the following advantages:

1. Thick seams and good reserves
2. Low volatile coals
3. Low sulphur content. No phosphor analysis exists, only a note "no trace"
4. The area has an open cut potential
5. The balance of the reserves in the range of 200 million tons is applicable to hydraulic mining
6. Manalta Coal Ltd. has an area in the neighbourhood and both areas together may have the potential for a larger mine if joint venture is acceptable

The disadvantages are:

1. Part of the reserves are maybe semi-anthracite
2. The railway connections may create a problem; the farest distance to a link is 35 miles
3. The project is environmentally sensitive

constructed to connect the property with the Canadian National Railroad and that will cost already 45 to 60 Million Dollars. The distance from the rail junction to the Port of Prince Rupert is then an additional approximate 550 to 600 miles. According to Mr. Olk's information, this would require a freight rate of approximately 6 Dollars and 2 Dollars amortization for the spur line.

4.18.2 COAL RESERVES AND COAL QUALITY

After the first investigation results, Notus has 45 Million sht of strippable raw coal in the proven category, and another 45 Million sht strippable raw coal in the inferred category. Including the underground reserves, (plenty of which would apply to the hydraulic mining methods), the total potential calculates to 300 Million sht in situ. The open cut potential is calculated on a basis of 10 : 1 (bcyd : lgt raw coal). Taking an overburden ratio of 7 : 1 into consideration, Mr. Olk believes that the open cut potential would decrease to 45 Million sht raw coal. The washability test of the coal has indicated a yield of about 70% recovering a product of 7.5 to 8.0% ash. In the property, three seams which are called No. 3, No. 4 and No. 7 were discovered. The above stated reserves refer to only two seams, namely No. 3 and No. 4. No. 7 is of minor significance. Seams No. 3 and No. 4 vary in thickness from 15 to 40 feet, but both seams together have more or less a constant aggregate thickness of 50 feet. Seams No. 3 and No. 4 have a low volatile coal (No. 4 = 19.8% db, No. 3 = 18.6% db). Seam No. 4 gives a coke button (FSI) of 7 to 8, and Seam No. 3 has a coke button of 1 to 4. The limit of oxidation is 50 feet deep, all oxidized coal is deducted from the above mentioned open cut reserves.

These scarce quality informations (See Tab.56) indicate that the coal has medium to inferior coking properties, but it might well be suitable in a blend with a high volatile coal.

Tab. 56 : Chemical Analysis, Thermal Rheological Properties, Kakwa River Deposit, Cyprus Mines Corp.

Description.....	Adit #1 Seam 4 Raw	Adit #1 Seam 4 floats 1.60 S.G.	Adit #2 Seam 3 Raw	Adit #2 Seam 3 floats 1.60 S.G.	Adit #3 Seam 4 Raw	Adit #3 Seam 4 floats 1.60 S.G.
Moisture %			0.7	0.7	0.5	0.7
Ash, db %			13.0	7.6	21.0	8.2
Volatile Matter, db %			18.6	18.6	18.3	19.8
Fixed Carbon, db %			68.5	73.8	60.7	72.0
Sulphur, db %			0.42	0.44	0.44	0.45
Total Reactive Components %			65.6	68.4	64.0	71.2
Total Inerts Components %			34.4	31.6	36.0	28.8
Mean Reflectance			1.51	1.54	1.33	1.38
Gieseler Plasticity						
Start °C	453	452	-	-	457	448
Fusion Temp °C	-	-	-	-	-	466
Max. Fluid Temp. °C	471	470	477	466	477	470
Final Fluid Temp. °C	486	485	-	-	486	486
Solidification Tp °C	492	494	486	481	492	495
Melting Range °C	33	33	-	-	19	38
Max. Fluidity dd/m	3.1	4.3	0.2	0.2	2.1	5.8
Total dd	28	37	1	1	19	44
Dilatation						
Softening Temp. °C	422	422	458	476	437	434
Max. Contraction Temp. °C	500	459	500	500	491	473
Max. Dilatation Temp. °C	500	485	500	500	500	494
Contraction %	20 at 500°C	25	3 at 500°C	2 at 500°C	20	26
Dilatation %	NIL	13	NIL	NIL	-19	5
Free Swelling Index	4+	8	1	1	6	7

Quality coke oven testing of the coal has only been done in Seam B, and the results were excellent. A rough estimation of the reserves in place of this Seam totals to 115 million tons possible category.

