FR-SAXON-74(2)A

1/3

INTERNATIONAL MAP OF THE WORLD 1:1,000,000
CARTE INTERNATIONALE DU MONDE AU 1:1,000,000

PRINCE GEORGE

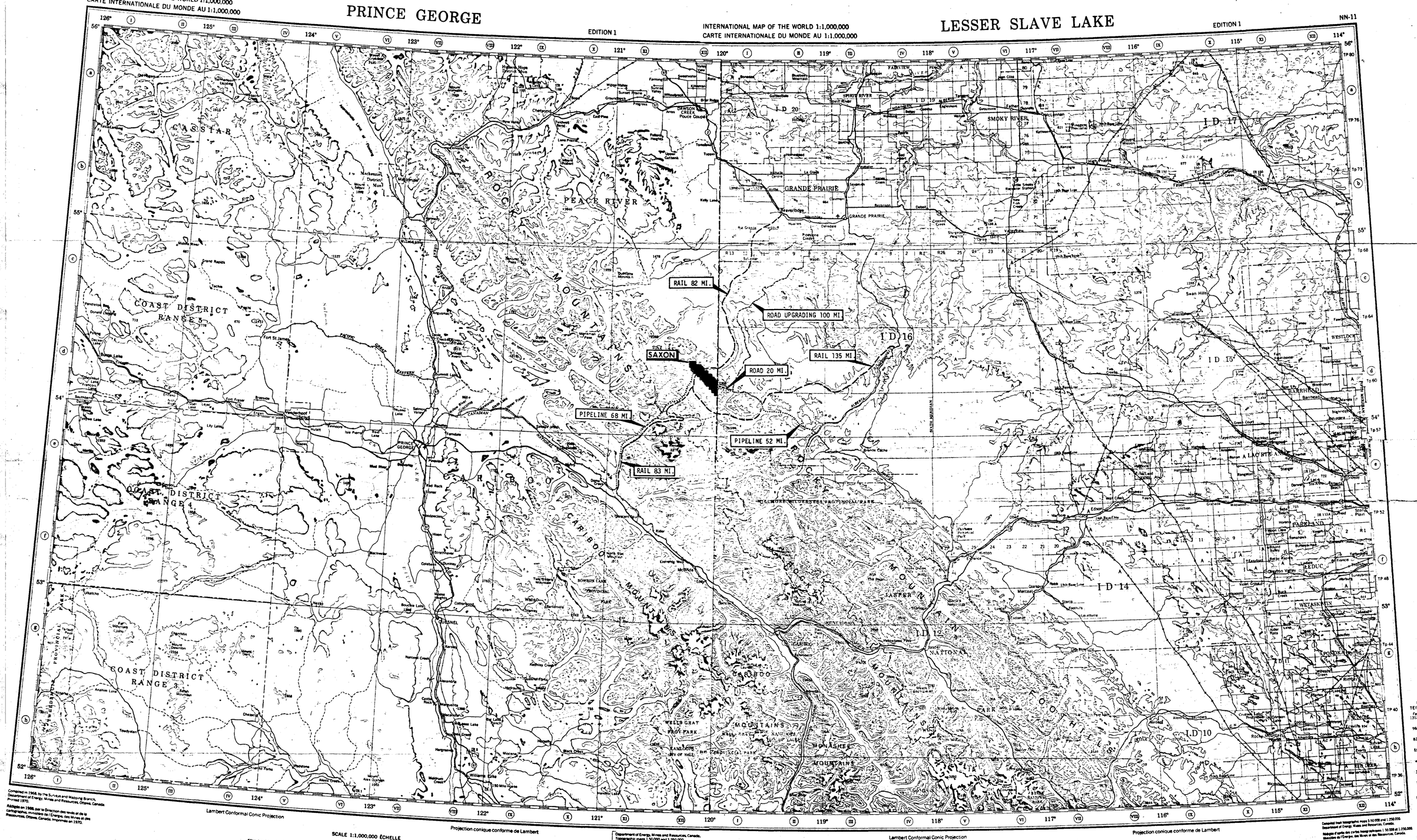
EDITION 1

INTERNATIONAL MAP OF THE WORLD 1:1,000,000
CARTE INTERNATIONALE DU MONDE AU 1:1,000,000

LESSER SLAVE LAKE

EDITION 1

NN-11



Compiled in 1968, by the Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa, Canada.
Printed 1970.

Rédigée en 1968, par la Direction des levés et de la cartographie, ministère de l'Énergie, des Mines et des Ressources, Ottawa, Canada. Imprimée en 1970.

Lambert Conformal Conic Projection

Projection conique conforme de Lambert

SCALE 1:1,000,000 ÉCHELLE

1 inch = 15.78 Statute Miles
1 Pouce = 15.78 Milles terrestres
1 inch = 13.71 Nautical miles
1 Pouce = 13.71 Milles marins

INDEX TO BOUNDARIES
TABLEAU DES LIMITES

ADJOINING SHEETS
FEUILLES ADJACENTES

GRAND CACHE 93-P	FORT NELSON 94-I
PRINCE GEORGE 93-O	PEACE RIVER 93-P
PRINCE RUPERT 103-A	LESSER SLAVE LAKE 83-L
VANCOUVER 92-G	KOOTENAY LAKE 82-I

Compiled from
Rédigée d'après les

Department of Energy, Mines and Resources, Canada.
Topographic maps 1:50,000 and 1:250,000

Department of National Defence, Mapping and Charting Establishment, Canada.
Topographic maps 1:50,000 and 1:250,000

Department of Lands and Forests, B.C., Canada.
Topographic maps 1:250,000

REFERENCE — LÉGENDE

Town, population 5,000 and over	Ville, plus de 5,000 habitants
Town, population 500 - 5,000	Ville, 500 - 5,000 habitants
Town, population under 500	Ville, moins de 500 habitants
Mine	Mine
International Airport	Aéroport international
Other Airfields	Autres aérodromes
Power line	Lignes de transport d'énergie
Pipeline	Pipeline
Elevation (in metres)	Altitude (en mètres)

PRINCE GEORGE
Wells
Clinton

Ces cartes sont en vente au Bureau de distribution des cartes, ministère de l'Énergie, des Mines et des Ressources, Ottawa.

REFERENCE — LÉGENDE

Railway, single track	Chemin de fer, voie unique
Dual highway	Route à deux chaussées séparées
Main highway	Route principale
Secondary road	Route secondaire
Other roads	Autres routes
Trail or track	Sentier ou piste
Ferry	Bac
Boundary, provincial or state	Limite de province ou d'état
Boundary, county or district	Limite de comté ou de district
Boundary, township	Limite de canton
Boundary, park or reserve	Limite de parc ou de réserve
Icefield, glacier	Champ de glace, glacier
Lake, intermittent	Lac intermittent
Marsh or Swamp	Marais ou marécage
Contours (in metres)	Courbes de niveau (en mètres)

Copies may be obtained from the Map Distribution Office, Department of Energy, Mines and Resources, Ottawa.

REFERENCE — LÉGENDE

Railway, single track	Chemin de fer, voie unique
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Lambert Conformal Conic Projection

Projection conique conforme de Lambert

SCALE 1:1,000,000 ÉCHELLE

INDEX TO BOUNDARIES
TABLEAU DES LIMITES

ADJOINING SHEETS
FEUILLES ADJACENTES

93-O	93-P	94-I
83-L	83-M	83-N
82-I	82-J	82-K

REFERENCE — LÉGENDE

Town, population 5,000-25,000	Ville, 5,000-25,000 habitants
Town, population 500-5,000	Ville, 500-5,000 habitants
Town, population under 500	Ville, moins de 500 habitants
Gas or oil field	Champ de gaz ou de pétrole
International airport	Aéroport international
Other airfields	Autres aérodromes
Power line	Lignes de transport d'énergie
Pipeline	Pipeline
Elevation (in metres)	Altitude (en mètres)

GRANDE PRAIRIE
Jasper
Kinuso

Ces cartes sont en vente au Bureau de distribution des cartes, ministère de l'Énergie, des Mines et des Ressources, Ottawa.

HYPSOMETRIC TINTS
TEINTES HYPSOMÉTRIQUES

Feet	Metres
9842	3000
8202	2500
6562	2000
4921	1500
3281	1000
1640	500
656	200

Compiled from topographic maps 1:50,000 and 1:250,000.
Department of Energy, Mines and Resources, Canada.
Rédigée d'après des cartes topographiques 1:50,000 et 1:250,000.
Ministère de l'Énergie, des Mines et des Ressources, Canada.

D7201

D7103

D7102

D7001

D7101

D7202

D7003

D7004

BOULDER CREEK

HULLCROSS

COMMOTION FORMATION

GATES

GETHING

MOOSEBAR

LEGEND

- SANDSTONE
- SILTSTONE
- SHALE
- SILTY, MUDSTONE
- CONGLOMERATE
- COAL
- CARBONIFEROUS SHALE
- MUDSTONE

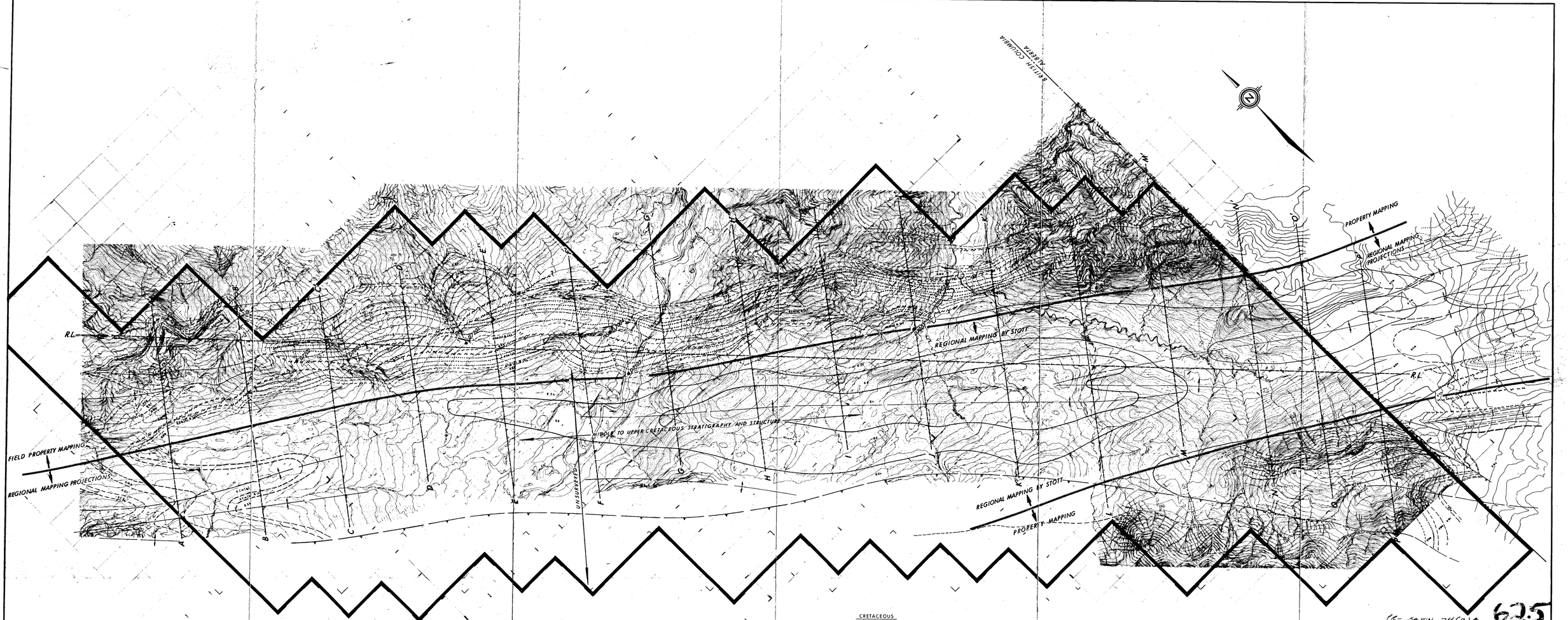
A/C 1/3 625

PR-SAXON 74(2)A

DENISON MINES LIMITED
(COAL DIVISION)
CALGARY ALBERTA

SAXON CORRELATION CHART (2)

DRAWN BY: E. LOTT	DATE: APR. 72	SCALE: 1" = 50'
APPROVED BY:	DRAWING NO: SXON 72-0295 - R03	



0 1000 2000 4000 6000 8000 10000 FEET
0 2 MILES
SCALE

LEGEND

CRETACEOUS

- Kc — Cardium
- Kd — Dunvegan
- Kbh — Shaftesbury formation
- KCm(b) — Commotion formation (Boulder Creek member)
- KCm(h) — Commotion formation (Hultcross member)
- KCm(g) — Commotion formation (Gates member)
- Kmh — Moosebar formation
- Kgh — Gething formation
- Kcd — Cadomin formation
- Kns — Nikanassin formation

- Cross-section lines
- Fault
- Contact (inferred, known)
- DT301 — Drill hole with hole direction
- Anticline
- Syncline
- 35 — Strike and dip
- Inferred coal seam
- Adit with number

Re- SAXON 74-218 625

DENISON MINES LIMITED
(COAL DIVISION)
CALGARY ALBERTA

1/3 SAXON
GEOLOGY (3)

DRAWN BY: E TSTK	DATE: Feb. '74	SCALE: 1" = 2000'
APPROVED BY:	DRAWING NO: SXON 72 - 0332 - R05	

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PR-SAXON 74 (1) A

DENISON MINES LTD.

SAXON PROPERTY 2/3

SUMMARY REPORT - MARCH 1974

CONFIDENTIAL

OPEN FILE

GEOLOGICAL BRANCH
ASSESSMENT REPORT

00 625

2/3

PR-SAXON 74(1)A.

CONFIDENTIAL

DENISON MINES LIMITED
(COAL DIVISION)

SAXON PROPERTY

SUMMARY REPORT

DENISON MINES LIMITED

SAXON PROPERTY

SUMMARY REPORT

A. JOHNSON
MARCH, 1974

SUMMARY

Denison Mines Limited's Saxon property is located in the Province of British Columbia along the well known Rocky Mountain Foothills coal belt from which all Western Canadian coking coal is produced. The property consists of 53 square miles (137 square kilometers) of coal licences situated just West of the border between the Provinces of British Columbia and Alberta. A major water course, the Narraway River, cuts through the centre of the property, providing a good potential transportation corridor as well as easy access to the coal reserves and excellent surface plant sites. The property is located approximately 68 miles (109 kilometers) from the Canadian National Railway at Bend, B. C., and about 100 miles (160 kilometers) from Grande Prairie, Alberta.

Exploration and development work to date has outlined some 264 million short tons of coal in place in seams greater than 10 feet (3.05 m) thick, to a depth of 1,500 feet (457 m). In excess of 40 million short tons of additional coal is available in seams 5 to 10 feet thick (1.5 m to 3.05 m).

Clean coal reserves have been calculated only for a portion of the Narraway River reserve block which contains 86.5 million short tons of indicated reserves. Of this amount 37.8 million tons, or 44%, is expected to be available as clean coal. Using 30% as a conservative estimate for the recovery of the remaining reserves (176 million tons), a total of 90 million short tons of clean coal can reasonably be expected from the presently explored underground reserves of the Saxon property. An additional 20 million tons of stripping coal is expected to be available from the Southern corner of the property. Most of the Western half of the property is virtually unexplored, and coal reserves that may be there may not be as accessible as those in the Eastern half of the property.

