Call week of Nov. 19.

Northern Coal Mines Ltd.
1930 - 1055 West Hastings Street, Vancouver 1, B.C.
Telephone: 687-9076

REFERRED TO	DATE	INITIAL
D.M. ✓		
C.G.S.		
C.C.		
D.C.G.C.		
D.C.C.		
ACCTS.		
C.M.B.		
C.I.		
C.A.		
R. T.		
C.P.E.		
FILING		

NOV 13 73 AM

12209

November 8th, 1973.

Mr. John McMynn,
Deputy Minister,
Department of Mines & Petroleum Resources,
VICTORIA, B. C.

Dear Mr. McMynn:

The purpose of this letter is to request a meeting with you at your earliest convenience with regard to coal licenses and other matters pertaining to Northern Coal Mines Ltd.

At present we are engaged in the preparations for a re-organization of the company's share structure and change of name. Following this we will consider a proposal for participation in a gas and oil drilling project which might serve to rejuvenate the company financially.

In addition, we have two apparently serious approaches with regard to the company's coal deposit in the Bowron River Valley east of Prince George.

For lack of funds the company's holdings have been reduced to three coal licenses. These cover the underground workings and most of the drill-tested area.

The chief points for discussion are:

(1). By what means and under what conditions we might acquire an additional 10 or 12 licenses (previously held) to provide sufficient area for a sizeable mining operation, should one be considered feasible by the new interests;

(2). The government's attitude with regard to foreign financial and equity participation.

Reference is also made to my letter to Mr. Nimsick of February 22nd, 1973 and his reply of April 24th, 1973.

A telephone call to the effect that you could meet me and other directors during the week of November 12th would be greatly appreciated.

. . . . / 2

Any help you can give us in these matters will also be greatly appreciated by the many (900 plus) long-suffering shareholders of the company.

Yours very truly,

NORTHERN COAL MINES LTD.

M. M. Menzies,
President.

MMM:bj

93H-4212

BW-BOWRON RIVER 74(10)A

NORTHERN COAL MINES LTD.

DATA COMPILATION

L. S. Trenholme
Vancouver, B. C.
January, 1974

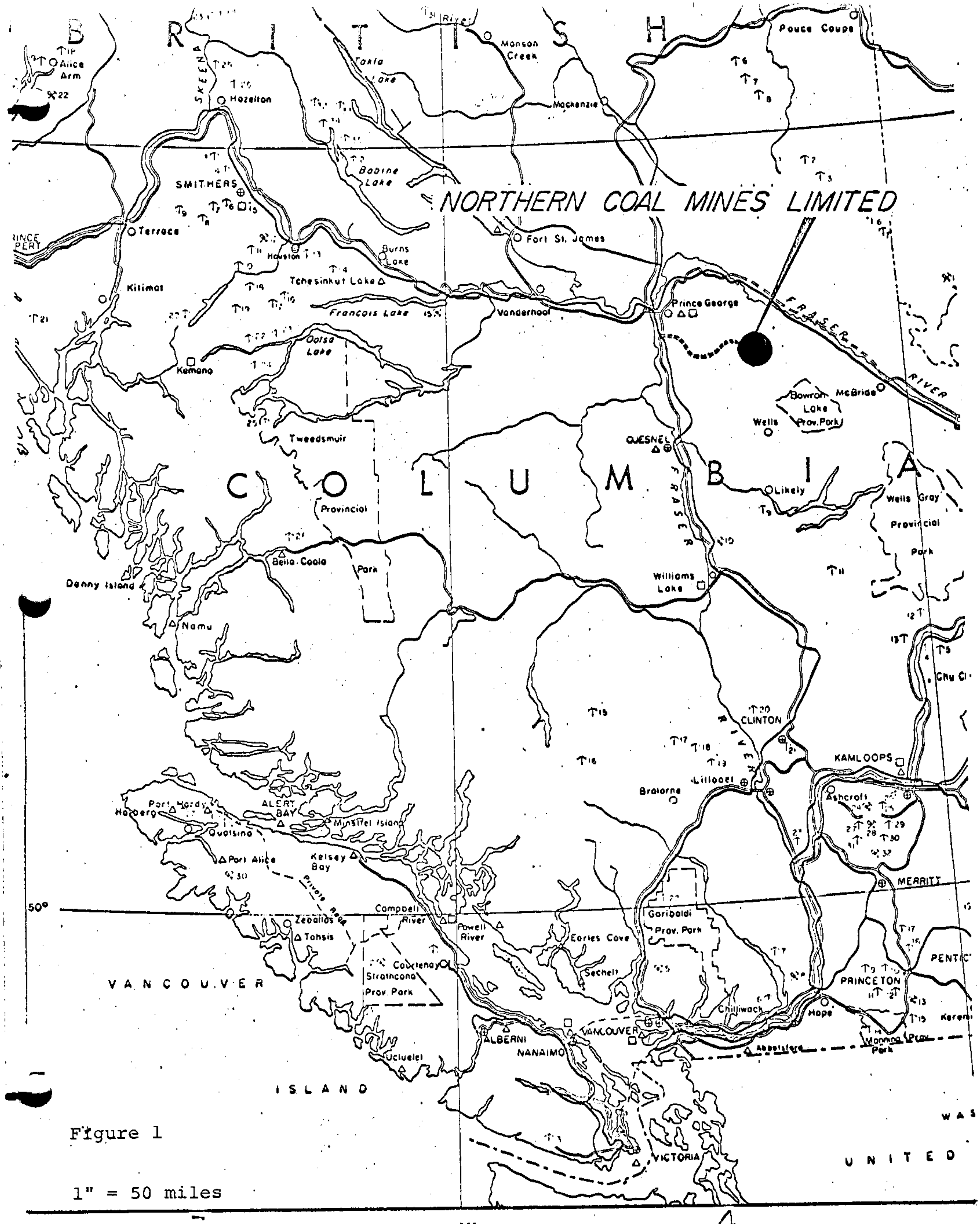


Figure 1

1" = 50 miles

CONTENTS

FIGURES

TABLES

● REFER TO: CONFIDENTIAL COAL ANALYSIS
BW-BOWRON RIVER 74(4)A

APPENDIX

Appendix A

A-1	Report by R. E. Kucera to Bethlehem Copper Corporation, September, 1971 Less maps.
A-2	Black, J. M., Report January 31, 1967
A-3	Black, J. M., Report September 8, 1967
A-4	Letter to the Shareholders June 6, 1969 RE: Underground Progress

Appendix B - Coal Testing

● B-1	Sink - Float Analysis of Drill Cores - 1969
● B-2	Black, J. M., Letter Report on Cleaning Tests June 4, 1969
✓B-3	Proximate Analysis - by Superintendence Company (Canada) Ltd. Nov. 19,1968 Mines sample from "Main Slope" at 400 feet.
● B-4	Washing Test - Osaka Shipbuilding Co. April 2, 1969 Bulk Sample, "Main Slope" at 200 feet.
✓B-5	Proximate Analysis - "Main Slope" at 200 feet by Nippon Kaiji Kentei Kyokai April 6, 1968
✓B-6	Proximate Analysis - No. 1 Seam "Ventilation Slope" by Coast Eldridge January 28, 1964
✓B-7	Petrography G. S. C. Technical Report 93-H-13W-1 1972

Appendix C - Resins and Radioactivity

C-1	"Radioactivity of Tertiary Lignites . . . ." G. S. C. Project 680106
C-2	Battelle Memorial Institute Report on Refind Resins November 30, 1966
C-3	Battelle Memorial Institute Summary Report on Resins February 28, 1967
C-4	Battelle Columbus Laboratories Letter and Attachments November 29, 1972

Appendix D - Mining and Coal Gasification

D-1	Hydraulic Mining in East Kootenay, B. C. C.I.M. Bulletin	January, 1974
D-2	"Status Report: the AGA/OCR Coal Gasification Program" Coal Age	January, 1973
D-3	Underground Gasification Coal Age	September, 1973
D-4	"Gasification of Coal Research Needed" Berkowitz, Edmonton Journal	November 9,1972
D-5	"Preliminary results....Wyoming in situ gasification test" Coal Age	December,1973

Appendix E - Strip Logs

E-1	D. D. H. 71-1	Sheets 1, 2
E-2	D. D. H. 71-2	Sheets 1, 2
E-3	D. D. H. 71-3	Sheets 1, 2, 3
E-4	D. D. H. 71-4	Sheets 1, 2
E-5	D. D. H. 71-5	Sheet 1

Other References

1. Coal Gasification, Feasibility, Economics and Viability
   Continental Oil Company March, 1973

GENERAL STATEMENT

This is a compilation of technical data relating to the company's coal properties and includes more detailed information than has been presented in any single report to date.