4.19.3 COAL QUALITY AND COKE OVEN TESTS

An average coal quality for the investigated area was calculated from one borehole, which went through eight major coal seams with a combined total thickness of 50 feet. The weighted average analyses for the total amount of the encounted coal is as follows: (details in Tab. 57)

	RAW SAMPLE		1.45 Float	
	As Received	Dry Basis	Dry Basis	Perc. Float
Moisture %	2.2			
Ash %	16.7	17.1	5.8	73.1
Volatile Matter %	22.9	23.4	26.0	
Fixed Carbon %	57.8	59.2	67.7	
Sulphur %	0.34	0.35	0.42	
BTU's	12353/lb	12619/lb	14354/lb	
Free Swelling Index	5.4		7.7	

It is not known if this average is representative for the whole deposit. One drillhole seems not enough for that purpose.

More important are the results of an adit driven in Seam B. This result indicates prime coking coal. The excellent coking characteristics indicated by the ASTM-Stability (58.8) and Hardness (69.8) and the Japanese Tumbler Test JIS + 15mm value of 95.1 of the single coal deteriorates by blending it with high volatile American coal. More detailed information is listed in Tab. 58.

Tab. 57 : COAL ANALYSIS, Woods Kakwa River Coal Project

HOLE NO.	SEAM INTERVAL	SEAM THICKNESS	MOISTURE %	ASH %			PERCENT FLOAT 1.45 Float	VOLATILE MATTER %			FIXED CARBON %			SULPHUR %			B.T.U's/lb			FREE SWELLING INDEX	
				Raw Sample		1.45 Float		Raw Sample		1.45 Float	Raw Sample		1.45 Float	Raw Sample		1.45 Float	Raw Sample		1.45 Float	Raw Sample	1.45 Float
			As Rec'd	As Rec'd	Dry Basis	Dry Basis	1.45 Float	As Rec'd	Dry Basis	Dry Basis	As Rec'd	Dry Basis	Dry Basis	As Rec'd	Dry Basis	Dry Basis	As Rec'd	Dry Basis	Dry Basis		
	W-1	215.7-220.3	4.6	2.5	32.8	33.7	6.2	49.4	22.3	22.8	31.2	42.0	43.1	62.0	0.44	0.46	0.60	9167	9389	12,311	4	8½
	W-2	58.9 - 66.1	7.2	2.2	21.8	22.3	7.3	62.1	24.1	24.6	27.4	51.6	52.8	65.0	0.28	0.28	0.34	11,483	11,750	14,284	4	7½
	W-2	68.6 - 74.3	5.7	2.5	9.9	10.1	4.4	89.8	24.4	25.0	26.9	62.9	64.6	68.4	0.31	0.31	0.33	13,360	13,711	14,731	5	7
	W-2	180.8-184.8	4.0	2.8	25.4	26.1	4.7	67.2	21.1	21.8	26.6	50.3	51.7	68.1	0.42	0.44	0.60	10,885	11,195	14,876	5½	8
C	W-2	345.6-353.2	7.6	2.2	18.0	18.4	6.4	70.8	22.2	22.7	24.9	57.2	58.5	68.2	0.40	0.41	0.49	12,129	12,399	14,397	5	8½
B	W-2	437.9-443.2	5.3	2.4	15.8	16.2	4.1	72.6	21.8	22.4	25.6	59.6	61.0	69.8	0.40	0.41	0.47	12,410	12,726	15,051	7½	8½
	W-2	446.0-457.7	11.7	1.9	7.9	8.1	5.7	84.8	23.9	24.2	24.8	66.1	67.5	69.4	0.25	0.25	0.29	14,057	14,341	14,514	7	8
A	W-2	525.0-528.9	3.9	1.5	14.5	14.7	7.6	72.9	21.3	21.6	22.4	62.3	63.3	69.6	0.37	0.37	0.43	13,014	13,211	14,301	3	4½
Weighted Average for coal coal (Footage analysed 4.6ft-W-1 45.4ft-W-2)			2.2	16.7	17.1	5.8	73.1	22.9	23.4	26.0	57.8	59.2	67.7	0.34	0.35	0.42	12,353	12,619	14,354	5.4	7.7