The average quality of the clean coal from the Saxon property is expected to be:

Ash	7.42%
Volatile Matter	20.94%
Total Moisture	0.75%
Fixed Carbon	71.40%
Sulphur	0.30-0.50%
F.S.I.	7-7½

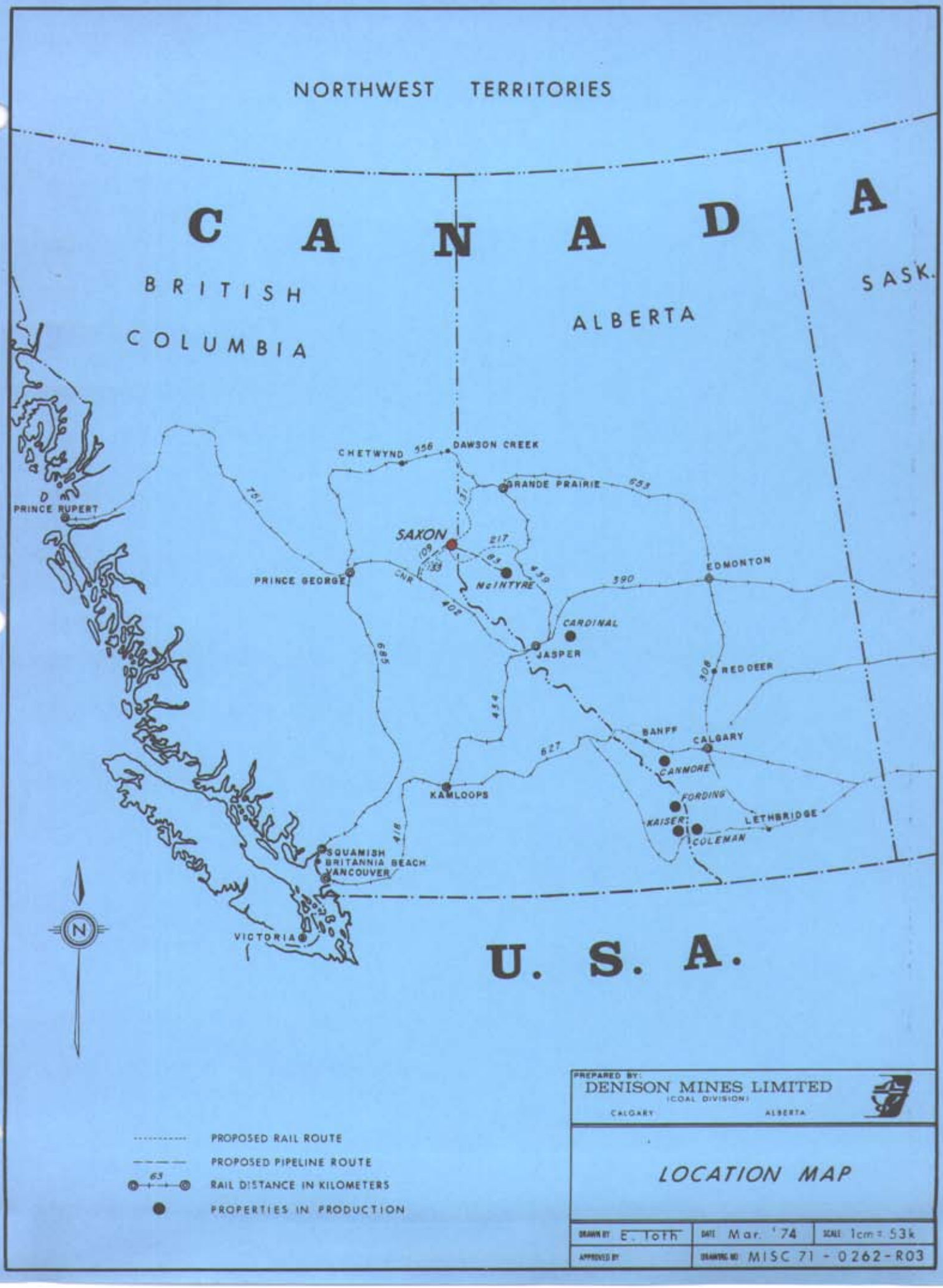
From the washability studies done to date (4 adit samples, numerous drill core samples), it appears that the coal will be cleaned at a specific gravity of about 1.50 to provide the above product at a recovery of about 73%.

Extensive testing of four adit samples by the Department of Energy, Mines and Resources in Ottawa, has shown that the Saxon coals are "premium medium volatile coking coals". In two cases, Saxon coals, blended in a 30/70

proportion with a standard high volatile coal produced coke with physical characteristics equivalent to a similar blend using a premium low volatile American coal. Individual stability factors for the Saxon cokes ranged from 57.4 to 63.0.

Denison's Saxon reserves are ideally suited for exploitation by hydraulic mining. The seams are 10 to 34 feet (3.05 to 10.3 meters)thick, dip 40 to 60 degress, and are easily accessible from the valleys of the Narraway River and Saxon Creek. From the Narraway site, the coal can be easily transported by pipeline to the Canadian National Railway where facilities for cleaning and loading the coal can be developed in an area where manpower is readily available.

The Saxon property is capable of producing at least 2 million and perhaps up to 4 million tons of premium quality medium volatile coking coal per year. The ability of this coal to replace, in part, premium low volatile coking coal in blast furnace blends, makes it particularly valuable in the international coal market.


NORTHWEST TERRITORIES
CANADA
BRITISH COLUMBIA
ALBERTA
SASK.
CHETWYND
556
DAWSON CREEK
GRANDE PRAIRIE
553
PRINCE RUPERT
751
SAXON
217
109
133
85
439
PRINCE GEORGE
CNR
402
McINTYRE
390
EDMONTON
CARDINAL
JASPER
585
308
RED DEER
454
BANFF
CALGARY
627
CANMORE
KAMLOOPS
FORDING
KAISER
LETHBRIDGE
COLEMAN
418
SQUAMISH
BRITANNIA BEACH
VANCOUVER
VICTORIA
N
U. S. A.
PROPOSED RAIL ROUTE
PROPOSED PIPELINE ROUTE
63
RAIL DISTANCE IN KILOMETERS
PROPERTIES IN PRODUCTION
PREPARED BY:
DENISON MINES LIMITED
(COAL DIVISION)
CALGARY
ALBERTA
LOCATION MAP
DRAWN BY E. Toth
DATE Mar. '74
SCALE 1cm = 53k
APPROVED BY
DRAWING NO MISC 71 - 0262 - R03

PROPERTY, LOCATION AND ACCESS

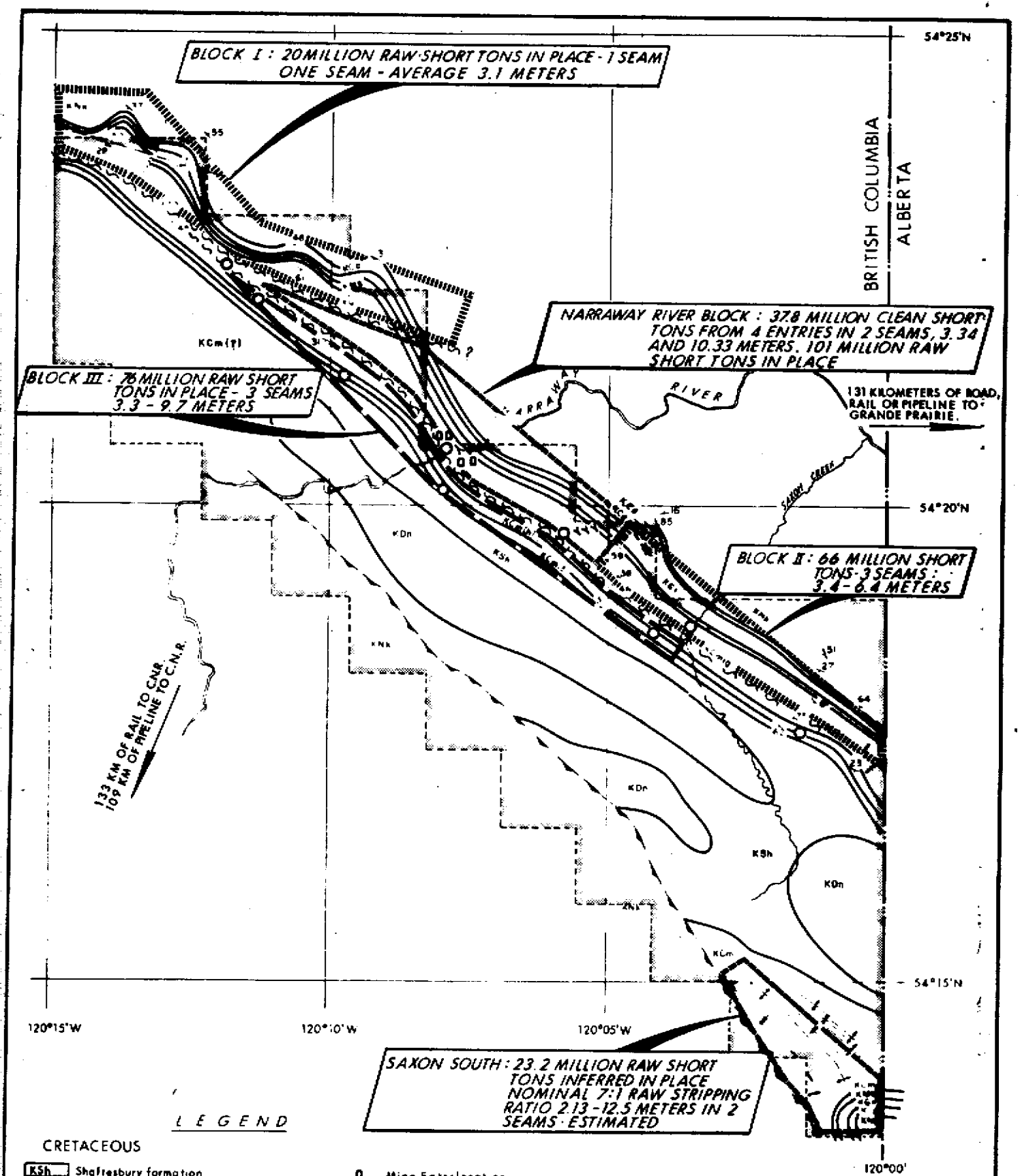
The Saxon property consists of 53 British Columbia Coal Licences acquired by Denison Mines Limited in the fall of 1970. Each licence is approximately one square mile in area (2.59 square kilometers). The Eastern boundary of the property is coincident with the British Columbia/Alberta boundary, about 50 miles (80 km) Northwest of Grande Cache, Alberta. The property was located to cover exposures of the Upper Cretaceous Commotion and Gething Formation, which are the main coal bearing horizons in this part of the Rocky Mountain Foothills coal belt.

Since Denison acquired the Saxon property, nine HQ, wireline diamond holes, totaling 9,871 feet, have geen drilled on the property to test the commotion stratigraphy and the geological structure, as outlined by preliminary geological mapping. In addition, four adits have been driven to obtain bulk samples from the seams for full tests on the coking characteristics of the Saxon coals.

The centre of the Saxon property is transected by the broad valley of the Narraway River. This valley forms the main transportation corridor for potential routes going both East and West from the property. To the West, the headwaters of the Narraway River meet those of Jarvis Creek at Gray Pass. The route to Gray Pass and from Gray Pass through Jarvis Creek, the McGregor River Valley, and Walker Creek, to Bend, B.C., is moderately good for rail construction, but Gray Pass itself forms a significant obstacle that would require some 15 miles (24 km) of extra rail construction compared to a pipeline route. This is one reason that a pipeline has been recommended for this Western route. Other rail and pipeline routes, both East and Southeast have been considered but they are not politically appropriate and result in much longer total transportation routes than the Western route. These local transportation options are illustrated on the map in the back packet of this report.

The pipeline distance from the property to the railhead (Bend, B.C.) is 68 miles (109 km). From there, there are three alternate routes to the Pacific coast: by Canadian National Railway to Vancouver (612 miles - 984 km); by Canadian National Railway to Prince Rupert (554 miles - 891 km); or by Canadian National Railway to Prince George, B.C., then by British Columbia Railway to Squamish, B.C. (513 miles - 825 km). No decision has yet been made as to which route would be most suitable. These routes are shown on the map on the preceeding page.

The Saxon project is almost equidistant from Grande Prairie, Alberta, Prince George, B.C. and Hinton, Alberta. These three population centres will provide most of the manpower for the project. Hinton is the supply centre for the Cardinal River Coal Mine and the McIntyre Porcupine Mine, as well as the pulp and paper industry. Grande Prairie also supports the pulp industry as well as a large farm population while Prince George is the major industrial centre of Northern British Columbia (mining, lumber, pulp and paper, and railways).


BLOCK I : 20 MILLION RAW SHORT TONS IN PLACE - 1 SEAM
ONE SEAM - AVERAGE 3.1 METERS
54°25'N
BRITISH COLUMBIA
ALBERTA
NARRAWAY RIVER BLOCK : 37.8 MILLION CLEAN SHORT TONS FROM 4 ENTRIES IN 2 SEAMS, 3.34 AND 10.33 METERS. 101 MILLION RAW SHORT TONS IN PLACE
BLOCK III : 76 MILLION RAW SHORT TONS IN PLACE - 3 SEAMS 3.3 - 9.7 METERS
NARRAWAY RIVER
131 KILOMETERS OF ROAD, RAIL OR PIPELINE TO GRANDE PRAIRIE.
SAXON CREEK
54°20'N
BLOCK II : 66 MILLION SHORT TONS - 3 SEAMS : 3.4 - 6.4 METERS
133 KM OF RAIL TO C.N.R.
109 KM OF PIPELINE TO C.N.R.
54°15'N
120°15'W
120°10'W
120°05'W
120°00'
SAXON SOUTH : 23.2 MILLION RAW SHORT TONS INFERRED IN PLACE NOMINAL 7:1 RAW STRIPPING RATIO 2.13 - 12.5 METERS IN 2 SEAMS ESTIMATED
KCm(f)
KDn
KSh
KNk
KCm
LEGEND
CRETACEOUS
KSh Shaftesbury formation
KCm(b) Commotion formation (Boulder Creek member)
KCm(h) Commotion formation (Hulcross member)
KCm(g) Commotion formation (Gates member)
KMb Moosebar formation
KGr Gething formation
KCd Cadomin formation
KNk Nikanassin formation
KDn Dunvegan formation
Mine Entry location
Adit location
Drill Hole location
Dip & Strike
Faults
Syncline
Anticline
Denison's property
Fault
TONNAGES IN PLACE CALCULATED FOR SEAMS GREATER THAN 3 METERS
DENISON MINES LIMITED
(COAL DIVISION)
CALGARY ALBERTA
SAXON GEOLOGY
Drawn by: E.J.T.
Date: Mar. '74
Scale: 1:100,000
Approved by:
Drawing No: SXON FI-0[illegible]-[illegible]

GEOLOGY AND RESERVES

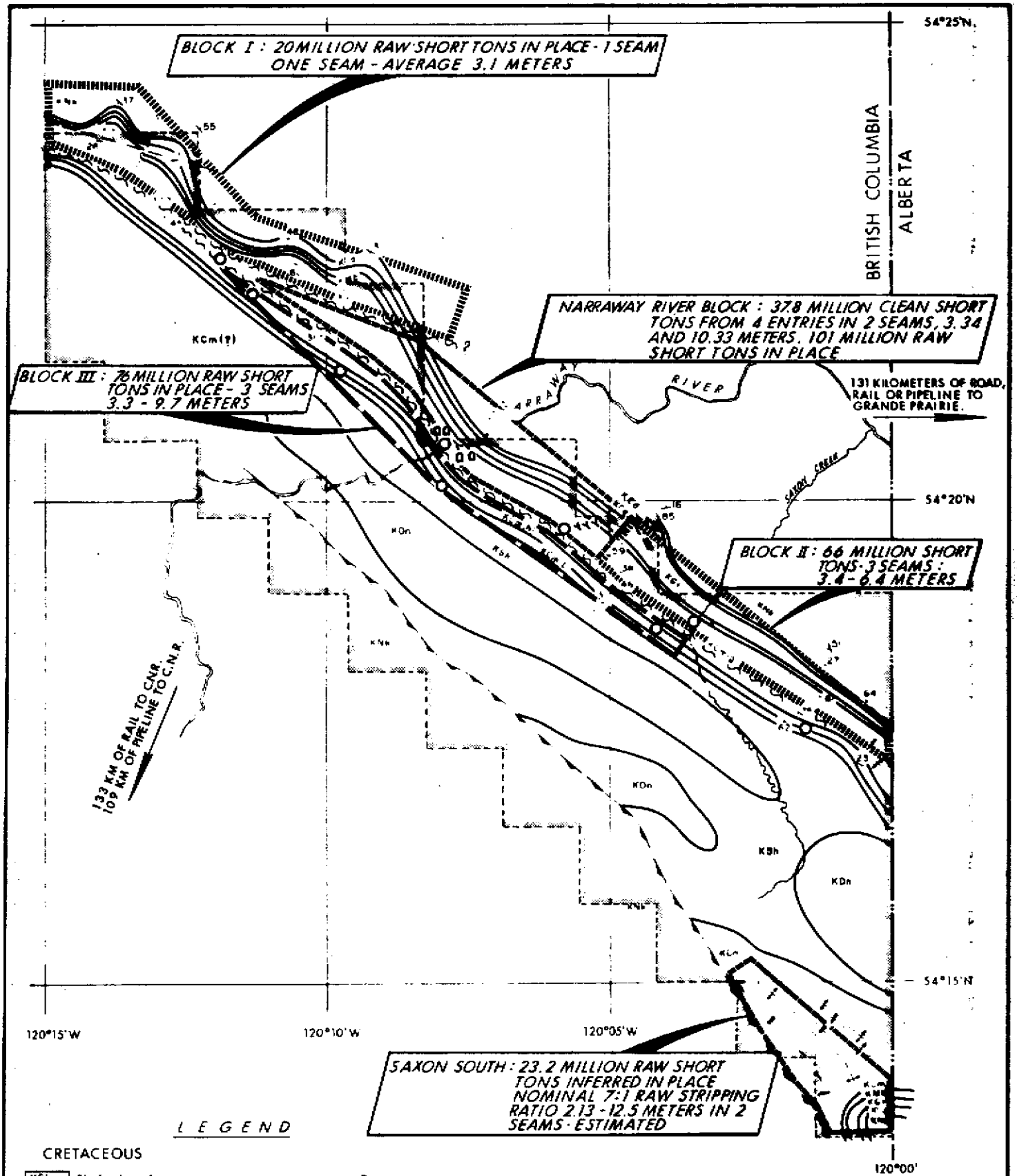
All of the coal reserves discovered to date on the Saxon property have been found in the Gates Member of the Commotion Formation. The formation strikes Northwest, dips 40 to 60 degrees to the West, and outcrops along the Eastern side of the property where it transects, and forms the basis of, a number of mountains in the Foothills belt. It also occurs in the Southern corner of the property where it is severely folded and again forms prominent hills.