A revised estimate of coal reserves is based on total coal in place, not necessarily mineable reserves, on the premise that such an estimate may be of value in considering the feasibility of gasification of the coal in-situ, either for generating electric power or for supplying a natural gas transmission system.

PROPERTY

The company's coal properties are situated in the valley of the Bowron River, 35 miles east of Prince George, B. C. at Lat. 52° 50' N., Long. 122° 55' W. (N.T.S. Reference 93H/13). At present the company holds three coal licences (C.L. 148, C.L. 162 and C.L. 163) of one square mile each (Fig. 2). Additional contiguous licences were relinquished for financial reasons, but representations have been made to the provincial government for the future re-instatement of some of the licences to avoid multiple ownership of the deposit. The three licences

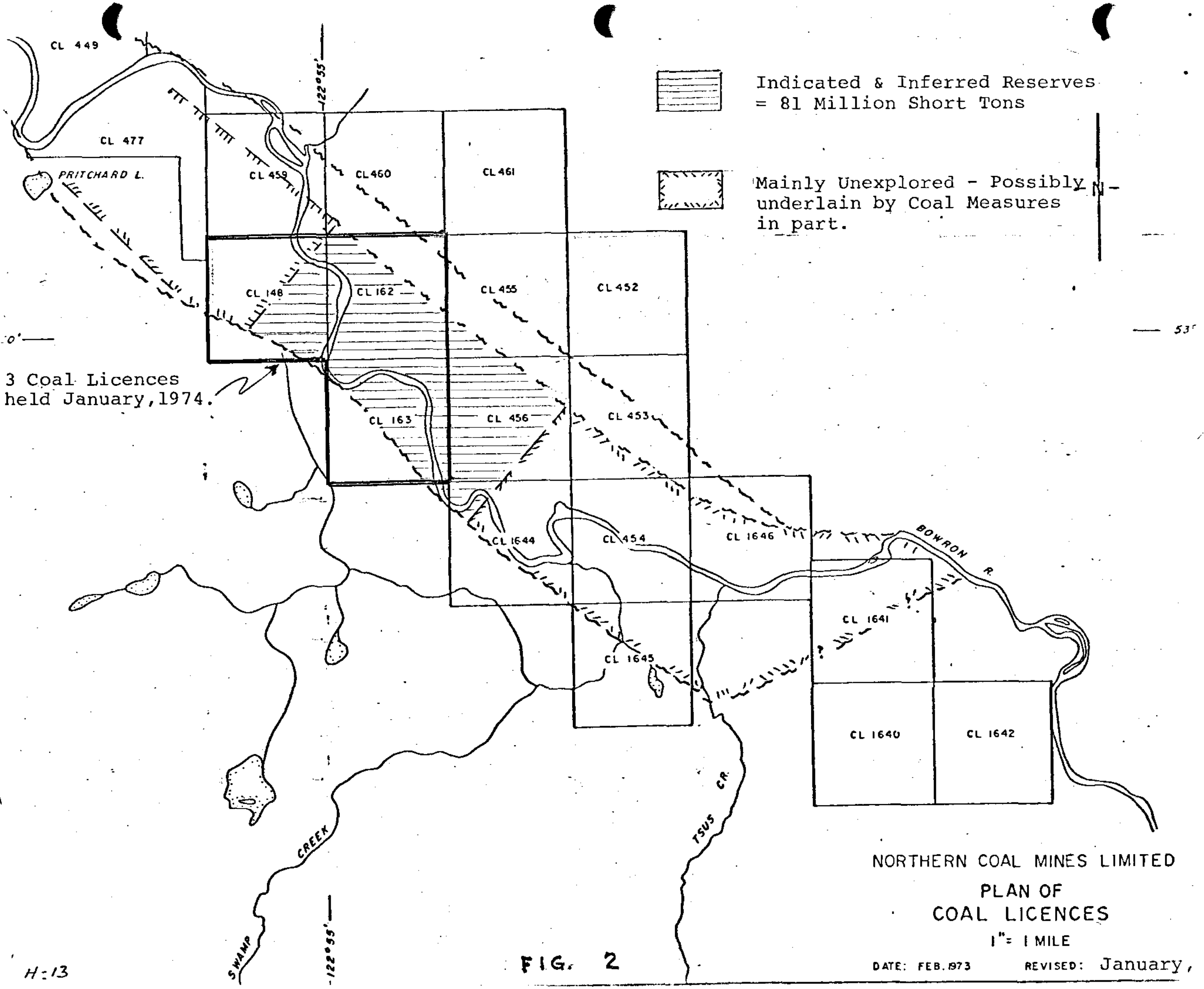
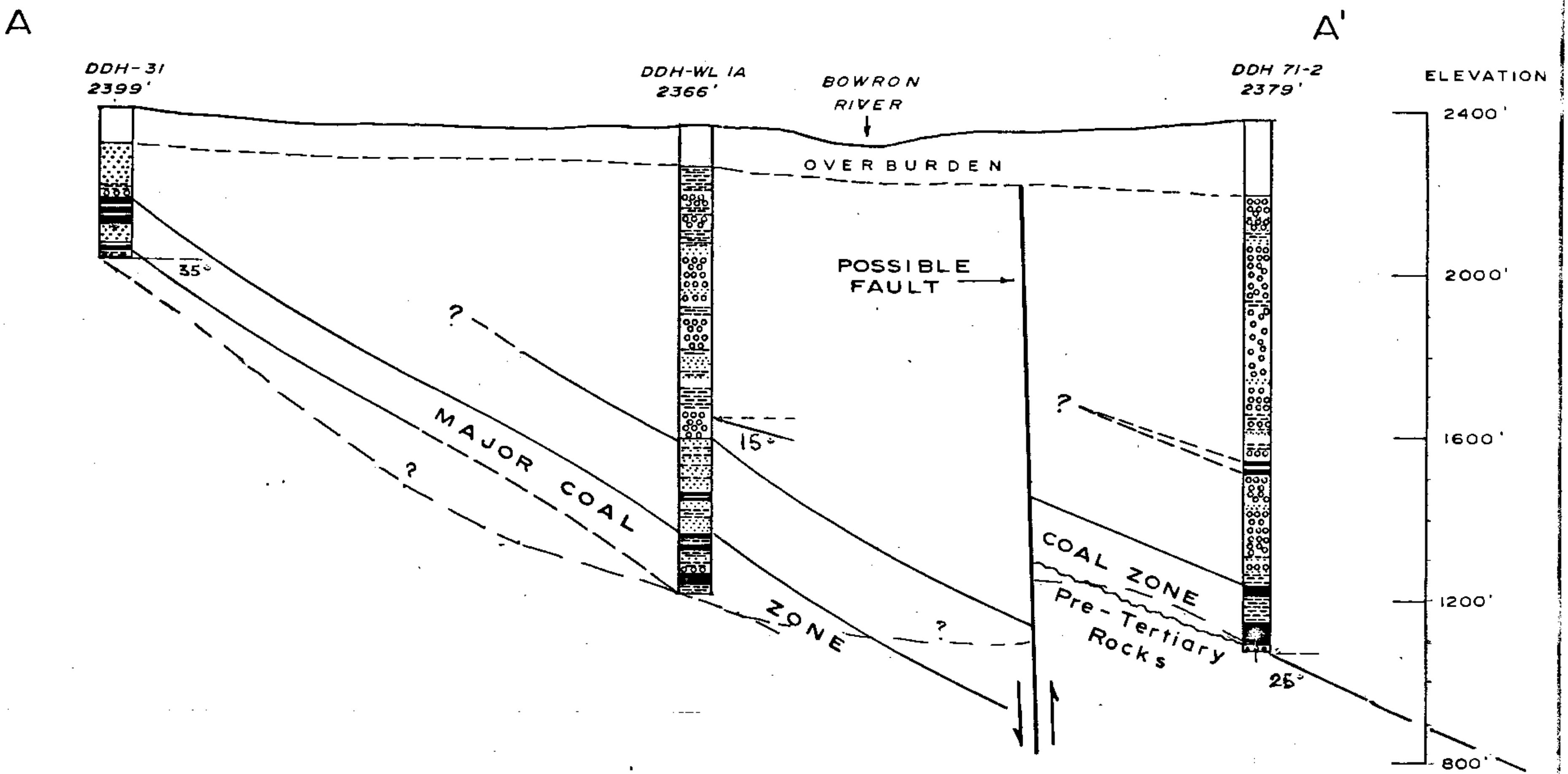

CL 449
CL 477
PRITCHARD L.
CL 459
CL 460
CL 461
CL 148
CL 162
CL 455
CL 452
CL 163
CL 456
CL 453
CL 1644
CL 454
CL 1646
CL 1645
CL 1641
CL 1640
CL 1642
BOWRON R.
SWAMP CREEK
TSUS CR.
122°55'
53°
N
Indicated & Inferred Reserves = 81 Million Short Tons
Mainly Unexplored - Possibly underlain by Coal Measures in part.
3 Coal Licences held January, 1974.
NORTHERN COAL MINES LIMITED
PLAN OF COAL LICENCES
1" = 1 MILE
DATE: FEB. 1973 REVISED: January,

FIG. 2



NORTHERN COAL MINES LTD.