Note Gradual Decrease in Volatile Matter % (1.45 Float) With Depth.

Coke Oven Charges						
Percentage of Coals In Charge:						
Kakwa Seam B		100			30	
High Volatile Ref. Coal			100		70	30
Low Volatile Ref. Coal				100		70
Proximate Analysis						
Ash %		7.2	4.6	7.0	5.5	5.1
Volatile Matter %		23.4	35.9	19.1	32.1	31.0
Fixed Carbon %		69.4	59.9	73.9	62.4	63.9
Sulphur %		0.41			0.54	0.66
Linear Expansion Bd. 52 lb/ft^3 at 2% moisture %		-4.0	-35.5	+7.0		
Gieseler Plasticity						
Start	°C	431	391	417		
Fusion Temp.	°C	446	403	435		
Max. Fluidity Temp.	°C	462	429	448		
Final Fluidity Temp.	°C	486	475	470		
Solidification	°C	490	478	478		
Melting Range	°C	55	84	53		
Max. Fluidity	dd/m	56	27900	17		
Dilatation						
Softening Temp.	°C	399	351	428		
Max. Contraction Temp.	°C	450	402	452		
Max. Dilatation Temp.	°C	478	440	482		
Contraction	%	25	27	22		
Dilatation	%	28	190	42		
Free Swelling Index		7	7½	8		
Carbonization Data						
Net Weight in Charge	lb	545.7			547.6	520.3
Moisture in Charge	%	3.0			2.9	3.2
ASTM Bulk Density	lb/ft^3	48.5			48.5	48.5
Oven Bulk Density	lb/ft^3	51.3			51.3	50.7
Resultant Coke						
Ash %		8.6			7.3	7.1
Volatile Matter %		0.2			0.4	0.7
Fixed Carbon %		91.2			92.3	92.2
Sulphur %		0.36			0.65	0.55
Carbonization Results						
Gross Coking Time hr:min		9:30			9:00	10:20
Maximum Wall Pressure lb/in^2		0.77			0.35	0.60
Coke Yield Actual %		78.7			73.1	76.9
Mean Coke Size, in		2.02			1.93	2.23
Apparent Spec. Gravity		0.933			0.893	0.89
Percentage -½" (Breeze)		3.0			3.0	3.4
Tumbler Test (ASTM)						
Stability Factor		58.8			51.7	53.7
Hardness Factor		69.8			65.6	69.7
Japanese Tumbler Test (JIS) (cumulative percentage retained on)						
50 mm sieve		22.5			13.0	14.1
25 mm sieve		90.4			87.5	85.2
15 mm sieve		95.1			92.9	91.6

Tab. 58 : Coke Oven Test Results, Kakwa River Seam B, plus High Volatile Reference Coal.

Pit	Raw Coal	Raw Coal Ratio (to 1)	Net Clean Coal	Clean Coal Ratio (to 1)	Plant Recovery	Total Bank Cubic Yards Overburden
Isolation Ridge	5,512,717	8.41	3,744,903	12.38	75.46	46,369,370
Isolation South	10,040,951	10.22	7,158,201	14.23	79.21	101,891,970
Honeymoon	5,014,692	9.14	3,168,307	14.47	70.20	45,843,000
Subtotal - North Pits	20,568,360	9.47	14,071,411	13.79	76.00	194,104,340
Coal Top	26,706,015	8.30	17,658,782	12.48	73.47	220,356,700
Outlook Ridge	3,706,757	4.20	2,191,207	7.10	65.68	15,553,496
Subtotal - South Pits	30,412,772	7.80	19,849,989	11.89	72.51	235,910,196
TOTAL - ALL PITS	50,981,132	8.83	33,921,400	12.68	74.35	430,014,536