There are two major repetitions of the Commotion Formation which are thrust one on top of the other in the Eastern part of the property. This fault and smaller, related faults, form the main boundaries of the coal reserve blocks as shown on the map on the following page.

The coal reserves which are outlined below are all in the inferred category, except for 86.5 million tons of the total 101 million tons of reserves in the Narraway River block. These indicated reserves are located within an area 5,000 feet North and 5,000 feet South of the Narrawy River which has been most intensively explored (3 drill holes, 4 adits).

Assuming that each of seams A and B could be mined from two entries, one North of the river and one South of it, the quantity of clean coal that would be available from these reserves has been calculated. This calculation assumes that the true plant recovery would be 4% less than the theoretical, that the reserves should be reduced by 15% for possible geological error, and then mining recovery would be 70%. The result is that 37.8 million of the 86.5 million tons or 44% of the coal should be available as net clean coal from this area. Using this calculation as a guide, and reducing the net recovery to 30% to account for additional uncertainty in the remaining inferred reserves, in this block and the other block, a further 52.7 million tons of clean coal is estimated to be available from the Saxon property. This is a total of some 90 million short tons of clean coal.

Reserves		Millions Short Tons	
Block I			
Inferred:			
Seam A	9.0-11.5 ft.	20.2	
		Total	20.2
Narraway River Block			
Indicated:			
Seam A	11.8-34.0 ft.	52.6	
Seam B	11.0-14.2 ft.	33.9	
	Total	86.5	
Inferred:			
Seam A	11.8 ft.	6.9	
Seam B	14.2 ft.	7.9	
	Total	14.8	
		Block Total	101.3



LEGEND

CRETACEOUS

- KSh — Shaftesbury formation
- KCm(b) — Commotion formation (Boulder Creek member)
- KCm(h) — Commotion formation (Hullcross member)
- KCm(g) — Commotion formation (Gates member)
- KMb — Moosebar formation
- KGt — Gething formation
- KCs — Cadomin formation
- KNk — Nikanassin formation
- KDn — Dunvegan formation

- Mine Entry location
- Adit location
- Drill Hole location
- Dip & Strike
- Faults
- Syncline
- Anticline
- Denison's property
- Fault

TONNAGES IN PLACE CALCULATED FOR SEAMS GREATER THAN 3 METERS

DENISON MINES LIMITED
(COAL DIVISION)
CALGARY ALBERTA

SAXON GEOLOGY

Drawn by: E.J.T.	Date: Mar. '74	Scale 1:100,000
Approved by:	Drawing No: SXON 71-0180-R02	

Reserves (cont.)

Block II		Millions Short Tons (cont.)	
Inferred:			
Seam A	16.8 ft.	11.9	
Seam B	13.9 ft.	10.5	
Seam D	11.2-21.0 ft.	43.0	
		Total	66.3
Block III			
Inferred:			
Seam A	11.8-32.0 ft.	31.5	
Seam B	11.0-14.2 ft.	23.4	
Seam D.	11.2-21.0 ft.	21.3	
		Total	76.2
		Total in place reserve	264.0

In addition to the above reserves, there is estimated to be in excess of 40 million tons of coal in place in seams 5 to 10 feet thick. In the Southern corner of the property, where the Commotion Formation is steeply folded, there is also expected to be some 20 million tons of coal in place which can be strip mined at a raw coal ratio of 7:1.

COKE AND BLEND TESTS

Four bulk samples were taken from adits in the Narraway River Block and shipped to the Metals Reduction and Energy Centre of the Department of Energy, Mines and Resources in Ottawa. These samples were completely analyzed and 500 lb lots were tested in a 12.5 inch, moveable wall oven. Charges consisted of 100% Saxon coal and blends of 30% Saxon coal with 70% standard high volatile coal. The results of these tests are available in a separate confidential report issued by the Centre. Some photographs of selected coke samples from these tests are presented in Appendix I.

In summary, the Saxon material was found to be a low sulphur, premium, medium volatile coking coal. The ash in the samples shipped averaged 6.8%. Phosphorous in the ash was 1.1% (0.03% P) and the alkaline level in the ash was 2.0% (0.14% in coal).

A summary of the physical properties of the coke produced from the Saxon coals and their blends is given in Appendix II. Two of the samples of Saxon coal produced blends that were equivalent to those produced by blending the same standard high volatile coal with a premium low volatile coking coal from the United States. Both of the other Saxon coals also performed well. Individual stability factors for the Saxon cokes ranged from 57.4 to 63.0

HYDRAULIC MINING

Hydraulic mining is the system most likely to be used to extract the majority of the coal on the Saxon property. This system has been in use for over 100 years. In the last 20 years it has been perfected in Britain, Germany, Japan and Russia. The most recent successful installation has been in British Columbia where production has exceeded the most optimistic predictions.

Two sketches have been prepared to show the essential differences between a normal, flat seam mining operation using continuous miners and a mining section in a steep seam equipped for mining with the hydraulic monitor.

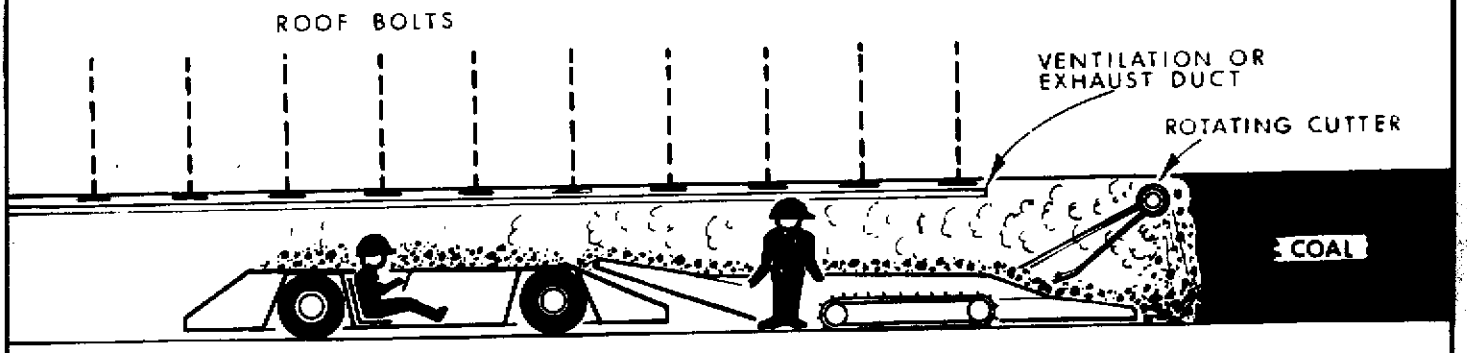
The hydraulic system is particularly suitable in the steeper, thicker seams of coal so common in the Rock Mountain Foothills. The method used consists of driving roadways in the coal near the bottom of the coal seam and then using a hydraulic monitor to cut out the coal above. The cut coal and water is sized in a feeder-breaker and then allowed to flow to a collecting point either inside or outside the mine. Normally, only two men are used on the monitor (with additonal support personnel well back from the mining face) and each monitor produces in the order of 2,000 tons in a shift.

Another main advantage of the hydraulic system is that it removes more coal from a seam than conventional mining techniques. For example, where only 20 per cent of a 40 foot seam might be removed conventionally, 50 to 70 per cent will normally be extracted hydraulically. The reduction in development costs is obvious.

The safety aspect of the system is also improved because: most roadways are supported by steel arches; the monitor is swung by hydraulic cylinders controlled from a manned station, under steel and well away from the mining area; all dust is suppressed by the large amounts of water used; the explosion hazard is reduced since no sparks are produced by cutter picks breaking the coal; and a large quantity of coal comes from one place and the ventilation can be concentrated there.

Although hydraulic mining may be considered a new technique in some mining districts, and, as with all mining systems, it will require modification and adjustments before it work effectively in any given situation, there is now ample evidence that this method will have a very marked effect on the economics of coal mining the the Rocky Mountain Foothills. In addition to the one, very successful, mine now operating, at least three other companies have hydraulic mines in the development or planning stages.

There is little doubt that the Saxon property with it's coal seams 10 to 34 feet (3.05 to 10.3 meters) thick is also an excellent candidate for development with this mining technique.

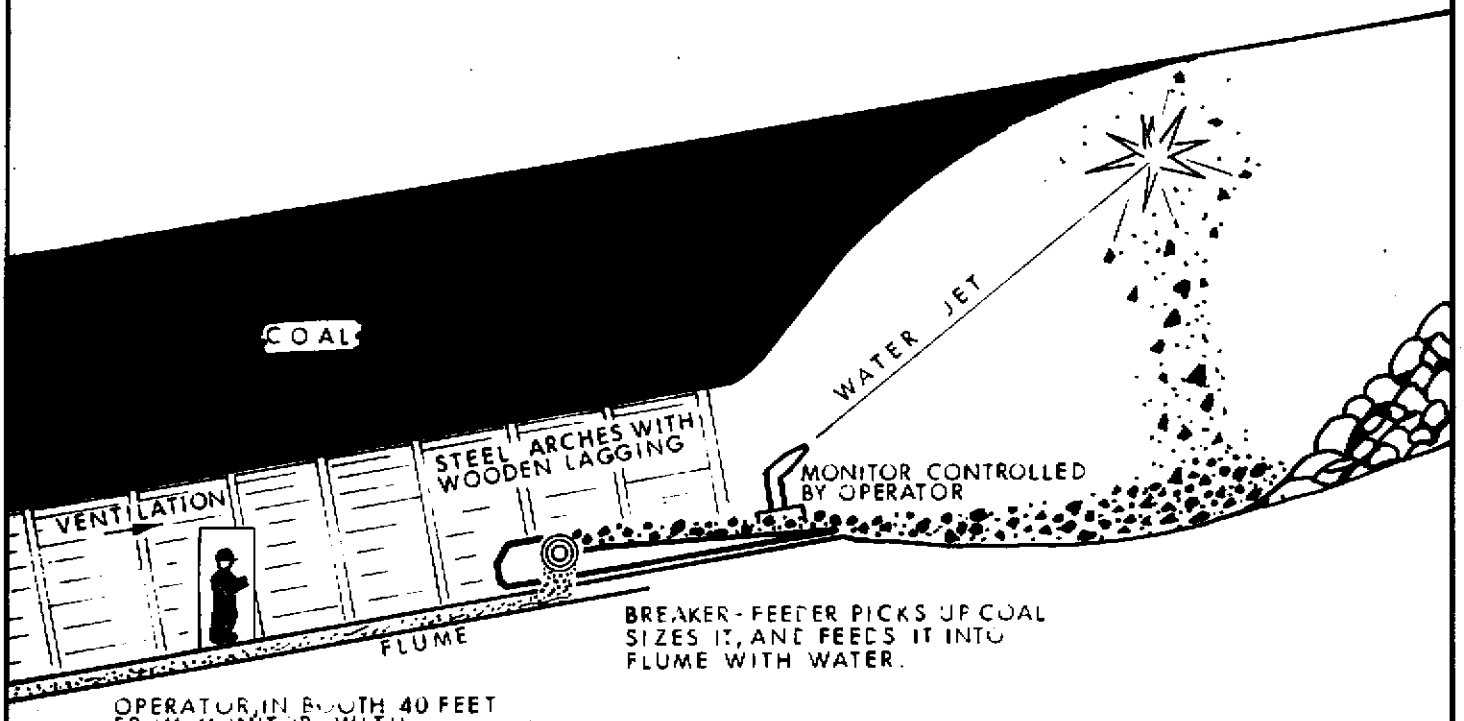


SHUTTLE CAR TO TRANSPORT COAL TO CONVEYOR.

ELECTRIC 500 HP CONTINUOUS MINER

ALL MACHINERY MOVES TO ANOTHER WORKING AREA AFTER CUTTING TWENTY FEET, SO BOLTING MACHINE CAN MOVE IN, DRILL ABOUT TWENTY-FIVE HOLES AND INSERT ROOF BOLTS.

CONVENTIONAL MINING



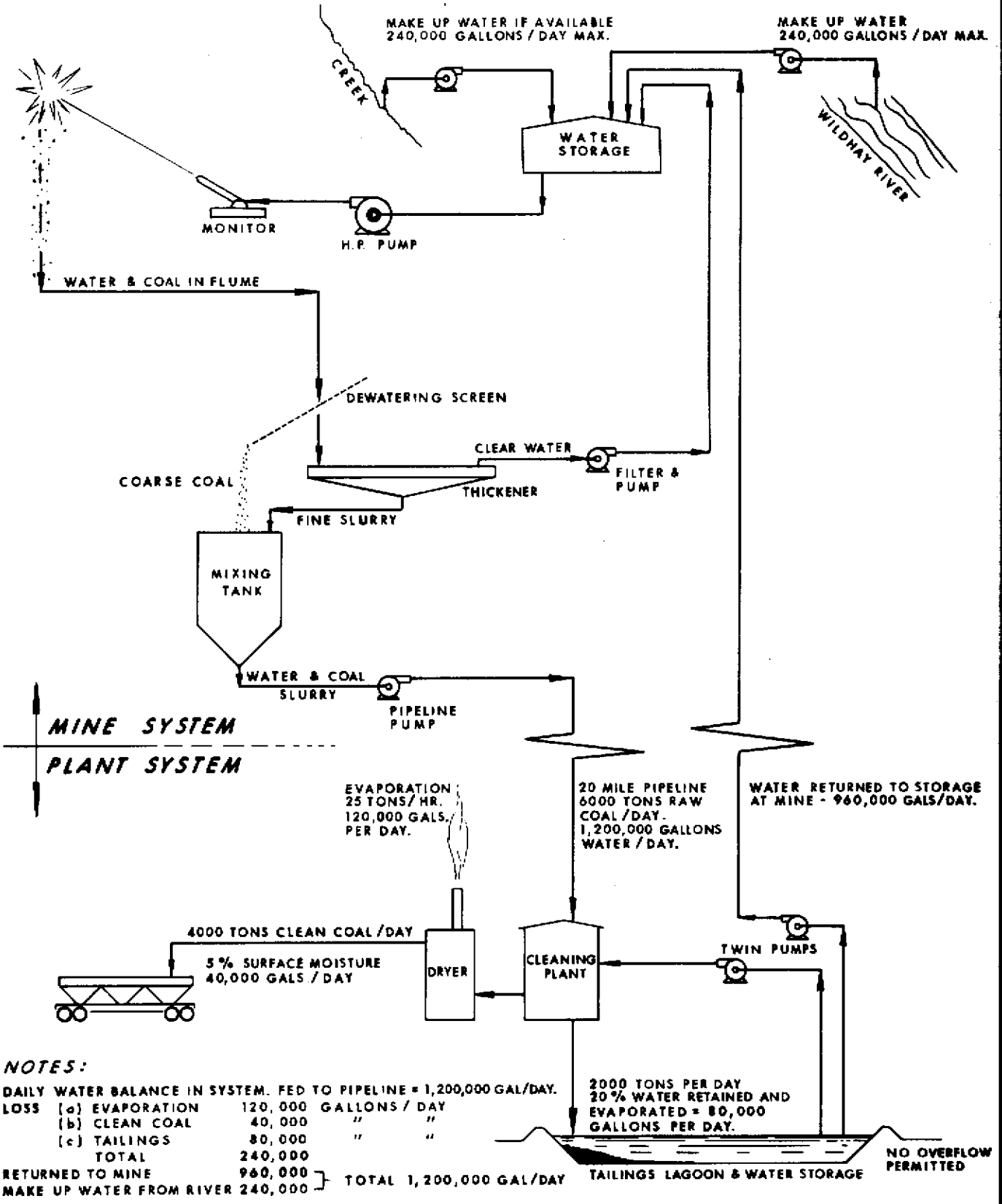
BREAKER-FEEDER PICKS UP COAL SIZES IT, AND FEEDS IT INTO FLUME WITH WATER.