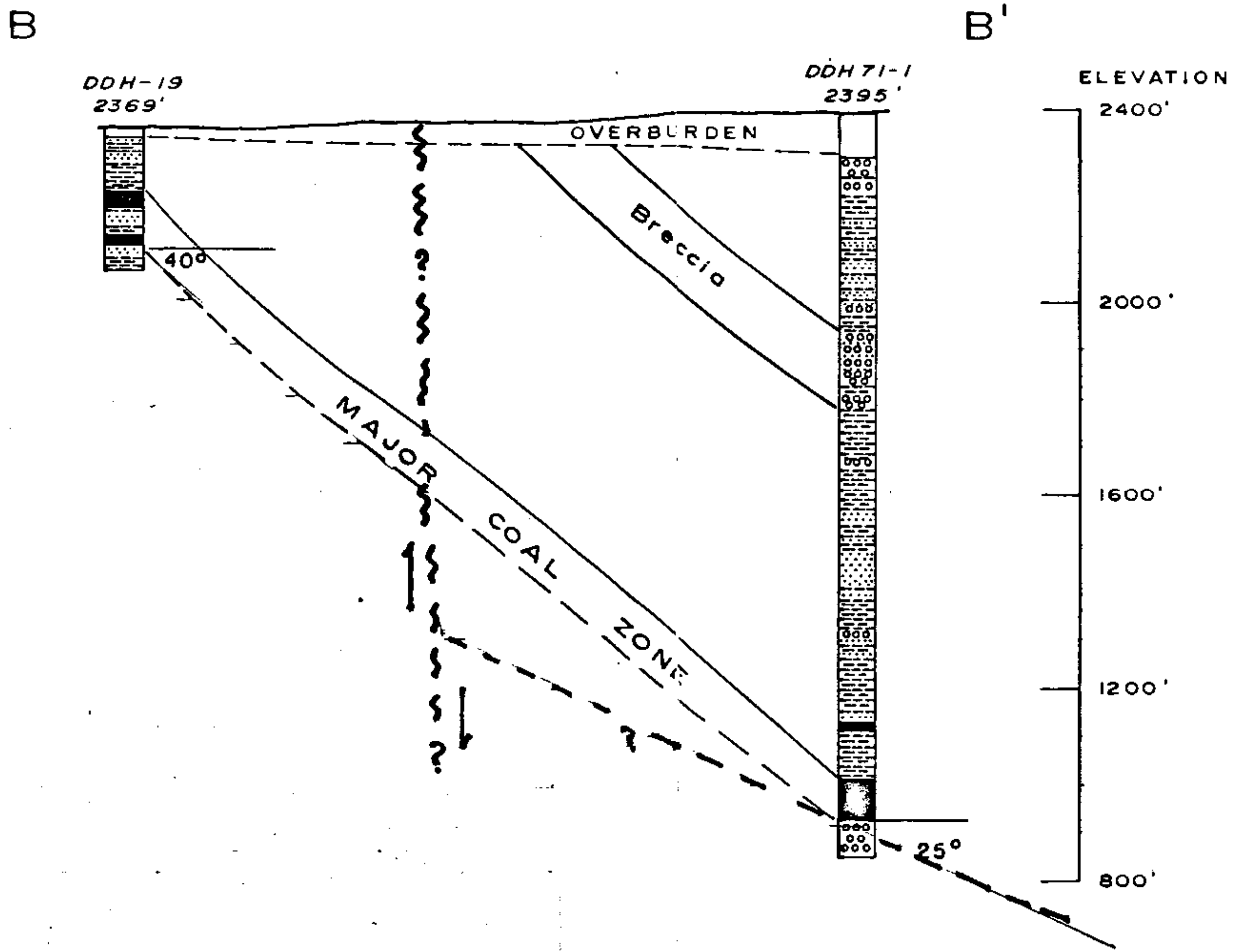
Geology (1971) by Richard E. Kucera
for
Bethlehem Copper Corporation Ltd.

With modifications by L.S. Trenholme
January, 1974

VERTICAL SECTION A-A'

LOOKING N. 7° W.

FIG. 5



NORTHERN COAL MINES LTD.

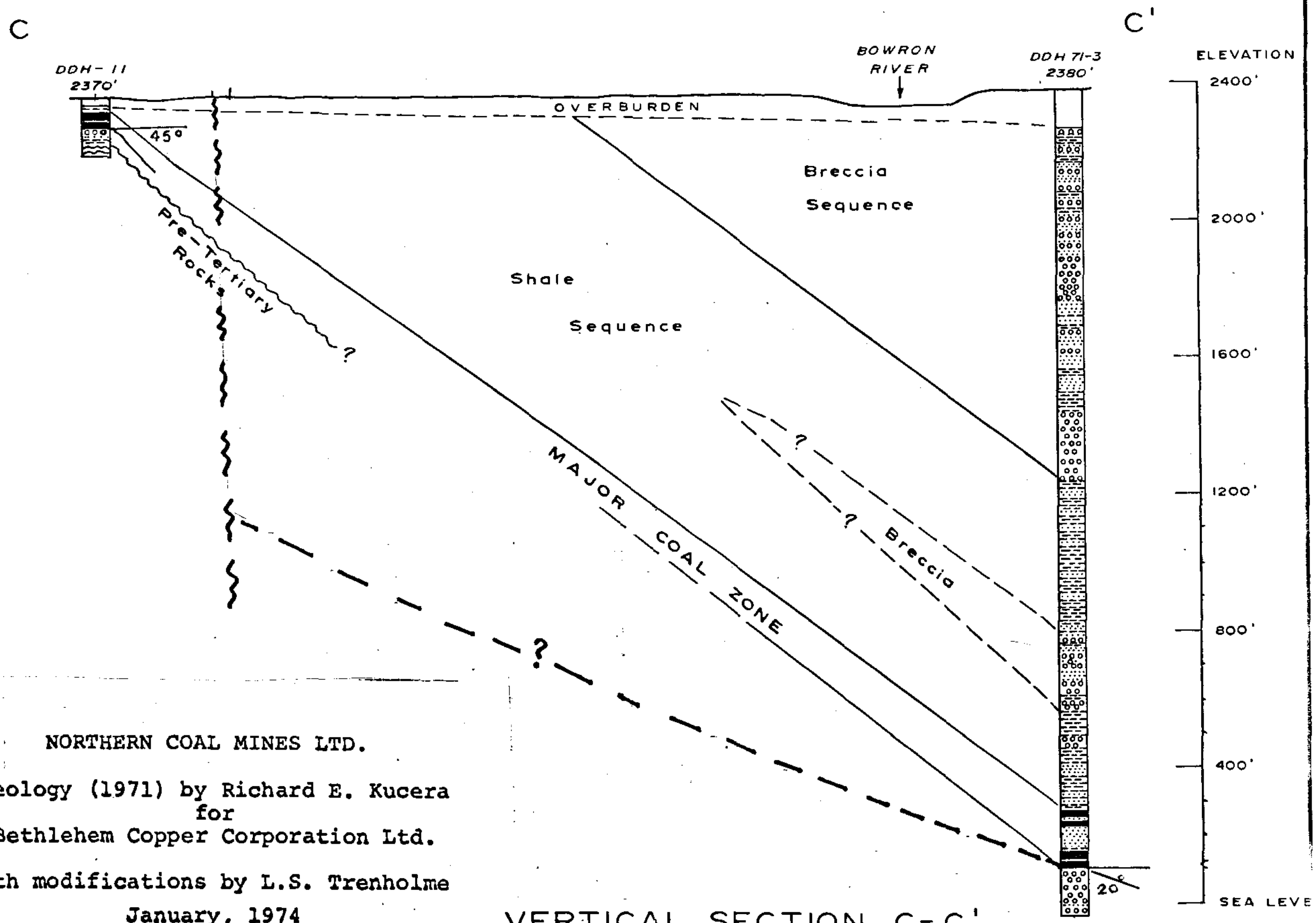
Geology (1971) by Richard E. Kucera
for
Bethlehem Copper Corporation Ltd.