Tab. 59 : Open Cut Coal Reserves, Isolation Ridge

For the open pit mining loss, a figure of 5% was applied. The same figure was used for loss of oxidized coal. As can be seen in Tab. 59, the total open pit recovered clean coal amounts to 34 million lgt clean coal with an overburden ratio of 8.83 : 1 (bcyd : lgt raw coal) or 12.68 : 1 (bcyd : lgt clean coal).

The hydraulic potential to drainage level is 200 lgt raw coal or approximately 100 million tons clean coal.

4.20.3 COAL QUALITY AND COKE OVEN TESTS

The average clean coal quality to be expected is shown in Tab.60 . The high weighted average of 0.37% P_2O_5 or 0.16% P is the factor which makes the deposit uninteresting for us.

Pit	Inherent Moisture %	Ash %	Volatile Matter %	Sulphur %	Cal. Value BTU/LB	P_2O_5
Isolation Ridge	0.38	7.13	20.43	0.63	14 630	0.36
Isolation Ridge South	0.50	7.53	18.74	0.57	14 396	0.46
Honeymoon	0.45	0.69	18.83	0.67	14 024	0.26
Average North Pits	0.46	7.91	19.21	0.61	14 375	0.39
Coal Top	0.48	8.49	20.63	0.51	14 179	0.37
Cutlock Ridge	0.70	10.02	20.85	0.55	13 884	0.27
Average South Pits	0.50	8.66	20.65	0.51	14 146	0.36
TOTAL ALL PITS	0.48	8.35	20.05	0.55	14 241	0.37

Tab. 60: Weighted Average of Clean Coal Quality, Isolation Ridge

The results of the coke oven tests are listed in Tab. 61. It is obvious, that the coal can most likely only be used as a blending coal. Blending of coal material of all adits with high volatile reference coal has a negative influence on the coke stability. The results reflect only the quality of Seam No. 7, which comprises 77.1% of the total reserves. Data on Seam No. 8 were not received.

COMPONENT COALS IN CHARGE (% by wt. on db)								
Composite Sample (incl. adit No.1)								100
Adit 3A = Seam 7 Lower		100						
Adit 4 = Seam 7 Upper			100					
Adit 5 = Seam 7 Upper				100				
Adit 6A = Seam 7 Upper					100			
Adit 6B = Seam 7 Upper						100		
Adit 6C = Seam 7 Lower							100	
Reference Hv Coal								
GIESELER PLASTICITY								
Start	°C	443	448	462	437	434	442	
Fusion Temp.	°C	-	461	-	449	448	453	
Max. Fluid Temp.	°C	467	468	477	465	463	466	
Final Fluid Temp.	°C	482	486	484	488	487	484	
Solidification Temp.	°C	488	495	490	492	492	490	
Melting Range	°C	39	38	22	51	53	42	
Max. Fluidity	dd/m	2.9	8	2.5	80	65	9.2	
DILATATION								
Softening Temp.	°C	428	434	437	422	407	402	
Max. Contraction Temp.	°C	500	477	475	466	456	451	
Max. Dilatation Temp.	°C	500	503	497	494	479	471	
Contraction	%	24	25	22	27	26	27	
Dilatation	%	NIL	4	-8	41	21	15	
FREE SWELLING INDEX		3½	7	6	8	6½	5	
CARBONIZATION DATA								
Net Weight in Charge	lb	527.9	527.8	524.8	526.6	517.3	515.1	518.4
Moisture in Charge	%	3.2	3.1	3.2	3.4	3.4	3.3	2.9
ASTM Bulk Density (Wet)	lb/ft^3	48.5	48.5	48.5	48.5	48.4	48.5	48.5
Oven Bulk Density (db)	lb/ft^3	51.5	51.5	51.2	51.2	50.6	50.4	50.9
CARBONIZATION RESULTS								
Gross Coking Time	hr:min	9:45	9:35	9:30	9:15	8:40	8:50	8:45
Max. Wall Pressure	lb/in^2	0.44	0.66	0.66	0.52	0.31	0.30	0.99
Coke Yield Actual	%	76.9	77.5	75.4	76.5	78.5	77.7	78.8
Mean Coke Size	in	2.04	2.11	1.71	1.94	1.94	2.03	1.93
Apparent Spec. Gravity		0.971	0.943	0.909	0.910	0.957	0.952	0.928
PERCENTAGE -½ Inch (Breeze)		10.8	4.4	11.6	4.2	3.7	4.4	4.4
TUMBLER TEST (ASTM)								
Stability Factor		48.3	57.2	53.5	55.3	50.3	48.4	54.5
Hardness Factor		59.7	68.1	64.5	69.2	70.0	66.1	69.3
JAPANESE TUMBLER TEST (JIS) (cumulative percentage retained on)								
50 mm Sieve		13.7	6.8	26.6	13.5	18.9	10.8	13.6
25 mm Sieve		79.7	84.6	87.0	88.8	85.0	87.8	87.3
15 mm Sieve		86.5	92.1	90.9	94.3	93.4	92.6	93.8