OPERATOR IN BOOTH 40 FEET FROM MONITOR, WITH HYDRAULIC & ELECTRIC CONTROLS.

HYDRAULIC MINING

PIPELINE TRANSPORTATION

A study of the possible transportation methods and corridors for the Saxon property as well as the limitations of manpower availability indicates that the best method for transporting Saxon coal would be to pipeline it to a cleaning plant at or near The Canadian National Railway at Bend, B.C. Although no long distance pipelines are in operation for coking coal transportation, thermal coal and other solids pipelines have been developed and in use for some years. The largest system operating is pumping coal in the U.S.A. from Arizona to Southest Nevada, a distance of 273 miles (435 km) at the rate of five million tons per year (Black Mesa Project). Other small systems are in operation, over shorter distances, pumping different materials of various sizes. Denison has studied the solids pipelining field in some detail in consultation with a number of companies with experience in this field. Our investigations show that coking coal in ½ x 0 inch size range can be successfully moved over the distances and gradients to be negotiated here.



SAXON

SCHEMATIC OF WATER FLOW SYSTEM FOR HYDRAULIC MINING

BASE: 1 MILLION RAW TONS PER YEAR

EXPLANATORY NOTES FOR ANALYTICAL DATA, CORRELATION CHART AND GEOLOGICAL MAP

ANALYTICAL DATA

A large amount of analytical data is available for the Saxon Property. This data demonstrates the washability or cleaning characteristics of the adit samples as well as for certain drill core intersections. The analytical flow sheet used for the early drilling (70 series holes) had sink/float cuts at 1.40, 1.50 and 1.60 only while later analytical work involved a more detailed analysis on the cleaning characteristics of the coal, including froth floatation, to prepare a nominal 7% ash product. The froth floatation cell was set at 1.5 minutes and, in some cases, this produced a higher ash product than was desired. In such cases, the +28 mesh clean coal product only is shown in the following tables to provide a more accurate comparison of coal quality. In actual practice, of course, the residence time in the froth floatation cells in a cleaning plant would be adjusted to provide a clean coal which would not be detrimental to coarse clean coal.

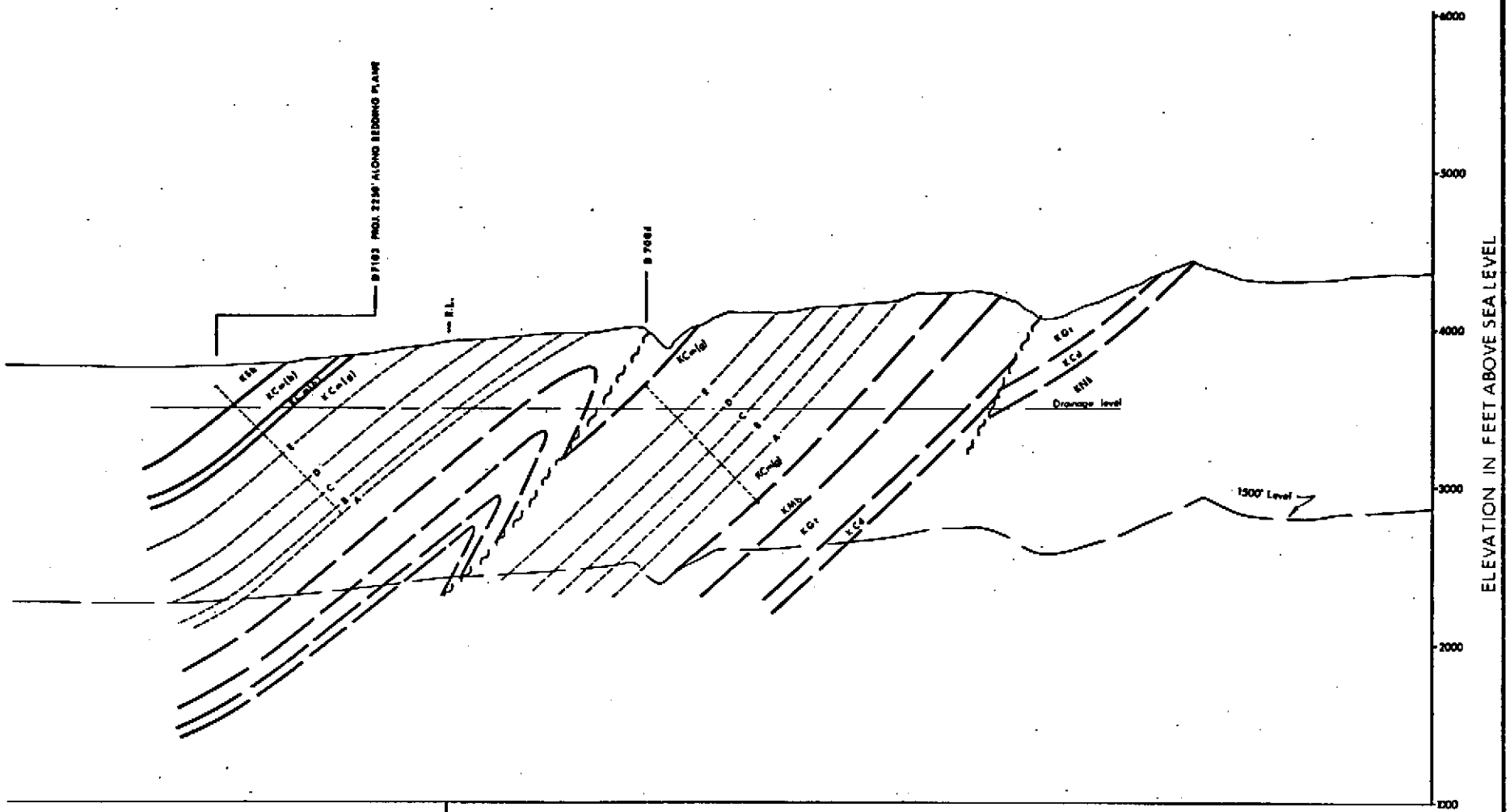
CORRELATION CHART (Drawing No. SXON 72-0295-R03 - Back Pocket)

A correlation chart has been prepared showing all of the drill log information, including lithologies, density response, neutron response and gamma radiation measurements. This data provides a reasonably high degree of certainty in the correlation, particularly for Seams A and B which contain the largest portion of the Saxon reserves. More detailed drilling may show that some revisions in seam nomenclature are required for the upper seams (C, D, and E). This would not affect the quantity of coal on the property.

GEOLOGY MAP (Drawing No. SXON 72-0332-R04 - Back Pocket)

The geological map of the Saxon property is based primarily on regional geological traverses made in conjunction with the various diamond drilling programs. This data has been adjusted to reflect the information obtained from drilling and from a structural analysis based on air photo interpretation. For these reasons, most of the area west of the reserve blocks is shown as unmapped, although some traverses have been made through it. This area is generally expected to contain middle and upper cretaceous strata and there may also be some exposures of the coal bearing Gates member. One of the primary objectives of the next phase of exploration on the Saxon property will be the mapping of this western area and the south corner of the property to determine the reserve potential in these areas.

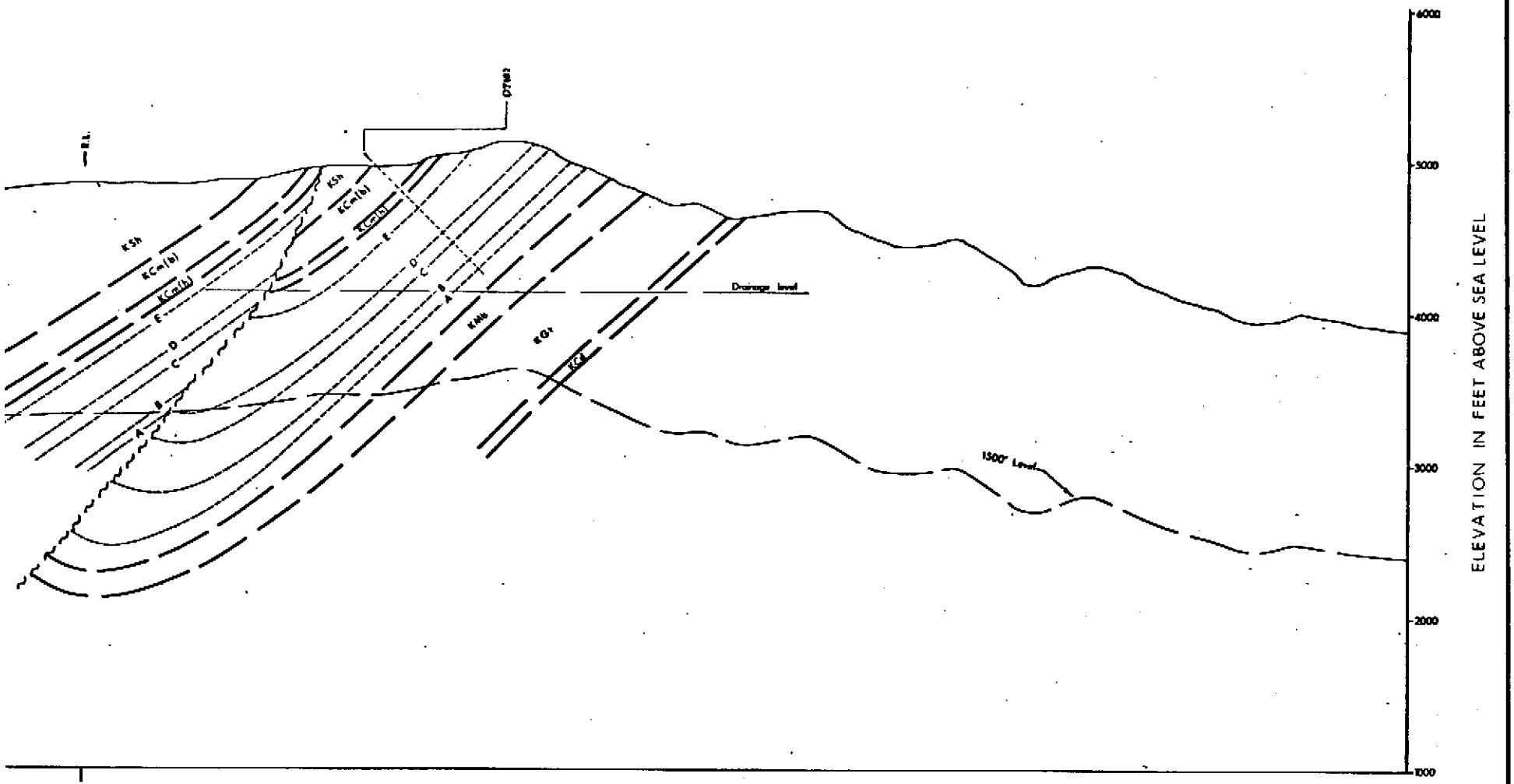
Two cross sections have been prepared at a scale of 1 inch equals 1,000 feet and are included in the following pages. Both sections cross the Narraway Block, one north of the river, and one south of it. It is in this Block that reserves have been best defined and where, as we presently understand the geology of the property, mining will be started.



DENISON MINES LIMITED
COAL DIVISION
CALGARY ALBERTA

SAXON CROSS-SECTION F-F'

DRAWN	DATE May '72	SCALE 1"=1000'
APPROVED	DRAWING NO.	220-802



DENISON MINES LIMITED
(COAL DIVISION)
CALGARY ALBERTA

SAXON CROSS-SECTION H-H'

DRAWN	BT May '72	SCALE 1" = 1000'
APPROVED	DRAWING SAXON 72-0320-B02	

INDUSTRIAL CONFIDENTIAL

APPENDIX 1

PHOTOGRAPHS OF SELECTED COKE SPECIMENS
DENISON MINES LIMITED
SAXON PROPERTY

Project 03-3-1/6-2

May, 1973.

LIST OF FIGURES

PHOTOGRAPHS OF SELECTED COKE SPECIMENS
DENISON MINES LIMITED
SAXON PROPERTY

Project 03-3-1/6-2

by

R.C. Guenette* and J.G. Jorgensen**

The photographs included in this report represent selected coke specimens from coals from the Saxon property relating to Project No. 03-3-1/6-2. All the specimens were carbonized in the Mines Branch 12-inch movable-wall technical scale coke oven.

The photographs were taken in the laboratory employing a Polaroid MP-3 Industrial camera.

*Coal Technologist, **Head, Petrography and Laboratory Services, Metals Reduction and Energy Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