With modifications by L.S. Trenholme
January, 1974

VERTICAL SECTION B-B'

LOOKING N.41° W.

FIG. 6



NORTHERN COAL MINES LTD.

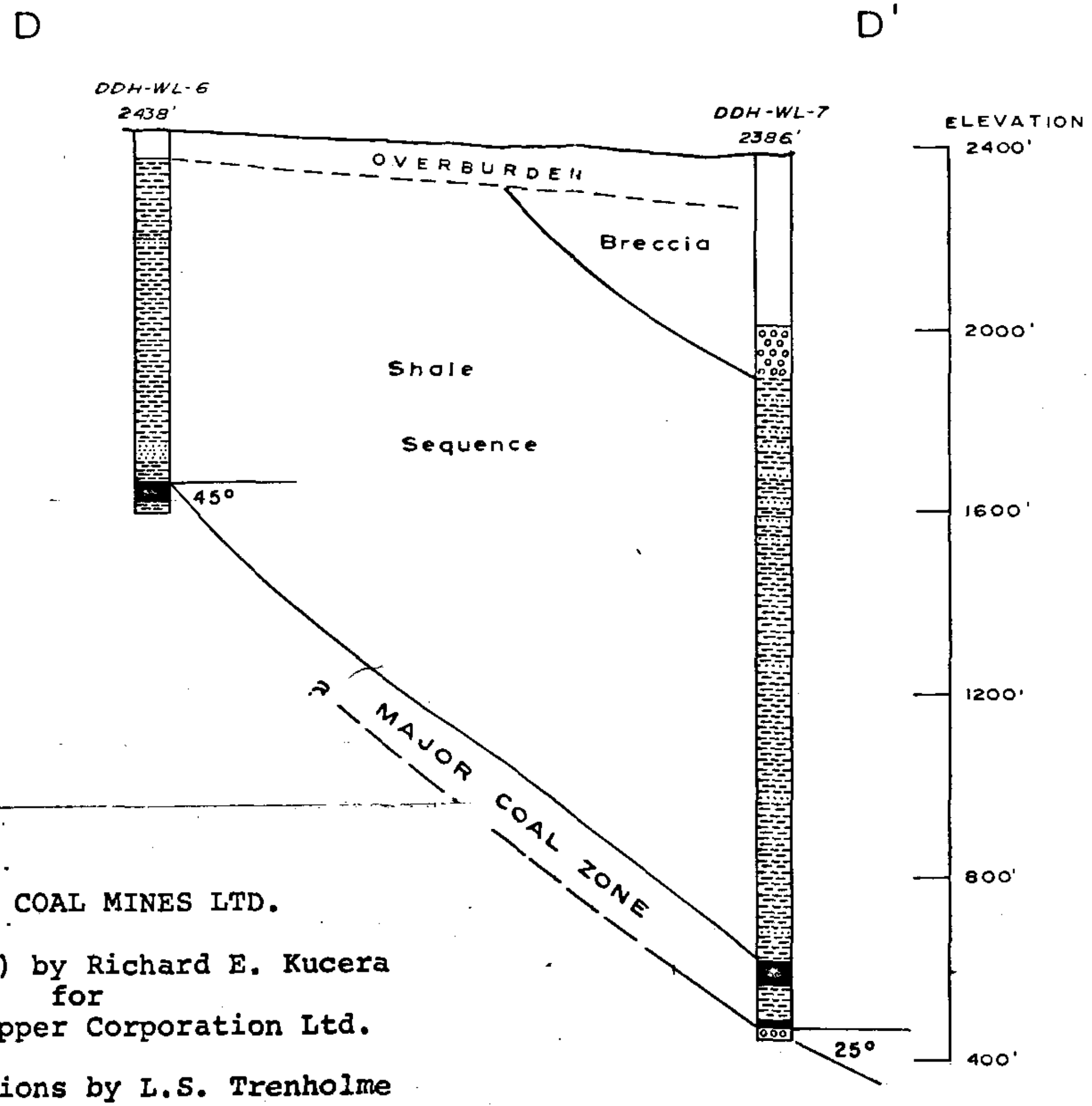
Geology (1971) by Richard E. Kucera
for
Bethlehem Copper Corporation Ltd.

With modifications by L.S. Trenholme
January, 1974

VERTICAL SECTION C-C'

LOOKING N.17°W.

FIG. 7



NORTHERN COAL MINES LTD.

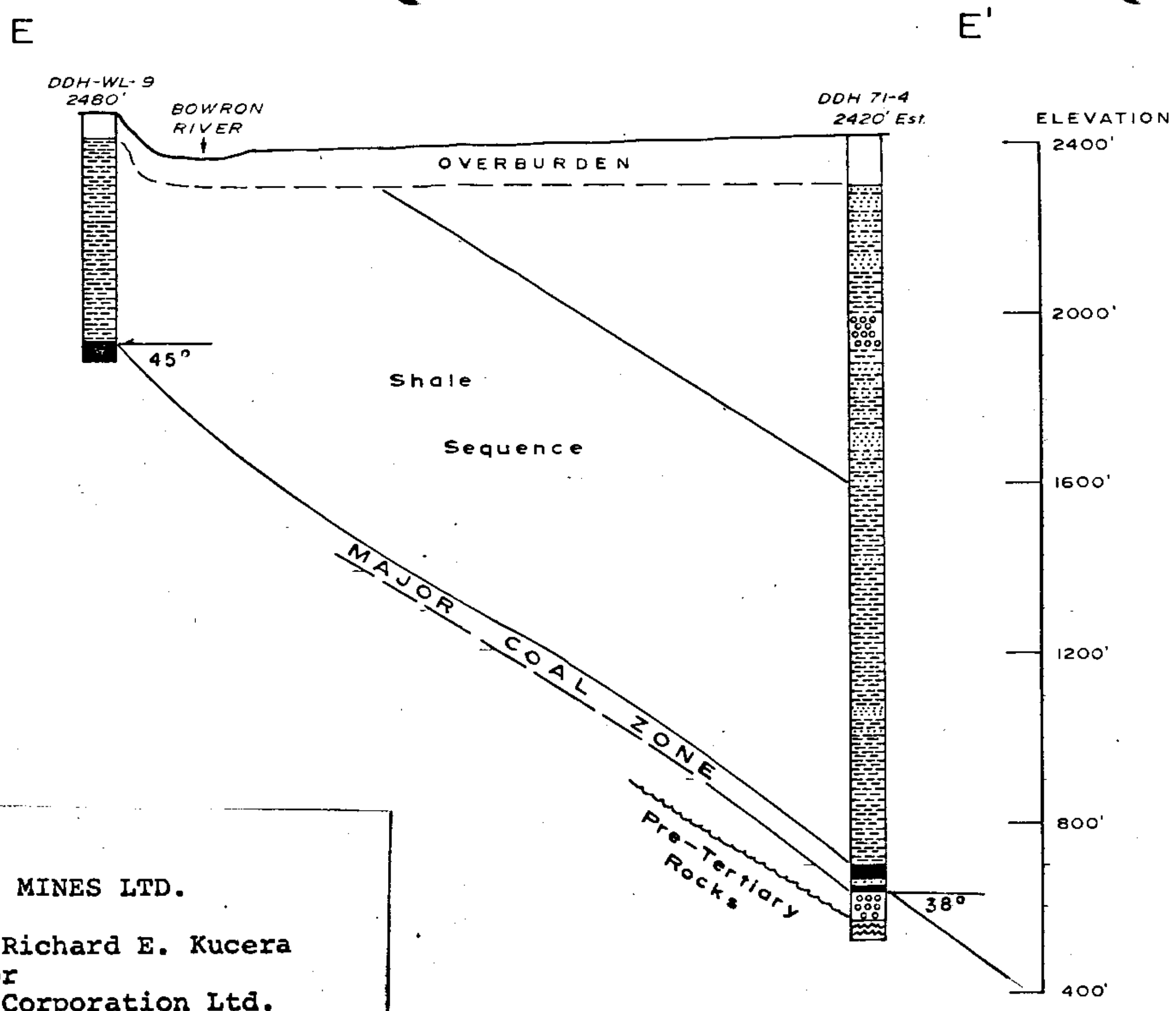
Geology (1971) by Richard E. Kucera
for
Bethlehem Copper Corporation Ltd.