Tab. 61 : Coke-Oven Test Results, Isolation Ridge

4.21.2 COAL RESERVES

The open pit coal reserves are tabulated in the following Tab. 62. The overburden ratio of the Big Pit area, which accumulates the bulk of the reserves is relatively high and calculates to 10.7 : 1 (bcyd : 1 lgt raw coal) or 9.56 : 1 (bcyd : 1 sht raw coal). That applies to the leased reserves. Taking all small pits into consideration the ratio can not be decreased considerably and remains at 10.3 : 1 (bcyd : 1 lgt raw coal).

4.21.3 COAL QUALITY

For the quality information, the quality summary of Paul Weir Company is copied here. Further information on the seams characteristics are stated in Tab. 63, which was compiled by Mr. Jaro Horacek. The coals do not form a useable coke by themselves, but blending with high volatile coal may produce a satisfactory coke. This statement is only indicated by the JIS + 15mm drum index and not by the ASTM-Tumbler Test.

4.21.4 PAUL WEIR COMPANY QUALITY SUMMARY

Findings from the analyses and testing of cores, cutting and adit samples of the Copton area coal seams can be summarized as follows:

1. Seam identification is possible by the use of sulfur, F.S.I. and dry MMF volatile matter of the 1.40 Float fractions of the diamond drill core samples. Reverse circulation hole cuttings are considerably less reliable.

2. Although the F.S.I. and volatile matter tend to increase with the upper seams over the lower seams, variations can be found over the geographical area. All the seams can be classified by ASTM Standards as of low volatile rank.

3. Dry, mineral-matter-free Btu values are high, running 15,700 to 15,822. Volatile matter on the same basis runs from 17.15 to 18.58 percent.

4. Ash content at 1.40 (considered the lowest practical washing gravity) runs from 4.17 to 5.64 percent, depending on the seams, and total sulfur from 0.34 to 0.62 percent. The No. 4 Seam sulfur averages 0.34 percent. The raw coal ash averages 19.2 percent.

5. F.S.I. for the No. 4 Seam averaged (D.D. cores) 4; the No. 5 Seam, 5-½; the No. 6 Seam, 7; the No. 7 Seam, 5; and the No. 8 Seam, 8; all on 1.40 float coal. The composite of Nos. 5, 6 and 7 in the Big Pit to be mined was 5-½ and the total for the Big Pit was 5, based upon core analyses. The adit samples were lower in F.S.I., averaging only 3-½ for Seam No. 4; 4-½ for Seam No. 5; and 3-½ for composite Seams Nos. 6, 7 and 9. All adit samples were at approximately a 7.0 percent ash level.