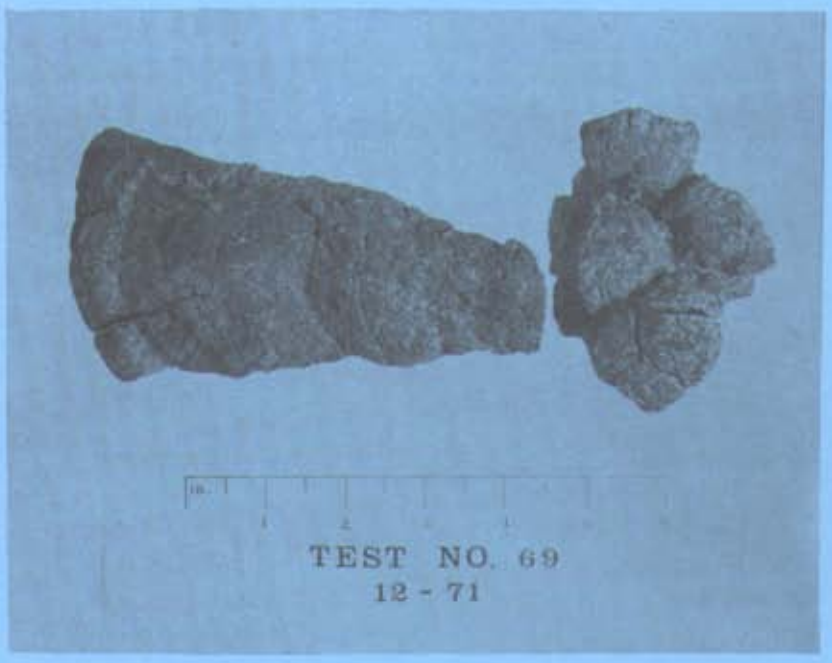


Figure 1 - 100% Saxon No. 1

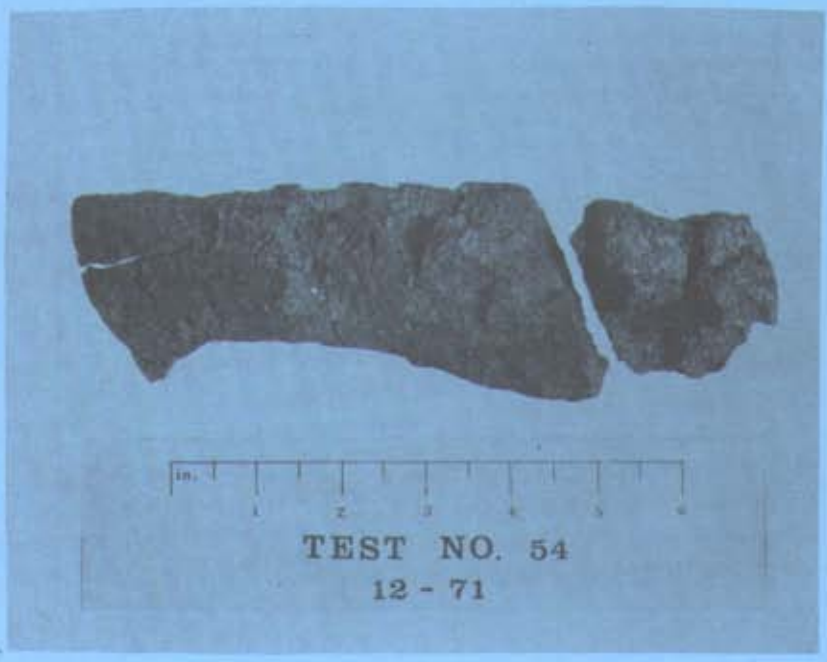


Figure 2 - 100% Saxon No. 2

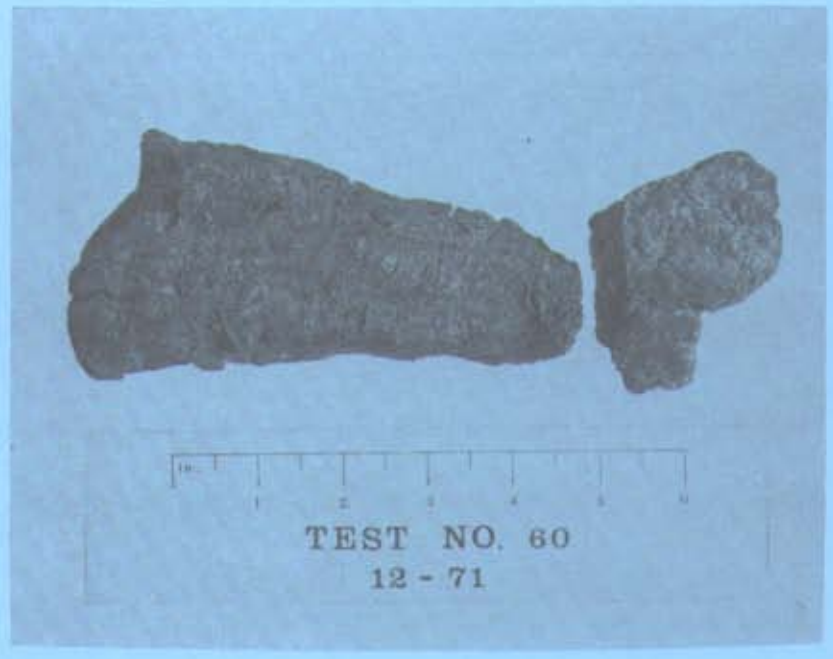


Figure 3 - 100% Saxon No. 3

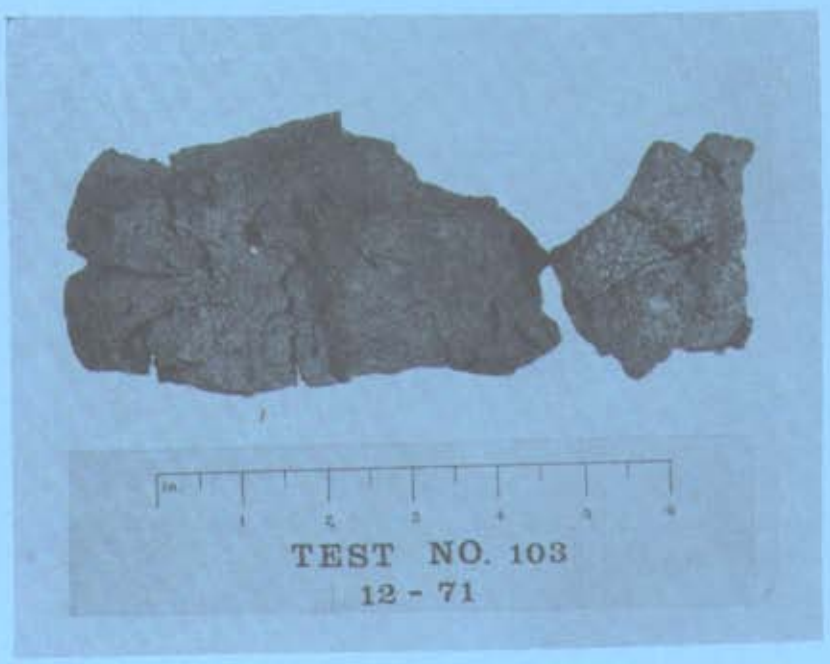


Figure 4 - 100% Saxon No. 4

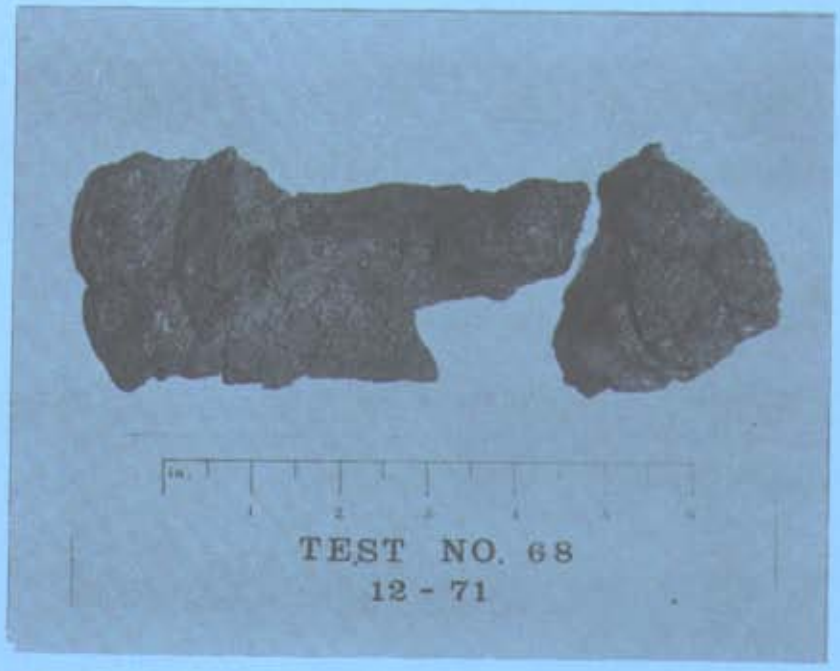


Figure 5 - 30% Saxon No. 1
+70% Reference H.V. Coal

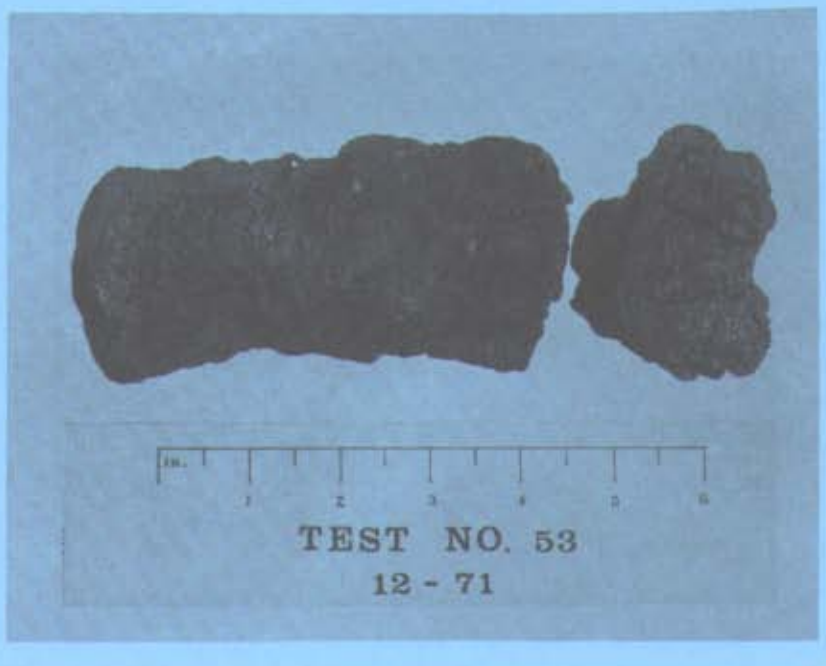


Figure 6 - 30% Saxon No. 2
+70% Reference H.V. Coal

Figure 7 - 30% Saxon No. 3
+70% Reference H.V. Coal

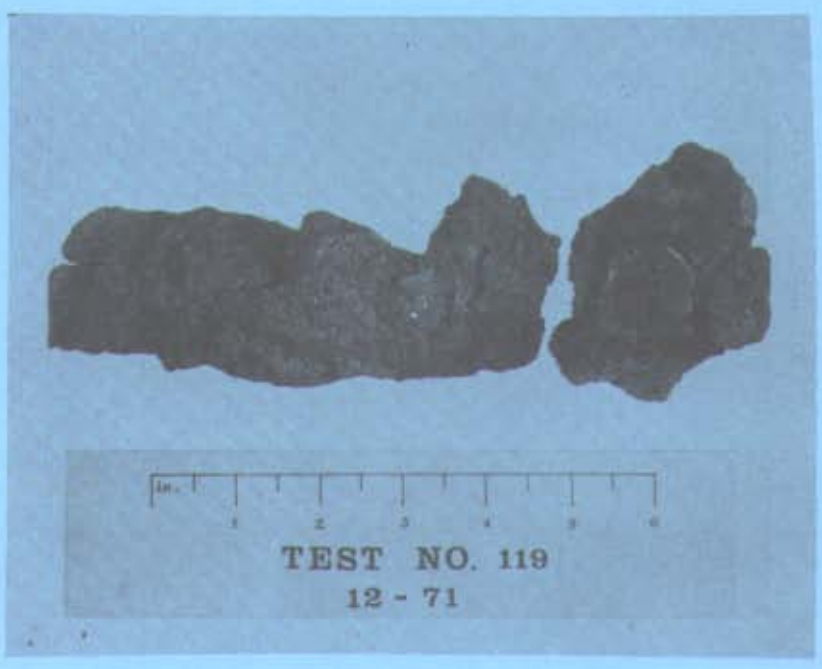


Figure 8 - 30% Saxon No. 4
+70% Reference H.V. Coal

PRELIMINARY GEOLOGICAL AND COAL QUALITY DATA FROM SAXON PROPERTY

DENISON MINES LIMITED
(COAL DIVISION)

APRIL 25, 1974

EXPLANATORY NOTES FOR ENCLOSED DATA

SAXON GEOLOGY MAP (Scale 1 inch = 2,000 feet)

The enclosed geology map has been updated from the interpretation of aerial photographs obtained subsequent to the commencement of exploration on the Saxon Property. All drill holes and adit sites have been accurately located on this map and revised cross sections are being prepared at the present time.

SAXON CORRELATION CHART (Scale 1 inch = 50 feet)

All geophysical drill logs obtained from the Saxon diamond drill holes are presented at a reduced scale with coal seam correlations. In addition to the geophysical responses, the lithology encountered in the drill core has been presented in the centre strips of each log.

QUALITY COMPARISON

Tables have been enclosed to indicate coal quality comparisons from each of the main coal zones obtained in the Saxon Property (Seams A, B, C, D & E). As the drilling was carried out during three phases over a three year period, the methods of coal analysis from this property were modified to obtain more meaningful quality data and thus analytical parameters vary slightly for drill holes completed in different years. The following list gives explanations of the various headings found on the quality comparison tables which have been enclosed.

1. ESTIMATED DRILL CORE RECOVERY IN COAL SEAM

The actual weight of sample sent for analysis was used to determine the percentage of recovery drom drill hole intersections in the coal seams. During the initial drilling at Saxon (i.e. the 70 series of drill hole numbers), sample weights were not obtained and thus the percentage recovery was derived from measured visual recovery of the actual coal core. It should be pointed out that drill recovery from Saxon must be considered low compared to other drill programmes we have carried out on other properties. This is due partly to the nature of the coal, however, it is felt that with recently developed techniques and a more sustained drilling programme, average recoveries could be improved considerably.

2. WASH TEST RECOVERY

For the 70 series of drill results, wash test recovery was calculated on +200 mesh fraction at a 1.5 specific gravity cut off.

For the 71 and 72 series of drill results, wash test recovery was calculated by combining yield from +28 mesh fraction at nominal 7% ash cut off with froth flotation yield on -28 mesh fraction.

3. PROXIMATE ANALYSIS OF CLEAN COAL COMPOSITE

Proximate analysis of clean coal composite from drill intersections has been presented with a 1.5 specific gravity cut off from +28 mesh fraction in 71 and 72 series holes.

QUALITY COMPARISON OF COAL SEAM DRILL INTERSECTIONS

FROM SAXON PROPERTY

DIAMOND DRILL HOLE #	COAL SEAM	ESTIMATED DRILL CORE RECOVERY IN COAL SEAM	WASH TEST RECOVERY	COAL SAMPLE INTERVAL	PROXIMATE ANALYSIS OF CLEAN COAL % ASH	% VOLATILE MATTER	% RESIDUAL MOISTURE	% FIXED CARBON	FREE SWELLING INDEX	% SULPHUR
7003	A	67.00%	89.23%	752.5-657.6	7.36	21.29	N.A.	70.94	3.5	.33
7004	A	49.50%	74.53%	859-902	6.96	21.62	N.A.	71.09	6.9	.32
7101	A	74.46%	68.52%	1206-1211.4	6.92	18.62	.93	73.53	8.5	.34
7102	A	74.60%	89.95%	1070.5-1087.5	6.92	20.89	.54	71.61	7.0	.23
7103	A	59.13%	38.58%	1187.0-1195.0	8.52	20.21	.54	70.73	5.5	.27
7103	A	65.35%	49.64%	1195.5-1207.0	8.97	20.58	.87	69.76	8.5	.25
7103	A	40.15%	38.48%	1207.0-1219.0	9.80	20.57	.98	68.65	7.0	.27
7201	A	85.00%	82.22%	1145.5-1157.4	7.11	20.11	1.02	71.76	8.0	.24
7201	A	80.73%	55.32%	1177.4-1183.5	8.73	18.25	1.22	71.80	4.0	.38
		66.21%	65.15%		7.92	20.23	.87	71.09	6.5	.29
7101	B	34.87%	56.18%	1160.8-1166.1	6.71	20.42	.87	72.00	8.0	.36
7102	B	56.57%	43.23%	999.2-1004.5	8.74	19.48	.95	70.83	7.5	.17
	B	66.52%	65.66%	1004.5-1014.0	9.89	20.68	1.11	68.32	8.5	.23
7103	B	55.28%	48.77%	1130.0-1135.0	8.84	21.39	.57	69.20	8.0	.31
	B	50.45%	44.89%	1138.0-1140.3	9.11	19.98	.46	70.45	7.0	.41
7201	B	37.08%	46.51%	1045.0-1051.0	12.49	19.45	.95	67.10	5.0	.33
	B	41.32%	65.00%	1051.0-1059.4	7.39	20.64	.78	71.19	8.0	.27
		48.87%	52.89%		9.02	20.29	.81	69.87	7.5	.30

QUALITY COMPARISON OF COAL SEAM DRILL INTERSECTIONS

FROM SAXON PROPERTY

DIAMOND DRILL HOLE #	COAL SEAM	ESTIMATED DRILL CORE RECOVERY IN COAL SEAM	WASH TEST RECOVERY	COAL SAMPLE INTERVAL	PROXIMATE ANALYSIS OF CLEAN COAL % ASH	% VOLATILE MATTER	% RESIDUAL MOISTURE	% FIXED CARBON	FREE SWELLING INDEX	% SULPHUR
7103	C	68.39%	37.41%	990.5-1000.0	8.99	22.13	.59	68.29	8.5	.62
7202	C	89.88%	47.92%	634.0-640.0	9.89	23.02	.73	65.36	8.0	.56
		79.13%	42.66%		9.44	23.07	.66	66.82	8.25	.59
7001	D	23.00%	81.85%	840.4-866.0	4.29	25.26	N.A.	70.06	8.25	.30
7003	D	78.00%	85.58%	399.0-406.0	4.38	25.45	N.A.	69.81	8.0	.42
7101	D	43.77%	59.85%	953.0-981.0	7.51	19.12	1.02	72.35	6.5	.46
7102	D	71.53%	45.03%	745.8-747.6	16.01	21.11	.84	62.84	8.5	.45
	D	59.48%	64.80%	748.2-759.2	6.96	20.15	.69	72.20	7.0	.43
7201	D	85.54%	71.31%	450.0-454.6	7.1	22.65	.98	69.27	7.5	.47
7202	D	81.09%	54.63%	533.0-536.5	11.89	23.41	1.37	63.33	8.5	.55
	D	77.22%	98.53%	537.2-541.5	6.37	24.98	.53	68.12	8.0	.48
	D	92.94%	38.28%	541.5-544.0	11.12	25.42	.82	62.64	9.0	.37
		68.06%	66.65%		8.45	23.06	.89	67.85	8.0	.44
7001	E	46.00%	39.32%	624.8-647.0	4.82	24.75	N.A.	69.97	8.5	.61
7101	E	57.45%	53.02%	652.0-658.7	8.67	20.72	.87	69.74	9.0	.48
	E	70.07%	67.35%	700.5-706.8	6.57	20.18	1.16	72.09	8.5	.60
		57.84%	53.23%		6.69	21.88	1.02	70.60	8.6	.56

PR - Saxon 75 (4) A

Analytical Data

3/3

625

APPENDIX 5

ANALYSIS OF DRILL LOGS

SUMMARY ANALYSIS OF DRILL HOLE INTERSECTIONS
FROM DESCRIPTION LOGS, CHEMICAL ANALYSES, AND
GAMMA RAY, DENSITY AND NEUTRON LOG RESPONSES
TO DETERMINE SEAM THICKNESSES
FOR RESERVE CALCULATIONS

DRILL HOLE: 7002

Intersected Moosebar and Gething formations only.

DRILL HOLE 7001

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
C	0.24	1.04	uneconomic	10^{o}	uneconomic
	REMARKS: Radiation log thickness has been taken from Neutron Log - thickness uneconomic.				
D	1.68	7.80	7.80	10^{o}	7.62
	REMARKS: Only 1.68 metres of core was recovered (27.5%). This was very clean and log response indicates seam is free of bands.				
E	2.74	6.52	omitted	5^{o}	omitted
	REMARKS: Excluded; logs indicate numerous thick rock bands.				