With modifications by L.S. Trenholme
January, 1974

VERTICAL SECTION D-D'

LOOKING N. 22° W.

FIG. 8



NORTHERN COAL MINES LTD.

Geology (1971) by Richard E. Kucera
for
Bethlehem Copper Corporation Ltd.

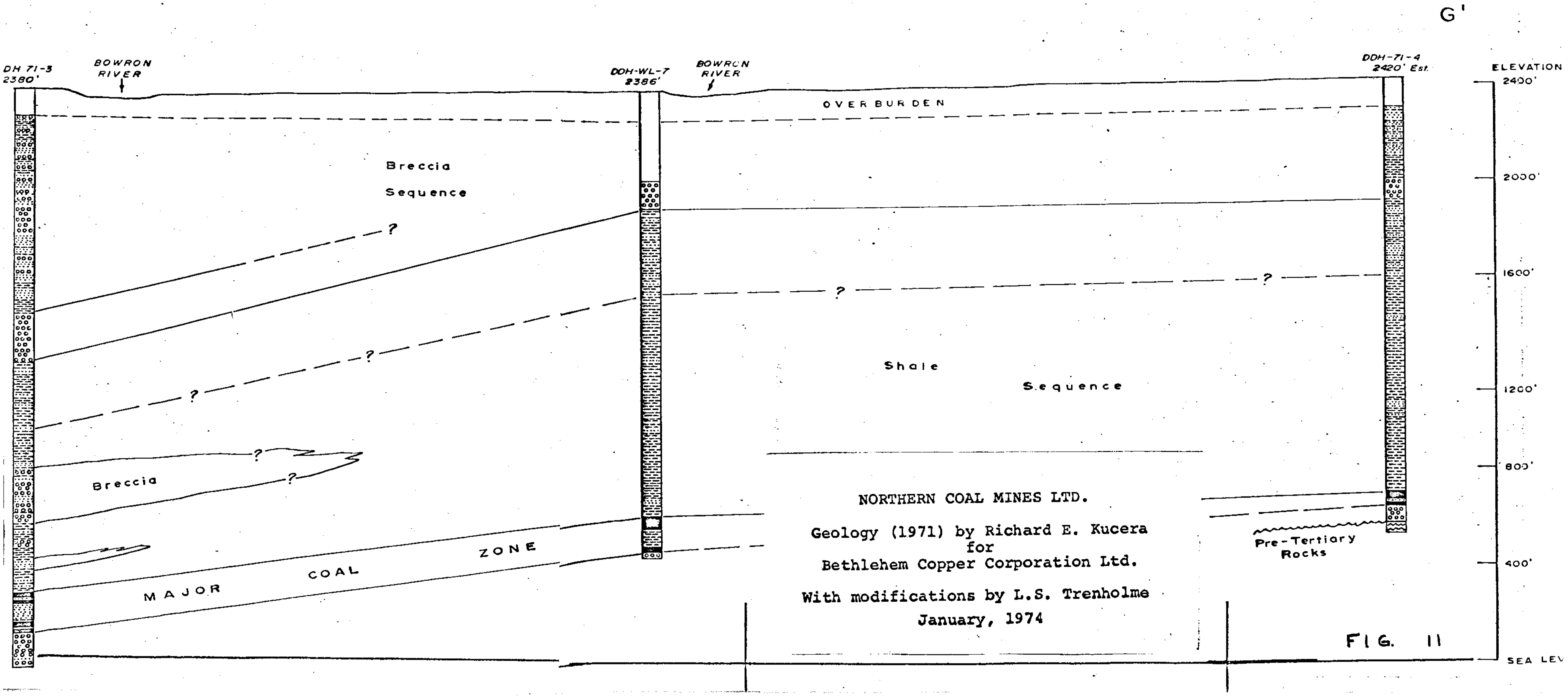
With modifications by L.S. Trenholme
January, 1974

VERTICAL SECTION E-E'
LOOKING NORTH

FIG. 9

VERTICAL SECTION G-G'

LOOKING N.63°E.

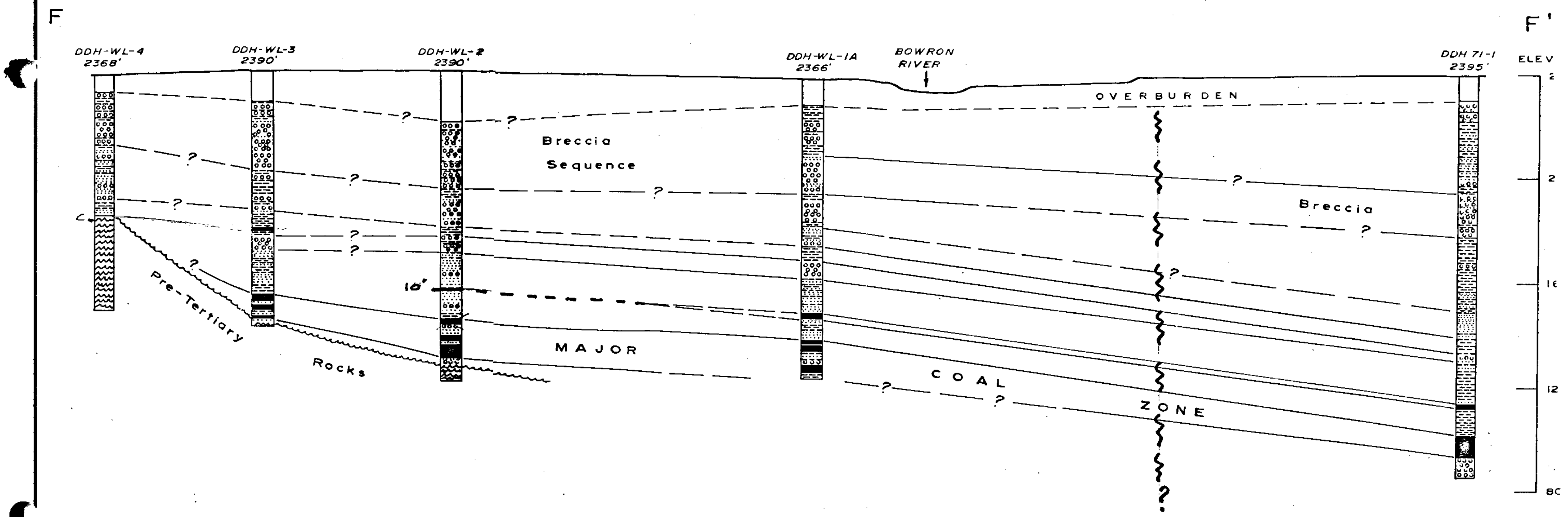


NORTHERN COAL MINES LTD.

Geology (1971) by Richard E. Kucera
for
Bethlehem Copper Corporation Ltd.

With modifications by L.S. Trenholme
January, 1974

FIG. 11



NORTHERN COAL MINES LTD.

Geology (1971) by Richard E. Kucera
for
Bethlehem Copper Corporation Ltd.

With modifications by L.S. Trenholme
January, 1974

VERTICAL SECTION F-F'

LOOKING N. 54° E.