6. Gieseler fluidity in all cases, except for the small amount of No. 8 Seam, was low, running not over 1.9 and the No. 8 Seam was erratic, ranging from 1.7 to 25.3 DDPM.

7. Tests show all the seams to be friable coals with Hardgrove grindabilities of 86 to as high as 126.

8. The ash fusion temperatures of all seams are high, being 2700°F plus.

9. The mineral analysis of the ash shows P_2O_5 from 1.00 to 2.18 percent. The latter pertains only to Seam No. 5. All seams have a high silica-alumina content. They are characterized by low Fe_2O_3 and CaO-MgO contents.

10. Petrographic analyses by the oil reflectance method show relatively high inerts in relation to reactive macerals.

Due to the variable weathered nature of the vitrinites, it was found impossible to make normal coke strength predictions.

11. Big Pit analyses compared to the overall Copton area show good agreement and indicate overall uniformity of product. Close agreement between the "Zone 7" Seams (5 to 8) and the No. 4 Seam analyses should simplify the blending of these coals. This is further evident in the sizing and washability analyses.

12. Coking tests indicate that Copton coals cannot be coked by themselves, but when properly blended with high volatile coals, can make a satisfactory strong coke.

13. Possible yields, ash, sulfur and Btu values are as follows:

a. Raw Coal (dry basis) using 4 percent dilution factor in mining

Ash, %	Sulfur, %	Btu
19.2	0.45	12,470

b. Clean (washed coal) dry basis, including 4 percent dilution factor, washing at 1.65 specific gravity:

Yield, %	Ash, %	Sulfur, %	Btu
79.9	7.2	0.44	14,518

c. Clean (washed coal) dry basis, including 4 percent dilution factor, washing at 1.40 specific gravity:

Yield, %	Ash, %	Sulfur, %	Btu
68.2	4.8	0.43	14,928

Analyses and Tests

SUMMARY SEAM No. ALL SEAMS - Individually

BASIC SEAM DATA

SIGNIFICANCE	No 4 Seam - major; 5A, 5B from No 7 Zone
THICKNESS AVE	as shown
THICKNESS RGE	

RESERVES

BIG PIT AREA	IN PLACE			
LONG TON-10³	110995	98% * 85%	97351	
METRIC TON-10³				
MINING METHOD	TRUCK AND SHOVEL			
POTENTIAL PRODUCTION	from 2 up to 5 x 10⁶ L tons during 25 years			

* 96% for No 4 SEAM
85% for No 7 ZONE

SOURCE OF DATA: ZAP
OTHER REFERENCES: by Paul

AUTHOR OF SUMMARY: Jan Horscheck
DATE: March 1974

QUALITY DATA

KIND OF SAMPLE	AVERAGE OF	A & K.H.	A & K.H.	KH & DH.	A & K.H.	D.H.	
SEAM		4	5	6	7	8	6+7+8
SEAM THICKNESS		20+	4.7	4.1	6.6	2.5	19.1
SAMPLE RECOVERED							

RAW COAL

PARAMETER	UNIT						
PROXIMATE ANALYSIS							
MOISTURE as received	%						
ASH	%	10.94	13.15	14.98		25.15	22.32
VOLATILE MATTER	%	16.22	15.91				15.74
FIXED CARBON	%						
CALORIFIC VALUE	BTU/lb	13848	13342				11898
SULPHUR	%	0.42	0.64				0.56
FSI		3½	4½				3½