DRILL HOLE: 7003

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
A upper	0.15	2.87	2.87	5°	thickness uneconomic
	REMARKS: No analysis available. Not used in calculations.				
A lower	1.22	2.56	2.56	5°	thickness uneconomic
	REMARKS: Analysis includes 1.83 m with F.S.I. of about 3; best coal lost in drilling; for comparative section see D 7201, A lower.				
B	1.22	4.15	4.15	5°	omitted
	REMARKS: No analysis; large core loss in drilling, comparison with D 7202 suggests a high ash mineable section.				
C	1.52	3.11	3.11	5°	omitted
	REMARKS: No analysis; neutron & gamma ray logs indicate a clean seam. Omitted pending clarification.				
D	1.68	3.66	3.66	5°	3.66
	REMARKS: Core interval below that sampled includes broken coal. Logs indicate this is clean coal. 1.68metres of core recovered (46%) is exceptionally clean.				
E	0.55	3.66	3.66	5°	omitted
	REMARKS: No analysis, logs indicate clean coal, omitted pending clarification.				

DRILL HOLE: 7004

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
A upper	6.49	10.36	10.36	0^{o}	10.36

REMARKS: Logs indicate clean coal throughout section. 49.5% core recovery. Approximately 80% recovery at 7% ash.

B	0.30	4.63	4.63	0^{o}	4.63

REMARKS: No analysis, log very similar to D 7201. Results of D 7201 analysis taken as indicative of coal quality.

C	-	-	uneconomic	0^{o}	uneconomic

REMARKS: Seam includes thick rock bands, no coal intervals in excess of 0.85 m.

D	1.98	1.95	uneconomic	0^{o}	uneconomic

REMARKS: Thin seam. Thickness excluded from reserve calculations.

E	0.00	1.40	uneconomic	0^{o}	uneconomic

REMARKS: Only thin coal splits present.

DRILL HOLE: 7101

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
A	1.31	1.89	uneconomic	0^{o}	uneconomic
	REMARKS: All logs indicate seam too thin to be included in reserve.				
B	1.98	4.57	uneconomic	0^{o}	uneconomic
	REMARKS: Several thick rock bands present, analysed sample indicates high ash, density log indicates no mineable section in excess of 1.62 metres.				
D	5.24	8.69	7.62	0^{o}	7.62
	REMARKS: Analysis and logs indicate a mineable section of 7.62 metres. Yield from analysis is 67.3%; actual recovery is estimated at 70% since logs indicate lost section is good coal.				
E	1.77	1.83	uneconomic	5^{o}	uneconomic
	REMARKS: Logs indicate thickness uneconomic.				

DRILL HOLE: 7102

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY)	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
A	4.63	5.18	5.18	10^{o}	5.12
	REMARKS: Density logs indicate clean coal throughout this interval. Core recovery 89%. Wash yield in excess of 80%.				
B	5.12	4.02	4.02	0^{o}	excluded
	REMARKS: Radiation logs indicate clean coal in conflict with analytical data hence results excluded from reserve calculations.				
C	0.73	1.13	uneconomic	0^{o}	uneconomic
	REMARKS: Thickness is less than that considered economic.				
D	3.75	3.35	3.35	0^{o}	3.35
	REMARKS: Wash recoveries of 65% at 7% ash.				
E	0.43	1.22	uneconomic	0^{o}	uneconomic
	REMARKS: Excluded from reserve calculations.				

DRILL HOLE: 7103

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY)	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
A	10.88	9.75	7.31	30^{o}	7.31
	REMARKS: Wash recoveries are about 40%. Due to conflict between logs and analysis and consistantly good wash recoveries for a seam elsewhere, the seam thickness has been included in reserve calculations. However, further clarification is required.				
B	2.80	3.35	high ash	-	excluded
	REMARKS: Excluded due to poor sink float recovery on good core samples (poor density log).				
C	2.29	-	high ash	5^{o}	high ash
	REMARKS: Analysis indicates high ash.				
D	0.61	1.07	uneconomic	10^{o}	uneconomic
	REMARKS: Density log indicates uneconomic thickness.				
E	0.91	1.04	uneconomic	0^{o}	uneconomic
	REMARKS: Density log indicates uneconomic thickness.				

DRILL HOLE: 7201

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
A upper	3.35	3.63	3.63	10^{o}	3.57
	REMARKS: Good core recovery, good washability. Wash recovery approximately 82%. Core recovery 92%.				
A lower	1.83	1.86	uneconomic	10^{o}	uneconomic
	REMARKS: Seam thickness uneconomic				
B	3.32	4.39	uneconomic	5^{o}	uneconomic
	REMARKS: Numerous thick rock bands in this section				
D	-	-	uneconomic	5^{o}	uneconomic
	REMARKS: Density log indicates high ash				

DRILL HOLE: 7202

SEAM	RECOVERED CORE THICKNESS	RADIATION LOG THICKNESS (GAMMA RAY NEUTRON AND/OR DENSITY)	SEAM INTERSECTION FOR RESERVE CALCULATION	CORE ANGLE	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
C	-	-	uneconomic	20^{o}	uneconomic
	REMARKS: Density log indicates high ash.				
D	3.08	3.35	3.35	10^{o}	3.26
	REMARKS: Good core recovery and good washability. Core recovery 75%, wash recovery 65%. Assuming lost core is coal plus 0.7 ft. of rock not sampled, 80% wash recovery is estimated.				

ADITS 1 to 4

ADIT NUMBER	SEAM	RECOVERED CORE THICKNESS	SEAM INTERSECTION FOR RESERVE CALCULATION	TRUE SEAM THICKNESS FOR RESERVE CALCULATION
1	A	3.66	3.66	3.66
REMARKS: Coal sample was cleaned to 7% ash with 90% yield.				
2	B	4.85	4.85	4.85
REMARKS: Coal sample was cleaned to 7% ash with yield of 73%.				
3	C	1.98	uneconomic	uneconomic
REMARKS: Seam thickness uneconomic				
4	C	1.80	uneconomic	uneconomic
REMARKS: Seam thickness uneconomic				

COAL QUALITY AND COKE TESTING

The following discussion has been derived from data collected during previous exploration programs. This information is provided here so that complete information regarding coal on the Saxon property is readily available.

The raw coal mined from the Saxon property is expected to have a raw ash content between 10 and 20%. All indications are that this coal will clean readily to a product with 7 - 8% ash at a recovery in the order of 70 to 80%.

If initial production is from the Narraway River area, Seams A and B will provide clean coal of approximately the following quality, analyzed on a dry basis. (Cut point 1.49 to 1.51.)

	Seam A	Seam B
Ash	7.46	7.34
Volatile Matter	21.14	20.56
Total Moisture	0.81	0.65
Fixed Carbon	71.38	71.47
Sulphur	0.27	0.35
Free Swelling Index	7	6½-7

A general unweighted average of all the analytical data obtained to date for the coal in the reserve category indicates that the expected product from the property as a whole will approximate:

Ash	7.42
Volatile Matter	20.94
Total Moisture	0.75
Fixed Carbon	71.40
Sulphur	0.30-0.50
Free Swelling Index	6½-7½

Four bulk samples were taken from adits in the Narraway River area and shipped to the Metals Reduction and Energy Centre of the Department of Energy, Mines and Resources in Ottawa. These samples were completely analyzed and 500 lb. lots were tested in a 12.5 inch moveable wall oven. Charges consisted of 100% Saxon coal and blends of 30% Saxon coal with 70% standard high volatile coal. The results of these tests, together with photographs of selected coke samples, are presented in Appendix I.

In summary, the Saxon material was found to be a low sulphur, premium, medium volatile, coking coal. The ash in the samples shipped averaged 6.8%. Phosphorous in the ash was 1.1% (0.03% phosphorous in coal) and the alkaline level in the ash was 2.0% (0.14% in coal).

A summary of the physical properties of the coke produced from the Saxon coals and their blends is tabulated below.

Average Fluidity	37.5 dd/m
Average Ruhr Dilation	31.8 percent
Average Maximum Reflectance	1.35 percent
Mean Predicted Stability Factor	58.6

Two of the samples of Saxon coal produced blends that were equivalent to those produced by blending the same standard high volatile coal with a premium low volatile coking coal from the United States. Both of the other Saxon coals also performed well. Individual stability factors for the Saxon cokes ranged from 57.4 to 63.0.

CONCLUSION

Sufficient information has been gathered from programs to date to indicate that an excellent coking coal is available at Saxon.

In the East Saxon area, 244 million metric tons of coal in place are included to a depth of 500 meters. These reserves could be mined from four entries into three seams, each producing one-half to one million metric tons of clean coal. A 7.52% ash level could be attained with a specific gravity of separation of 1.50 in the preparation plant. As the seams are steeply dipping, mining could be by hydraulic methods.

The Saxon South area contains as many as 5 seams, two of which have been measured during the current geological mapping program at 9 meters and 4 meters respectively. These two seams constitute an inferred, raw, in situ reserve of 119 million metric tons accessible by surface mining operations. The overburden ratio is about 5.10 cubic meters per metric ton.

Additional geological mapping, diamond and rotary drilling, adit drivage, further washability studies, and coking tests will be necessary as a basis for mining feasibility studies.

Gates Member strata have been mapped at the surface in the Saxon West area. On the basis of the area of outcrop and the total coal thicknesses known to be in the Gates Member in surrounding areas, an exploration potential of 250 million metric tons in situ has been assigned. Extensive exploration will be required to establish inferred reserves in this area.

APPENDIX I

DEPARTMENT OF ENERGY, MINE AND RESOURCES

MINES BRANCH

SAXON PROPERTY

COKING TESTS

INDUSTRIAL CONFIDENTIAL

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MINES BRANCH

OTTAWA

METALS REDUCTION AND ENERGY CENTRE
DIVISIONAL REPORT MREC 73/89

- Project No. 03-3-1/6-2 -

AN INVESTIGATION OF THE COKING PROPENSITIES OF COAL SAMPLES DESIGNATED AS ADIT NUMBERS 1, 2, 3 AND 4 FROM THE SAXON PROPERTY, NORTH EASTERN BRITISH COLUMBIA SUBMITTED BY DENISON MINES LIMITED

by

J.C. Botham, W. Gardiner, J.G. Jorgensen and T.A. Lloyd

October 1973

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AN INVESTIGATION OF THE COKING PROPENSITIES OF COAL SAMPLES DESIGNATED AS ADIT NUMBERS 1, 2, 3 AND 4 FROM THE SAXON PROPERTY, NORTH EASTERN BRITISH COLUMBIA SUBMITTED BY DENISON MINES LIMITED

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INTRODUCTION

Since 1959, the Mines Branch, Department of Energy, Mines and Resources (EMR) has carried out periodic investigations to assist in the development of the coking coals of Western Canada with a view to their ultimate exploitation as an export commodity, principally for use in the manufacture of coke by the Japanese steel industry. These studies have also included departmental representation on several coal missions to Japan to discuss specific technical aspects regarding the use of Canadian coals. During the initial visit in 1958, general discussions were held in Tokyo with representatives of the Japanese steel industry, and it was agreed at the time that continuing test work by EMR in Canada would be of mutual benefit in helping to maintain the continuing supply of good quality coking coal for the growing market in Japan. Subsequently, many carbonization investigations

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have been completed in these laboratories, including evaluations for most of those coal companies involved in the export market prior to their obtaining firm coal export contracts. The resulting investigational reports are, in most cases, confidential and usually restricted to the principals concerned.

The present investigation deals with an evaluation of four adit samples from the Saxon property of the Denison Mines Limited. The coal deposit is located in the province of British Columbia approximately 100 miles northeast of Prince George. The location is indicated on the map of the coalfields and coal areas of British Columbia given in Figure 1. The evaluation project was initiated in a letter from Mr. John Kostiuk, President, Denison Mines Limited to Dr. John Convey, Director, Mines Branch, dated May 27, 1970 and subsequent communications between Mr. J.C. Botham and company officials during the period May 1971 and February 1972. The procurement of the bulk samples was arranged by Denison Mines Limited. Prior to their shipment to Ottawa for evaluation of the coking propensity the samples were cleaned by Cyclone Engineering Sales Limited, Edmonton, Alberta to ash levels specified by the principals.

The data presented herein consist of chemical analysis, bench-scale testing pertinent to coke-making, and technical-scale coke oven evaluations of the aforementioned samples. Each coal sample was prepared and carbonized alone, and also in a blend composed of 30 per cent Adit sample, and 70 per cent reference high volatile coal. For comparative purposes a reference low volatile coal was carbonized under the same conditions. The reference coals are premium coking coals of United States origin.

Pertinent test results were sent to the company during the course of the investigation.

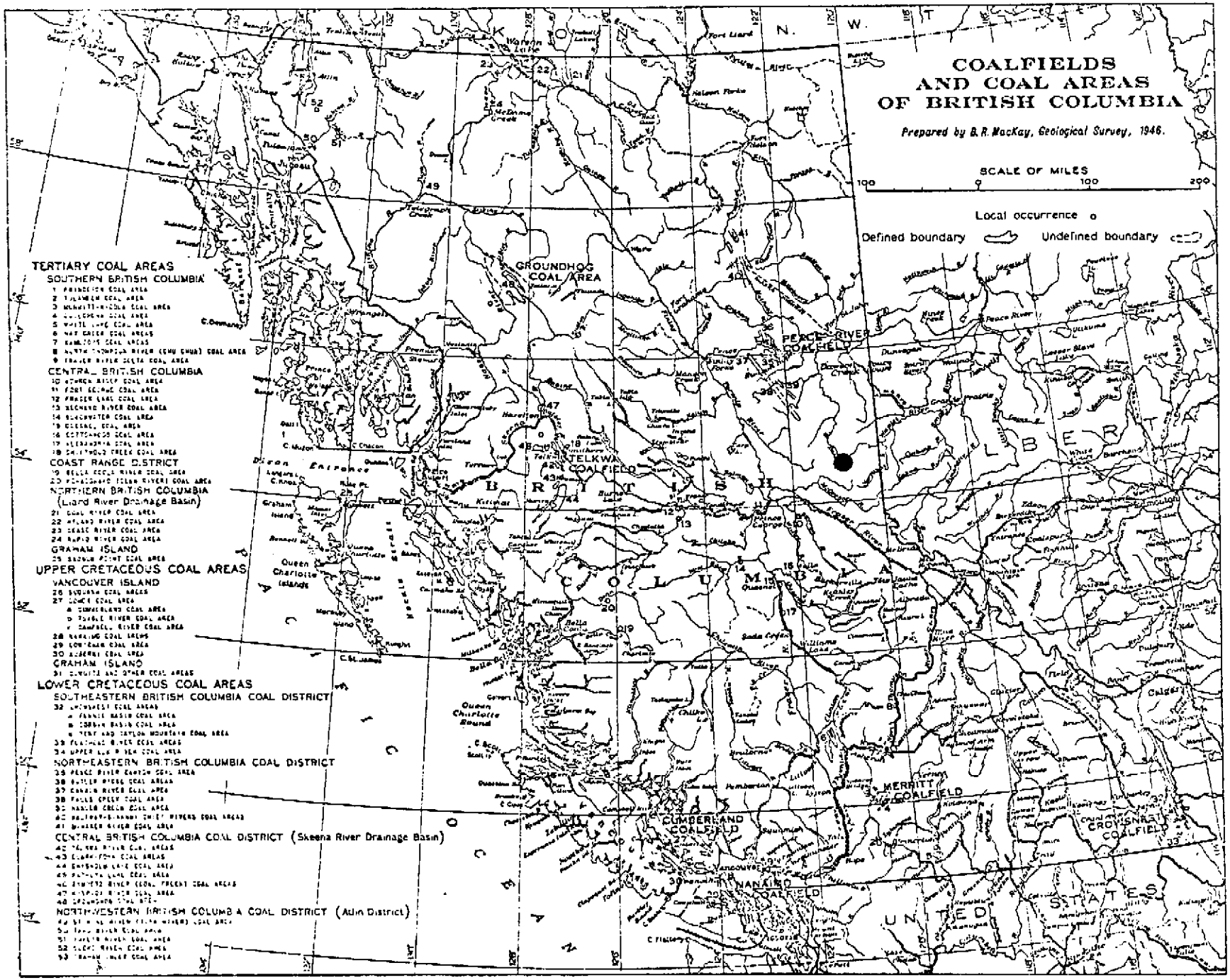


FIGURE 1 - Coalfields and Coal Areas of British Columbia

SAMPLE PREPARATION

Four samples of clean coal were received at the Mines Branch, Ottawa, and were identified as Saxon No. 1, Saxon No. 2, Saxon No. 3 and Saxon No. 4. The date of receipt and approximate weight of each sample were:

Saxon No. 1: February 16, 1972 - 3000 lbs.