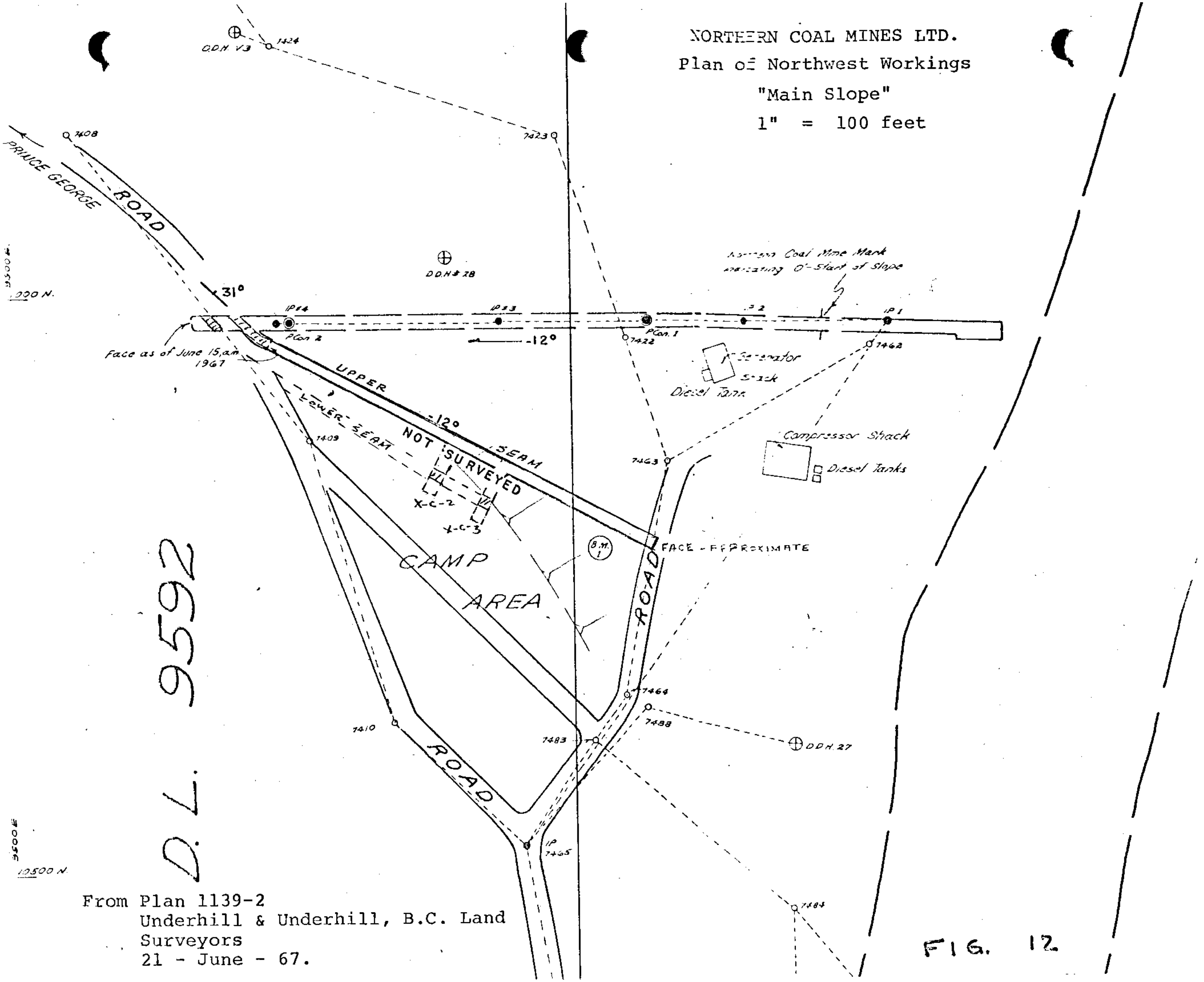
FIG. 10

NORTHERN COAL MINES LTD.

Plan of Northwest Workings

"Main Slope"

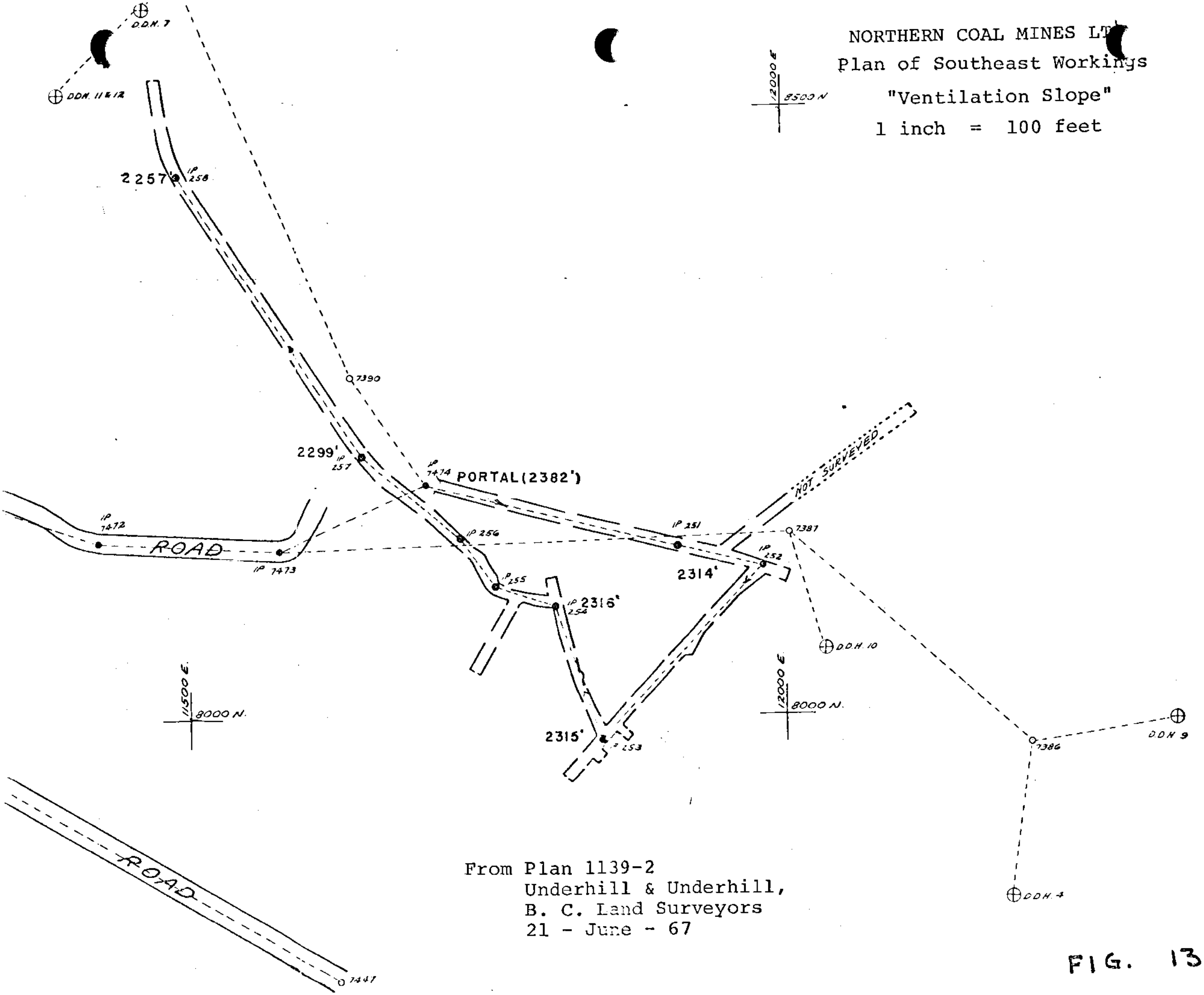
1" = 100 feet



From Plan 1139-2
Underhill & Underhill, B.C. Land
Surveyors
21 - June - 67.

FIG. 12

NORTHERN COAL MINES LT
Plan of Southeast Workings
"Ventilation Slope"
1 inch = 100 feet



From Plan 1139-2
Underhill & Underhill,
B. C. Land Surveyors
21 - June - 67

FIG. 13

which have been retained contain 85% of the indicated reserves and 31% of the inferred reserves of the Bowron River coal field as herein calculated.