WASHED COAL

SEPARAT. SPECIF GRAVITY		1.49	1.52	1.40	1.45	1.40	1.51
YIELD	%	78.0	78.7	69.9	71.4	52.00	65.3
PROXIMATE ANALYSIS							
MOISTURE (as received)	%	1.27	0.98	0.95	0.98		
ASH	%	5.75	5.13	3.66	6.60	5.18	7.3
VOLATILE MATTER	%	16.86	17.17	17.75	17.45	18.13	17.6
FIXED CARBON	%	77.25	77.18	78.75	75.93		
CALORIFIC VALUE	BTU/lb	14741	14883	15157	14785	14851	14521
SULPHUR	%	0.34	0.68	0.61	0.44	0.61	0.51
FSI		4	6	7	4½	8	4½
ULTIMATE ANALYSIS (dry basis)							
CARBON	%	84.42	84.91				83.61
HYDROGEN	%	4.20	4.23				4.28
OXYGEN	%	2.68	2.71				2.59
NITROGEN	%	1.09	0.98				1.05
CHLORINE	%	0.10	0.10				0.06
DRY MINERAL MATTER FREE							
VOLATILE MATTER	%	17.32	17.51	17.98	17.67	18.58	
CALORIFIC VALUE	BTU/lb	15750	15806	15808	15794	15749	
ASH ANALYSIS	%						
P_2O_5	%	0.01	1.61	0.91	1.69		1.09
S, O_2	%	55.00	56.61	59.85	62.17		58.73
Al_2O_3	%	28.66	27.18	26.34	24.08		23.38
Fe_2O_3	%	3.15	3.97	3.41	1.60		4.27
Ca O	%	4.66	4.36	3.16	4.44		5.22
Mg O	%	0.73	0.98	1.09	0.60		0.83
FUSIBILITY OF ASH							
SOFTENING TEMPERATURE	°F	2770+	2715+	2700+	2640		2610
FLUID TEMPERATURE	°F	2700+	2750+	2750+	2750+		
T 250	°F	3000	2975	3000+	3000+		3000+
HARDGROVE GRINDABILITY		986	107.15	970	940		944

PLASTIC PROPERTIES

GIESELER PLASTICITY							
INITIAL TEMPERATURE	°C	452	450	426	448		
TEMP AT MAX FLUIDITY	°C	470	469	464	471	471	479
FINAL TEMPERATURE	°C	482	485	477	485		
MELTING RANGE	°C	30	35	51	37	52	
MAXIMUM FLUIDITY	ddpm	0.7	1.05	1.35	2.32	1.7+ 25.5	1.69
AUDIBERT-ARNU DILATATION							
MAXIMUM CONTRACTION	%	-21	-28		-28		-27
MAXIMUM DILATATION	%	-21	-28				-27
TEMP AT MAX CONTRACTION	°C	480	476		472		471

COKE PROPERTIES

COKING PRESSURE	psi	0.90	2.91		2.75		2.84
COKE YIELD	%	81.58	80.45		81.48		81.05
SCREEN TEST - retained at 2"	%	51.72	67.05		66.05		68.58
SHATTER TEST - retained at 2"	%	61.6	64.2		64.87		65.88
ASTM TUMBLER STABILITY	%	39.15	45.23		46.65		46.05
JIS DRUM TEST on 15mm.		79.73	88.47		87.65		88.20
APPARENT SPECIF. GRAVITY		0.95	0.92		0.93		0.93
POROSITY	%	50.07	51.63		50.53		50.35

PETROGRAPHIC ANALYSES

MEAN MAX REFLECTANCE							
ALL VITRINITES		1.67	1.67				
VITRINOIDS		1.66	1.65				
PSEUDOVITRINOIDS		1.72	1.70				
MACERAL CONTENT							
VITRINOIDS	%	54.4	52.53				
PSEUDOVITRINOIDS	%	18.3	24.4				
INERT CONTENT							
EFFECTIVE INERTS	%	29.91	29.25				
WEATHERED VITRINITES	%	10.9	33.8				
MEASURED COKE STABILITY		39	46				

At present, there is insufficient data to form any definite conclusions on the merit of the area and exploration should be continued.

A summary of the coal quality is given by Mr. D. F. Symonds, Birtley Engineering (Canada Ltd.,), which is submitted as follows. (The important conclusions are underlined):

Seam B:

This seam represented the most promising overall prospect in terms of coal quality. Excellent yield values of approximately 90% can be expected at 2 - 3% ash and 22.0% volatile (dmmf basis). Good swelling properties were also encountered in the composite analyses.