Saxon No. 2: February 16, 1972 - 3000 lbs.

Saxon No. 3: March 9, 1972 - 3000 lbs.

Saxon No. 4: May 9, 1972 - 2400 lbs.

A supply of reference hv coal was set aside for use in the blend samples. All the above samples were crushed in a hammermill crusher to approximately 80 per cent minus 1/8 inch in size and processed as outlined in the flowsheet shown in Figure 2.

FIGURE 2

General Project Flowsheet

(Project No. 03-3-1/6-2)

COALS FOR PROJECT

Adit Saxon No. 1

Adit Saxon No. 2

Adit Saxon No. 3

Adit Saxon No. 4

Ref. hv coal

Ref. lv coal

GENERAL PREPARATION

- Air Dry
- Screen
- Crush Oversize
- Blend to 80% - 1/8"
- Split Head Sample to Lab.
- Re-Drum & Store for Future Blending as Required

CARBONIZATION

- Weigh out Blend Components Allowing for Moisture Contents
- Blend in V. Shell Blender
- Air Dry to 48.5 lb/ft^3 ASTM Cone Method
- Charge Mines Branch MW Coke Oven
- Retain Sample of Charge for Lab.
- Standard Procedures for Coke Oven Operation

COKE EVALUATION

- Screen Analysis
- Select Coke for ASTM Tumbler JIS Drum Test
- Apparent Specific Gravity
- Oven Wall Pressures

LABORATORY WORK

	Head	Blend
. Petrography	x	
. Moisture	x	x
. Proximate	x	x
. Sulphur	x	x
. Btu/lb (dmmf)	x	
. Screen Tests	x	
. Ultimate	x	
. Ash Analysis	x	
. Plasticity	x	
. FSI	x	
. SVI Calculation	x	
. Dilatation	x	
. Grindability	x	
. Expansion/Contraction	x	
. Ash Fusibility	x	

Analytical Program

Representative coal samples from all the gross samples submitted were analysed as follows:

A. Chemical and Related Analysis-Conducted by the Fuels Research Centre, Mines Branch (reported in Table 1)

(a) Proximate Analysis
(1) Moisture
(2) Ash
(3) Volatile Matter
(4) Fixed Carbon

(b) Ultimate Analysis
(1) Carbon
(2) Hydrogen
(3) Sulphur
(4) Nitrogen
(5) Oxygen (by difference)

(c) Gross Calorific Value

(d) Ash Analysis
(1) Silicon Dioxide
(2) Aluminum Oxide
(3) Ferric Oxide
(4) Titanium Oxide
(5) Phosphorus Oxide
(6) Calcium Oxide
(7) Magnesium Oxide
(8) Sulphur Trioxide
(9) Sodium Oxide
(10) Potassium Oxide

B. Physical Tests (reported in Table 2)

(a) Hardgrove Grindability
(b) Size Consist of Oven Charge
(c) Ash Fusibility

Representative samples of coke oven coal charges and resultant cokes were taken for proximate analysis and sulphur determination. These values are listed in Table 7.

C. Thermal Rheological Properties (reported in Table 3)

(a) Gieseler Plasticity
(b) Ruhr Dilatation
(c) Free Swelling Index
(d) Linear Expansion

D. Petrography (reported in Table 8)

(1) Microscopic Determination of Volume Per cent of Maceral Components

(2) Microscopic Determination of Reflectance Values of Organic Components
(3) Mathematical Determination of Potential Coke Stability

CARBONIZATION

Technical-scale evaluations of the coals and coal blend were carried out in the Mines Branch movable-wall test oven. This type of oven is presently under consideration for adoption as a standard test method, by Sub-Committee XV of ASTM Committee D-5 as "Proposed Method of Test for Measuring Coking Pressures of Coal by a Movable-wall Slot Oven". The Mines Branch test oven is identical with the "Quality Coke Oven" as designed and used by the Eastern Gas and Fuel Association(1), differing from the latter unit in minor details only. A schematic drawing of the oven, showing the supporting steel and fire-brick construction is given in Figure 2.

The width of the coke-oven chamber is 12.5 inches and the oven capacity is approximately 500 lbs of dry coal at an oven bulk density of 51 lb/ft^3 (db). The coking chamber is equipped with two doors and the coke is discharged by means of a pusher machine.

The oven is electrically heated with "Globar" -type resistance elements, provided with a sensitive control system to regulate and maintain desired oven-wall temperatures. The oven walls consist of silicon-carbide tile with a high thermal conductivity relative to silica brick. In order to simulate the conditions of heating in a commercial oven, energy input to the test oven is normally programmed. The coal is charged to the oven at a flue temperature of $1650^{o}F$. The temperature is then increased at a rate of $35^{o}F/hr$ to $1950^{o}F$ and maintained for balance of coking time at this temperature. The coke is pushed 1/2 hour after the temperature in its center has reached $1850^{o}F$.

This heating cycle simulates a commercial oven coking rate of 1 inch per hour as would be obtained in a conventional 18-inch silica lined coke oven. With such programming the slot-face temperatures average approximately 1850^{o}F for the coking cycle.

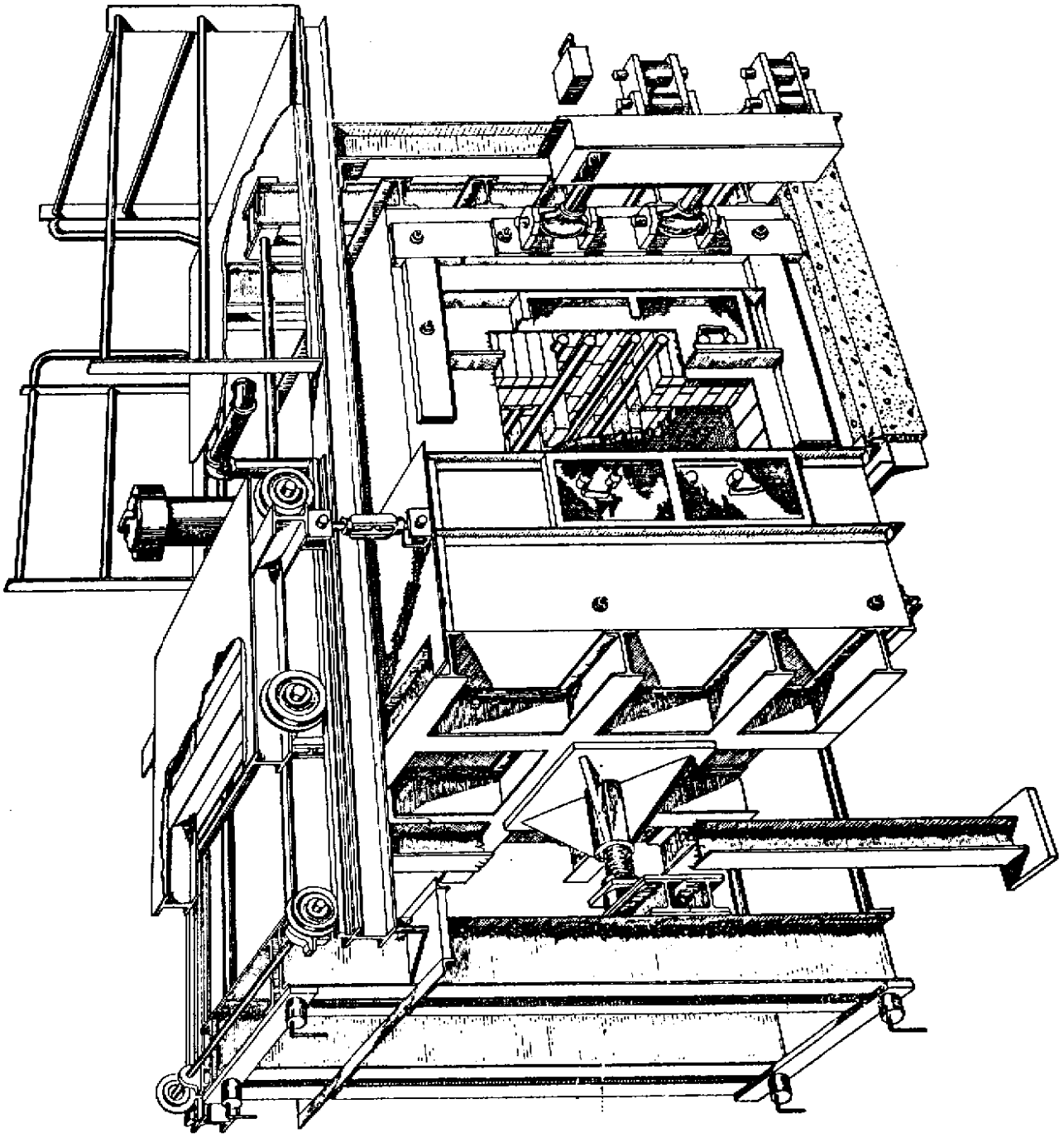
The wall pressure developed by the coal charge during the test is measured by means of a single compression-type load cell. The movable-wall section of the test oven is suspended from an overhead carriage rolling on rails. Motion of the movable-wall is restrained by an assembly of heavy steel beams held against the fixed wall by four water-cooled tie rods. A single BLH load-cell, Type CXX, with a range of 0-10,000 pounds, is mounted between the movable-wall and the restraining structure. A Foxboro "Dynalog" electronic strain-gauge continuously records the force transmitted through the movable-wall during the test.

All cokes discharged from the oven are dropped from a height of 10 feet to simulate handling of the coke in commercial practice. The cokes are dried prior to screening and testing.

The chemical analysis and the coal and coke testing conform as closely as possible to ASTM test-methods. Standard test-method designations, other than chemical analysis, are given in the references.

The four subject coals were each carbonized alone in the 12-inch movable-wall oven, and also in 30:70 blend with a reference hv coal, the results of these tests being reported in Table 4 and Table 5. For purposes of comparison the test results obtained from carbonizing the reference hv coal alone and in 30:70 blend with a reference lv coal are given in Table 6.

FIGURE 3



Mines Branch Movable-Wall Coke Oven

TABLE 1 - Chemical Analyses of Component Coals

Identification				
Laboratory Number	2710-72	2563-72	2643-72	3376-72
Description	Adit Saxon No. 1	Adit Saxon No. 2	Adit Saxon No. 3	Adit Saxon No. 4
Classification				
Rank (ASTM) .....mvb.....	mvb	mvb	mvb	mvb
International System	433	433	433	434
Specific Volatile Index	198	205	199	194
Carbon (dmmfb) .....%	91.1	91.2	86.3	89.9
Proximate Analysis (db)				
Ash .....%	6.5	6.9	5.4	8.4
Volatile Matter .....%	22.2	21.8	22.7	22.1
Fixed Carbon .....%	71.3	71.3	71.9	69.5
Gross Calorific Value (db)				
Btu per pound	14,600	14,670	14.820	14,191
Ultimate Analysis (db)				
Carbon .....%	84.6	84.3	81.2	81.5
Hydrogen .....%	4.5	4.5	4.6	4.5
Sulphur .....%	0.34	0.50	0.49	0.80
Nitrogen .....%	0.9	0.9	1.0	1.2
Ash .....%	6.5	6.9	5.4	8.4
Oxygen (by difference) .....%	3.2	2.9	7.3	3.6
Ash Analysis (db)				
SiO_2 .....%	48.6	52.8	54.3	62.0
Al_2O_3 .....%	27.4	31.8	25.2	27.7
Fe_2O_3 .....%	3.7	8.6	4.2	3.4
TiO_2 .....%	1.1	1.6	1.2	0.8
P_2O_5 .....%	1.8	0.7	1.4	0.4
CaO .....%	7.5	1.9	7.0	1.5
MgO .....%	2.3	0.8	1.4	1.3
SO_3 .....%	6.6	0.7	5.3	0.9
Na_2O .....%	2.7	0.6	0.4	0.4
K_2O .....%	0.3	0.7	0.6	2.4

TABLE 2 - Physical Tests and Fusibility of Ash of Component Coals

Identification					
Laboratory Number		2710-72	2563-72	2643-72	3376-72
Description		Adit Saxon No. 1	Adit Saxon No. 2	Adit Saxon No. 3	Adit Saxon No. 4
Coal Pulverization					
Sieve Analysis					
Passing	Retained On				
	1/4 in. %	0.3	0.3	0.1	0.0
1/4 in.	1/8 in. %	9.3	9.1	8.4	7.0
1/8 in.	1/16 in. %	15.0	13.7	14.5	16.0
1/16 in.	1/32 in. %	24.2	22.6	23.4	19.6
1/32 in.	.....%	51.2	54.3	53.6	57.4
Total Passing	1/8 in. %	90.4	90.6	91.5	93.0
Grindability					
Hardgrove Index		102	108	106	103
Fusibility of Ash					
Initial Deformation Temp. ... °F		2550	2700+	2450	2600
Softening Temp. Spherical ... °F		2600	2700+	2550	2700+
Softening Temp. Hemispherical °F		2700+	2700+	2650	2700+
Fluid Temp. ..... °F		2700+	2700+	2700+	2700+

TABLE 3-Thermal Rheological Properties of Component Coals

Identification				
Laboratory Number	2710-72	2563-72	2643-72	3376-72
Description	Adit Saxon No. 1	Adit Saxon No. 2	Adit Saxon No. 3	Adit Saxon No. 4
Linear Expansion				
Bd. 52 lb/ft^3 at 2% moisture...%	NA*	-6.7	-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
Torque .....g.in.	40	40	40	40
Dilatation				
Ti - Softening Temp. .....°C	427	413	429	427
Tii - Max. Contraction Temp. °C	461	454	467	463
Tiii - Max. Dilatation Temp. .°C	485	482	489	493
Contraction .....%	23	26	30	26
Dilatation .....%	10	29	18	70
Free Swelling Index				
F.S.I.	6½	8	7	8½

*Not available due to aborted test caused by mechanical failure

TABLE 4 - Carbonization Tests in the Mines Branch 12-Inch Movable-Wall Oven
- Component Coals Alone -

Test Identification Number.....	69	54	60	103
Date of Test.....	19/4/72	16/3/72	4/4/72	25/7/72
Laboratory Number (refer for analysis of charge).....				
COMPONENT COALS IN CHARGE (% by wt. on db)				
Saxon No. 1	100			
Saxon No. 2		100		
Saxon No. 3			100	
Saxon No. 4				100
CARBONIZATION DATA				
Net Weight of Charge (wet).....lb	519.2	517.8	514.2	541.0
Moisture in Charge.....%	3.4	3.3	3.3	3.2
ASTM Bulk Density (wet).....lb/ft^3	48.5	48.5	48.5	48.5
Oven Bulk Density (db).....lb/ft^3	50.7	50.6	50.3	50.8
CARBONIZATION RESULTS				
Gross Coking Time.....hr:min	8:55	9:07	8:50	9:20
Maximum Wall Pressure.....lb/in^2	0.50	3.02	0.75	8.00
Coke Yield Actual.....%	79.3	77.8	78.2	77.9
Mean Coke size.....in	1.96	2.01	1.89	2.12
Apparent Specific Gravity.....	0.97	0.92	0.92	0.86
Screen Analysis of Coke (cumulative percentage retained on)				
3 inch sieve.....	5.9	5.3	4.0	7.6
2 inch sieve.....	42.9	47.7	38.8	57.6
1 1/2 inch sieve.....	73.8	78.6	70.9	82.4
1 inch sieve.....	93.1	93.4	93.1	93.8
3/4 inch sieve.....	95.8	95.7	95.9	95.8
1/2 inch sieve.....	96.5	96.3	96.6	96.5
Percentage -1/2 inch (breeze).....	3.5	3.7	3.4	3.5
Tumbler Test (ASTM)				
Stability Factor.....	59.5	63.0	60.0	57.4
Hardness Factor.....	74.7	71.7	73.8	69.6
Japanese Tumbler Test (JIS) (cumulative percentage retained on)				
50 mm sieve.....	* -	24.7	15.0	28.5
25 mm sieve.....	-	89.6	87.7	90.7
15 mm sieve.....	-	95.0	93.7	94.8

*Insufficient sized coke to perform test

TABLE 5 - Carbonization Tests in the Mines Branch 12-Inch Movable-Wall Oven
- 30% Component Coal +70% Reference hv Coal -

Test Identification Number	68	53	62	119
Date of Test	18/4/72	15/3/72	6/4/72	6/9/72
Laboratory Number (refer for analysis of charge)				
COMPONENT COALS IN CHARGE (% by wt. on db)				
Saxon No. 1	30			
Saxon No. 2		30		
Saxon No. 3			30	
Saxon No. 4				30
Reference H.V. Coal	70	70	70	70
CARBONIZATION DATA				
Net Weight of Charge (wet) lb	515.6	517.8	517.3	538.5
Moisture in Charge %	3.1	3.0	2.7	2.7
ASTM Bulk Density (wet) lb/ft^3	48.5	48.5	48.6	48.5
Oven Bulk Density (db) lb/ft^3	50.5	50.8	50.8	50.9
CARBONIZATION RESULTS				
Gross Coking Time hr:min	8:18	8:40	8:46	9:10
Maximum Wall Pressure lb/in^2	0.25	0.23	0.27	0.27
Coke Yield Actual %	72.0	71.6	71.6	73.0
Mean Coke size in	1.97	1.92	1.99	1.90
Apparent Specific Gravity	0.87	0.80	0.84	0.87
Screen Analysis of Coke (cumulative percentage retained on)				
3 inch sieve	5.9	4.7	5.3	2.1
2 inch sieve	45.7	40.8	45.8	40.7
1 1/2 inch sieve	74.4	73.8	77.4	73.7
1 inch sieve	92.8	92.8	93.9	93.8
3/4 inch sieve	95.2	95.5	95.8	96.2
1/2 inch sieve	96.1	96.3	96.1	97.0
Percentage -1/2 inch (breeze)	3.9	3.7	3.9	3.0
Tumbler Test (ASTM)				
Stability Factor	50.4	52.2	50.6	54.3
Hardness Factor	64.6	67.0	64.2	69.9
Japanese Tumbler Test (JIS) (cumulative percentage retained on)				
50 mm sieve	16.0	19.6	22.8	* -
25 mm sieve	82.9	86.2	85.0	-
15 mm sieve	92.0	91.9	92.2	-

*Insufficient sized coke to perform test.