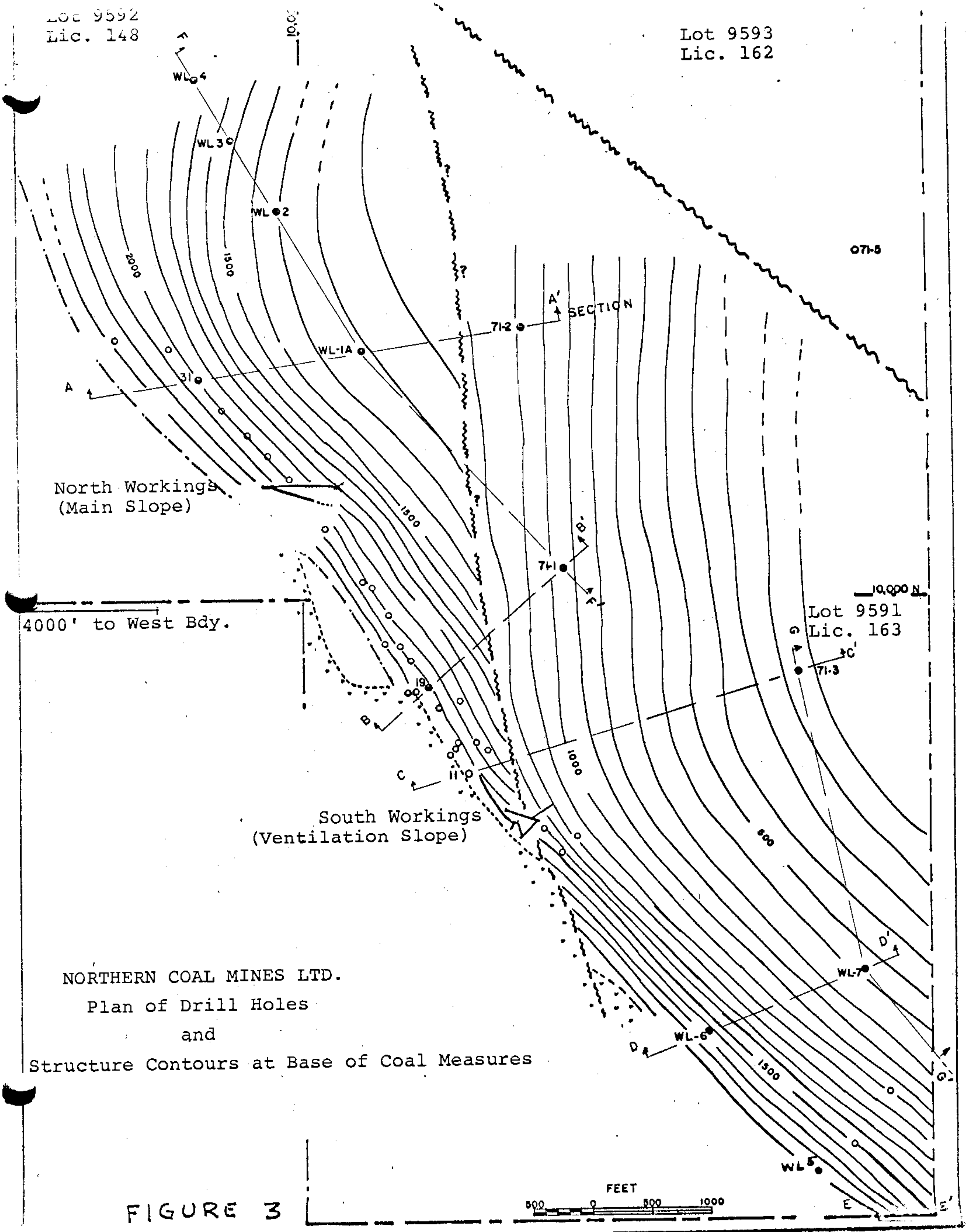
ACCESS

The property is reached by 6 miles of gravel road running southerly from provincial Highway 16.

WORK TO DATE

At least 42 holes were drilled prior to 1971, mainly near the southwest margin of the coal basin. These indicated continuity of the coal measures for a strike length of 2 miles. During this time, several hundred feet of underground entries indicated thicknesses of 7 to 11 feet of fairly clean coal dipping about 30° to 45° to the northeast (Black, A-2, A-3)

In 1971, Bethlehem Copper Corporation Limited drilled 5 diamond drill holes (1-7/8" core) to a maximum depth of 2,200 feet, for a total of 7,474 feet. This drilling confirmed the continuation of the coal measures' northeasterly dip into the basin and established the approximate northeasterly limit of the basin. (Kucera, A-1)



NORTHERN COAL MINES LTD.
Plan of Drill Holes
and
Structure Contours at Base of Coal Measures

FIGURE 3

GEOLOGY

The coal measures occur within a few hundred feet of the base of a thick succession of Tertiary (?) sedimentary and volcanic strata which occupies a trough-like depression in the underlying Slide Mountain strata of Mississippian age.

General descriptions are provided by Black (A-2, A-3) and a more detailed account of structure and stratigraphy is given by Kucera (A-1).

COAL RESERVES

Black (A-3) 1967, calculated indicated and probable reserves of 20,185,000 short tons of coal in place.

The 1971 drilling programme by Bethlehem Copper Corporation substantially extended the area of the known coal reserve. However, because of the lack of continuity of individual coal seams it has not been possible to make a reliable estimate of any additional <u>mineable</u> reserve.

The present calculation of 81.4 million tons of total coal in place considers only an explored strike length of 14,000 feet and a horizontal width of

5000 feet terminated down dip by an assumed limiting fault on the northeast flank of the basin, as inferred from the log of D.D.H. 71-5.

The strike limits are determined by D.D.H. WL-4 to the northwest and an arbitrary extension of 2200 feet beyond D.D.H. 71-4 to the southeast.

Kucera (P. 9) considers that there is little likelihood of significant coal deposition beyond these limits but there is neither rock outcrop nor drilling information to support this opinion. It must therefore, be considered a possibility, at least, that some untested parts of the Bowron basin, with size comparable to or greater than the explored area, may contain significant coal reserves (Fig. 2)