However, the upper part of Seam B in hole number 4 did give poor FSI readings. The macroscopic petrographic analysis indicated that this depressed value was due to petrography rather than any oxidation. The sulphur content values for this seam were above average.

SUMMARY:
- Excellent yield-ash characteristics
- Low/Medium Volatile Content
- Good FSI
- Above average sulphur for W. Canada, but still less than 1.0%.

Seam C

It is noticeable with Seam C, that not only is there a high proportion of inert material occurring as bands within the Seam, but that much of this material remains locked within the coal itself,

even after washing and subsequent sink-float analysis. The result is that the overall yield-ash characteristics of this seam are poor. The sample from hole 5, however, is the exception giving a yield of 90% at a clean coal ash content of 4%.

N.B. The clean coal composite results appear worse than they actually are, because in holes 3 and 5 the raw fines were added into the clean coal sample, rather than the more desirable froth flotation concentrates.

The swelling characteristics of Seam C were generally good, although the low value encountered in Samples 1-A and 3-C may give some cause for concern.

SUMMARY: Yield-ash characteristics: poor
Low/Medium Volatile Content
Average FSI
Average Sulphur

Seam D

It appeared that the distinct banding of coal and shale that occurred for Seam D, in hole 2, graded into a more uniform inferior coal in hole 4. Regrettably, the good characteristics of the individual bands in hole 2 are destroyed when the whole section is considered as one seam. The FSI values are generally good.

SUMMARY: Yield-ash characteristics: poor
Low/Medium Volatile Content
Average FSI
Average Sulphur

Unnamed Seams

Composite Sample C from Hole 1

This sample exhibited excellent yield-ash characteristics, but had very poor swelling properties, which was due to the elevated rank of the coal (16.7% VM (dmmf)).

SUMMARY: Excellent Yield-ash characteristics
Low Volatile Content (Coal is bordering on Semi-Anthracite)
Poor FSI

Composite Sample D from Hole 2

SUMMARY: Poor Yield-ash characteristics
Medium Volatile Content
Average FSI

CONCLUSIONS

The overall characteristics of the coal samples are good. The clean coal ash contents are very low; the volatile content lies in the desirable low to low/medium range and the FSI values are generally acceptable. Unfortunately, the coal seams are broken up by shale bands, which would have to be mined with the coal sections. As a result, the yield-ash characteristics are poor. The results have shown that the coal quality is generally good; the problem, however, is locating uninterrupted seams of economic thickness (greater than 8 feet).

4.23 SAVANNA CREEK DEPOSIT

The Savanna Creek deposit, which is adjacent to the Isolation Ridge deposit, belongs to Bralorne Resources Limited. Our group has not shown any interest in this deposit, because of limited reserves in situ and the likelyhood of high phosphorous content. The seams of Isolation Ridge extend directly into the Savanna Creek property.

4.23.1 LOCATION

The Savanna Creek deposit is located in Alberta, between the towns of Canmore and Coleman, directly north of the Isolation Ridge deposit and approximately 12 miles east of the operating Fording River mine. The railway distance to Robertsbank would be approximately 775 miles.

4.23.2 COAL RESERVES AND COAL QUALITY

Two seams are known in the property, which are called A-Seam and C-Seam. Both seams are dipping 58^{0} and have a combined thickness of 6.7 m. Both seams accumulate 10 million tons in situ of O/C potential and 25 million tons of U/G potential in situ. The O/C potential is calculated on a 10 : 1 (bcyd : lgt) raw coal basis.

The quality of seams known to us is as follows:

SEAM	A	C
Ash%	5	9
Volatile Matter %	22.5 - 23.0	27.0
Inherent Moisture %	1	1
Sulphur %	0.35	0.36
FSI	8½	6½
Fluidity dd/m		38

The washery recovery is estimated to be 75% and the phosphorous content is likely to be high, due to continuation of seams into the Isolation property.