TABLE 6 - Carbonization Tests in the Mines Branch 12-Inch Movable-Wall Oven
- Carbonization of Reference Coals -

Test Identification Number.....	730	731
Date of Test.....	4/11/67	24/11/67
Laboratory Number (refer for analysis of charge).....		
COMPONENT COALS IN CHARGE (% by wt. on db)		
Reference hv	100	70
Reference lv		30
CARBONIZATION DATA		
Net Weight of Charge (wet).....lb	522.6	520.3
Moisture in Charge.....%	2.8	3.2
ASTM Bulk Density (wet).....lb/ft^3	48.6	48.5
Oven Bulk Density (db).....lb/ft^3	51.2	50.7
CARBONIZATION RESULTS		
Gross Coking Time.....hr:min	9:33	10:20
Maximum Wall Pressure.....lb/in^2	0.10	0.60
Coke Yield Actual.....%	73.3	76.9
Mean Coke size.....in	2.05	2.23
Apparent Specific Gravity.....	0.93	0.89
Screen Analysis of Coke (cumulative percentage retained on)		
3 inch sieve.....	8.3	6.7
2 inch sieve.....	50.8	54.5
1 1/2 inch sieve.....	77.6	81.8
1 inch sieve.....	93.0	94.3
3/4 inch sieve.....	95.5	96.0
1/2 inch sieve.....	96.5	96.6
Percentage -1/2 inch (breeze).....	3.5	3.4
Tumbler Test (ASTM)		
Stability Factor.....	39.6	53.7
Hardness Factor.....	64.6	69.7
Japanese Tumbler Test (JIS) (cumulative percentage retained on)		
50 mm sieve.....	8.4	14.1
25 mm sieve.....	71.7	85.2
15 mm sieve.....	87.2	91.6

TABLE 7

Analyses of Coke Oven Charges and Resultant Cokes of Component Coals

Identification				
Test Number.....	69	54	60	103
Date Charged.....	19/4/72	16/3/72	4/4/72	25/7/72
Description.....	Adit Saxon No. 1	Adit Saxon No. 2	Adit Saxon No. 3	Adit Saxon No. 4
Coke Oven Charge				
Laboratory Number.....	2710-72	2563-72	2643-72	3376-72
Proximate Analysis (db)				
Ash.....%	6.5	6.9	5.4	8.4
Volatile Matter.....%	22.2	21.8	22.7	22.1
Fixed Carbon .....%	71.3	71.3	71.9	69.5
Sulphur (db).....%	0.34	0.50	0.49	0.80
Resultant Coke				
Laboratory Number.....	2813-72	2583-72	2660-72	3416-72
Proximate Analysis (db)				
Ash.....%	8.9	8.6	7.3	10.2
Volatile Matter.....%	1.5	1.5	1.2	0.8
Fixed Carbon.....%	89.6	89.9	91.5	89.0
Sulphur (db).....%	0.30	0.45	0.43	0.77

TABLE 7 (Continued)

Analyses of Coke Oven Charges and Resultant Cokes of Blends

Identification				
Test Number.....	68	53	62	119
Date Charged.....	18/4/72	15/3/72	6/4/72	6/9/72
Description.....	30% Saxon No. 1 70% Ref. hvAb	30% Saxon No. 2 70% Ref. hvAb	30% Saxon No. 3 70% Ref. hvAb	30% Saxon No. 4 70% Ref. hvAb
Coke Oven Charge				
Laboratory Number.....	2711-72	2564-72	2654-72	3884-72
Proximate Analysis (db)				
Ash.....%	5.3	5.3	5.0	5.8
Volatile Matter.....%	32.1	31.4	32.0	31.0
Fixed Carbon .....%	62.6	63.3	63.0	63.2
Sulphur (db).....%	0.65	0.64	0.68	0.72
Resultant Coke				
Laboratory Number.....	2812-72	2582-72	2806-72	3970-72
Proximate Analysis (db)				
Ash.....%	7.6	7.7	6.9	8.1
Volatile Matter.....%	1.3	1.4	1.1	1.1
Fixed Carbon.....%	91.1	90.9	92.0	90.8
Sulphur (db).....%	0.47	0.52	0.54	0.65

TABLE 8 - Petrographic Analysis of Component Coals

Identification				
Laboratory Number	2710-72	2563-72	2643-72	3376-72
Description	Adit Saxon No. 1	Adit Saxon No. 2	Adit Saxon No. 3	Adit Saxon No. 4
Distribution of Vitrinoid Types				
Type No.				
11 ....%	0.8	0.9	3.6	0.9
12 ....%	6.3	10.6	29.6	20.6
13 ....%	34.2	34.5	25.1	33.3
14 ....%	18.6	20.2	4.5	18.8
15 ....%	0.8	1.0	0.8	4.3
Reactive Components				
Total Vitrinoid ....%	60.7	67.2	63.6	77.9
Reactive Semi-fusinoid (1/3)...%	6.4	5.5	6.4	3.1
Exinoid + Resinoid ....%	0.0	0.0	0.0	0.4
Total ....%	67.1	72.7	70.0	81.4
Inert Components				
Inert Semi-fusinoid (2/3).....%	12.7	11.1	12.7	6.3
Micrinoid ....%	6.4	4.2	3.1	1.7
Fusinoid ....%	10.2	8.1	11.2	5.8
Mineral Matter ....%	3.6	3.9	3.0	4.8
Total ....%	32.9	27.3	30.0	18.6
Petrographic Indices				
Mean Reflectance ....%	1.37	1.36	1.30	1.36
Balance Index	2.59	2.08	1.99	1.23
Strength Index	5.96	6.00	5.31	5.92
Stability Index	55.3	58.6	55.6	65.0

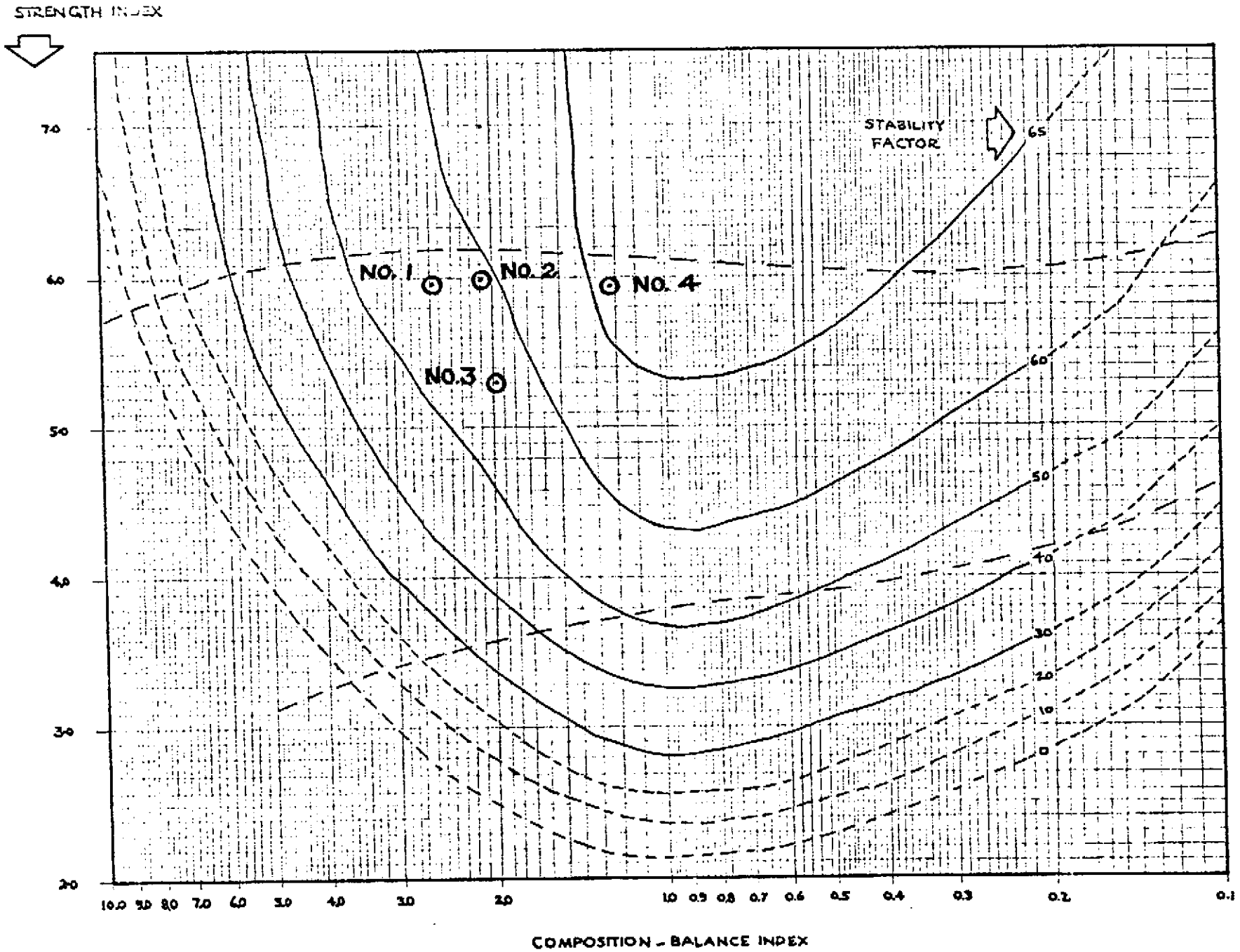


FIGURE 4 - Potential Stability Factors of Coal Samples from Saxon Adits No. 1, 2, 3 and 4

PROJECT OBSERVATIONS AND DISCUSSION

Rank

Based on the ASTM system of rank classification, coals from Adit Nos. 1, 2, 3 and 4 are medium volatile bituminous coal.

Based on the International Classification of Hard Coals by type, the coals from Adit Nos. 1, 2 and 3 are classed as 433 and coal from Adit 4 is classed as 434.

The Specific Volatile Index (S.V.I.) developed at the Mines Branch to classify coals numerically, range from 194 to 199 for Adit Nos. 1, 3 and 4, indicating that these coals are classed as blending coals in the meta-bituminous class. Coal from Adit No. 2 with an S.V.I. of 205 is a semi or "super" bituminous coal suitable for blending with high volatile coals for improving coke quality.

The Specific Volatile Index is defined as the heat value expressed in BTU per 1 per cent volatile matter content of a coal and it is computed on a unit coal basis by the following formula:

$$\text{S.V.I.} = \frac{\text{BTU/lb dmmfb} - (14{,}500 \times \text{weight of fixed carbon, dmmfb})}{\text{per cent volatile matter, dmmfb.}}$$

Sulphur Content

The sulphur values of the four adit samples are favourably low, averaging 0.52 per cent.

Ash Level and Ash Analysis

The average ash value for the four adit samples is 6.8 per cent which is acceptable for metallurgical coke production.

The average phosphorus pentoxide in the ash is 1.1 per cent which based on an average ash value of 6.8 per cent calculates to an average

phosphorus (P) level in the coal of 0.03 per cent.

The average alkaline ($Na_2O + K_2O$) level as determined in the ash is 2.0 per cent which based on the average ash value of 6.8 per cent in the coal calculates to an alkaline ($Na_2O + K_2O$) level in the coal of 0.14 per cent.

Both the phosphorus and alkaline levels are well below the tolerated limits set by the steel-making industry.

Thermal Rheological Properties

The average fluidity of the four adits is 37.5 ddpm, the average Ruhr dilatation value is 31.8 per cent, and the average Free Swelling Index is 7.5. These values indicate coals with good agglomerating, caking and swelling properties.

The linear expansion values for Saxon Adit Nos. 2 and 3 are negative (-6.7 and -3.1) indicating contraction and the value for Saxon No. 4 is +2.8 indicating expansion.

These values indicate that these coals if coked alone without blending with high volatile coals could result in difficulty in pushing the charge from the oven.

Petrography

The average maximum spectral reflectance value of the four Saxon adits is 1.35 per cent. The mean maximum spectral reflectance value of a coal is related to the degree of metamorphism or coalification that the coal has undergone which, in turn, is related to the rank of the coal. The Saxon coals are classed petrographically as mature medium volatile coals.

The mean balance index, a relationship between the reactive and inert components, is 1.97 which is indicative of a coal with an excess of inert components. This type of coal is usually blended with high volatile coals to achieve an optimum blast furnace coke.

The mean predicted stability factor for the Saxon adits calculated from the petrographic data is 58.6 - a high potential coking coal.

Carbonization Test Results

TABLE 9

Summary of Key Carbonization Data for Component Coals

	Saxon No. 1	Saxon No. 2	Saxon No. 3	Saxon No. 4
Charge Composition..... %	100	100	100	100
Stability Factor.....	59.5	63.0	60.0	57.4
Hardness Factor.....	74.7	71.7	73.8	69.6
JIS 15mm Value..... %	NA	95.0	93.7	94.8
Coke Yield.....%	79.3	77.8	78.2	77.9
Max. Wall Pressure..lb/in^2	0.50	3.02	0.75	8.00
Coke Breeze (-½in).....%	3.5	3.7	3.4	3.5

The results in the above table show that all of the subject coals produced a good yield of high strength coke, with a minimum amount of breeze when carbonized individually.

The maximum wall pressures recorded for Adits 2 and 4 were 3.02 and 8.0 lbs/in^2 respectively. These values would have to be considered if these coals were to be carbonized alone in slot type ovens owing to the possibility of pressure damage. This is a cautionary note as factors such as bulk density and coking time affect the amount of pressure generated in the oven. If these coals were carbonized in a blend with high volatile coals as would almost certainly be the case in commercial practice, the pressure factor would be an asset as it would tend to offset the effect of shrinkage of the high volatile coal and reduce fissuring, thus enhancing the strength of the coke.

TABLE 10

Summary of Key Carbonization Data from the Blend Tests

	Percentages in Charges					
Reference lv Coal		30				
Reference hv Coal	100	70	70	70	70	70
Saxon No. 1			30			
Saxon No. 2				30		
Saxon No. 3					30	
Saxon No. 4						30
Stability Factor.....	39.6	53.7	50.4	52.2	50.6	54.3
Hardness Factor.....	64.6	69.7	64.6	67.0	64.2	69.9
JIS 15mm Value.....%	87.2	91.6	92.0	91.9	92.2	NA
Coke Yield.....%	68.1	72.4	72.0	71.6	71.6	73.0
Max. Wall Pressure..lb/in^2	0.10	0.60	0.25	0.23	0.27	0.27
Coke Breeze (-½in).....%	3.5	3.4	3.9	3.7	3.9	3.0

For comparative studies and not for the optimization of the physical properties of the resultant coke, high rank coals are routinely blended in a 30:70 ratio with a reference high volatile coal. The marked improvement in the physical properties of the carbonized reference high volatile coal is revealed in Table 10, when 30 per cent of coal from the Saxon adits are introduced into the blend. A comparison of the 30:70 Saxon coal blends with a similar blend of reference low volatile and high volatile coal indicates that the physical properties of the resultant coke produced, from Saxon No. 2 and No. 4 coal blends are equal to the premium low volatile coal blend.

In summary, these are premium medium volatile coking coals. The Saxon coals tested exhibit very good coking properties and should produce

excellent high strength metallurgical coke.

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