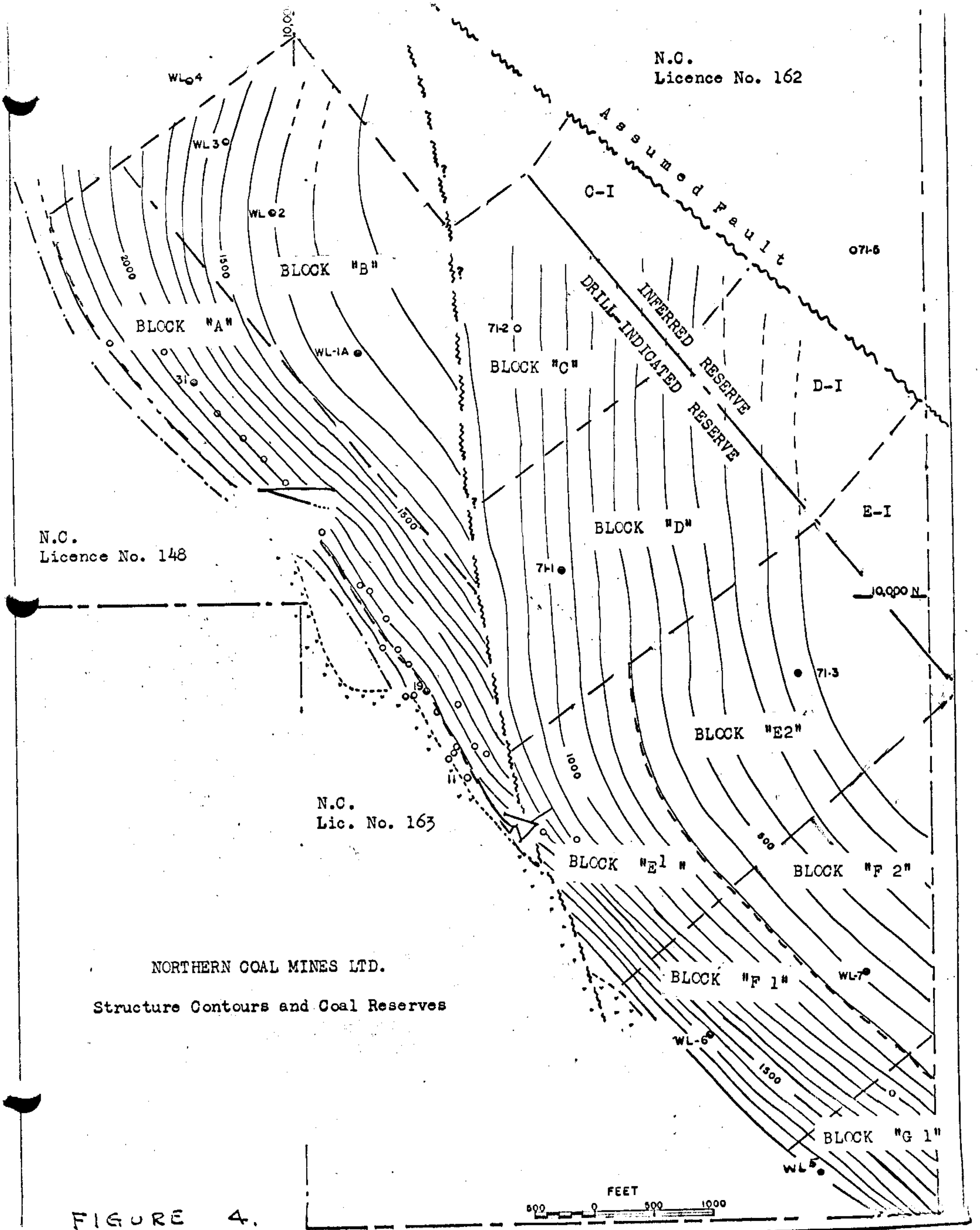

N.C.
Licence No. 162
Assumed Fault
C-I
071-5
WL 4
WL 3
WL 2
2000
1500
BLOCK "B"
BLOCK "A"
INFERRED RESERVE
DRILL-INDICATED RESERVE
71-2
WL-1A
BLOCK "C"
D-I
31
1500
E-I
BLOCK "D"
N.C.
Licence No. 148
71-1
10,000 N
71-3
19
BLOCK "E2"
1000
N.C.
Lic. No. 163
11
800
BLOCK "E1"
BLOCK "F 2"
NORTHERN COAL MINES LTD.
Structure Contours and Coal Reserves
BLOCK "F 1"
WL-7
WL-6
1500
BLOCK "G 1"
WL 5
FEET
500
0
500
1000

FIGURE 4.

NORTHERN COAL MINES LTD.

SUMMARY OF RESERVES ON PROPERTIES AND VICINITY

I. Drill - Indicated Reserves Short Tons

Block	Northern Coal	Adjoining Lots				Total Reserve
		Lot 9594	Lot 9590	Lic 1644	Total	
A	7,344,000					7,344,000
B	9,500,000					9,500,000
C	2,631,000					2,631,000
D	9,160,000					9,160,000
E^1	4,127,000					4,127,000
E^2	7,174,000					7,174,000
F^1	4,757,000					4,757,000
F^2	3,260,000		1,086,000		1,086,000	4,346,000
G^1	1,855,000		1,200,000	600,000	1,800,000	3,655,000
G^2			2,331,000		2,331,000	2,331,000
H^1				1,776,000	1,776,000	1,776,000
H^2			441,000	1,323,000	1,764,000	1,764,000
	49,808,000		5,058,000	3,699,000	8,757,000	58,565,000

II. Inferred Reserves Short Tons

Block	Northern Coal	Adjoining Lots				Total Reserve
		Lot 9594	Lot 9590	Lic 1644	Total	
CI	1,392,000					1,392,000
DI	2,880,000					2,880,000
EI	2,800,000	2,646,000	600,000		3,246,000	6,046,000
FI		132,000	3,900,000		4,032,000	4,032,000
GI			4,535,000		4,535,000	4,535,000
HI			3,500,000	460,000	3,960,000	3,960,000
	7,072,000	2,778,000	12,535,000	460,000	15,773,000	22,845,000
Total:	56,880,000	2,778,000	17,593,000	4,159,000	24,530,000	81,410,000

Table 1

NORTHERN COAL MINES LTD.

CALCULATIONS - INDICATED RESERVES

Block	Length	Slope Dist.	Area	Thickness	Cu.Ft.	Short Tons
A	5400	1360	7,344,000	25'	183,600,000	7,344,000
B	3300	2000	6,600,000	36'	237,600,000	9,500,000
C	1300	1745	2,268,500	29'	65,786,500	2,631,000
D	1900	3013	5,724,700	40'	228,988,000	9,160,000
E^1	1900	1697	3,224,300	32'	103,317,500	4,127,000
E^2	1900	2622	4,981,800	36'	179,349,800	7,174,000
F^1	2100	1770	3,717,000	32'	118,944,000	4,757,000
F^2	2100	2156	4,527,600	24'	108,662,400	4,346,000
G^1	1850	1703	3,150,550	29'	91,365,950	3,655,000
G^2	1850	1432	2,649,200	22'	58,282,000	2,331,000
H^1	2800	1442	4,037,600	11'	44,413,600	1,776,000
H^2	2800	1432	4,009,600	11'	44,105,600	1,764,000
						58,565,000

NOTE: "Thickness" = total coal true thickness as reported by R. E. Kuceva to Bethlehem Copper Corporation-1971.

Tonnage Factor = 25 cu. ft. per short ton.

Table 2

NORTHERN COAL MINES LTD.
INFERRED RESERVE CALCULATIONS

Block	L	W	Area	Thickness	Cu.Ft.	Tons (Short)
CI	2000	600	1,200,000	29	34,800,000	1,392,000
CI	1800	1000	1,800,000	40	72,000,000	2,880,000
EI	3000	1400	4,200,000	36	151,200,000	6,046,000
FI	1800	2000	3,600,000	28	100,800,000	4,032,000
GI	1900	3200	6,080,000	22	133,760,000	4,535,000
HI	2500	3600	9,000,000	11	99,000,000	3,960,000
						22,845,000

NOTE: No adjustment for slope distance versus horizontal width.

Thickness = true thickness extrapolated from adjacent blocks of indicated reserves.

Table 3

COAL QUALITY

The rank is "High Volatile B Bituminous". This coal is indicated to be good quality thermal coal (subject to some sulphur removal) and might be suitable for blending with other coals to produce a good quality metallurgical coke (Donaldson, B-7, p. 11).

Summary of Coal Analyses - Air Dry Basis

Location	*Moisture*	*Ash*	*V.M.*	*F.C.*	*S.*	*B.T.U.*	*F.S.I.*	*Referenc*
"Ventilation Slope" 9' seam	0.40	9.8	43.0	46.8	0.80	11,070	3	B-6
"Main Slope" 200'	5.7	4.0	39.1	51.2	0.80	--	1	B-5
"Main Slope" 400'	4.92	2.77	36.50	55.31	0.85	12,550	2 ½	B-3
Bethlehem 19 samples 4 drill holes		24.63	36.73	42.0	1.39	11,000	?	A-1

COAL QUALITY

The rank is "High Volatile B Bituminous". This coal is indicated to be good quality thermal coal (subject to some sulphur removal) and might be suitable for blending with other coals to produce a good quality metallurgical coke (Donaldson, B-7, p. 11).

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"Main Slope" 200'	5.7	4.0	39.1	51.2	0.80	--	1	B-5
"Main Slope" 400'	4.92	2.77	36.50	55.31	0.85	12,550	2 ½	B-3
Bethlehem 19 samples 4 drill holes		24.63	36.73	42.0	1.39	11,000	?	A-1

Summary of Washing Tests

Sample Description	Medium S.G.	Recovery %	% Ash	% S	Reference
13 Core Samples - 182' from 6 drill holes					
CORE (Raw Coal)	1.40	100.0	7.96	1.29	
FLOAT	1.40	86.0	4.66	1.22	
SINK	1.40	14.0	22.86	1.79	B-1

Sample Description	Medium S.G.	Recovery %	% Ash	% S	Reference
Bulk Sample "Main Slope"					
FLOAT	1.50	82	6.3		
SINK	1.50	18	52.2		
FLOAT	1.60	85.6	7.3		
SINK	1.60	14.4	57.9		B-4

(Reported that some roof shale was included in the bulk sample)

COAL RESINS

A. Soluble (invisible) Resin		Reference
Ventilation Slope	4.05% 3.80%	B-6 A-2
Detailed description		B-7 C-2 C-3

B. Insoluble (Amber) Resin		Reference
Estimate locally	4 %	A-3
General description		C-2,C-3,C-4
Ocurrence noted in Bethlehem Drill Cores		

The Battelle Memorial Institute (C-3) describes detailed tests of a highly technical nature which suggest that these resins could be valuable products. A letter (C-4) from Battelle confirms their interest in continuing research.

FLOAT TESTS IN 1.40 MEDIUM

CORE				FLOAT 1.40			SINK		
Hole	Thickness Feet	Ash °/o	S °/o	Recovery	Ash	Sulphur	Recovery	Ash	Sulphur
20	42	6.10	1.46	87.8	4.08	1.31	12.2	20.66	2.52
21	14	6.36	1.21	87.1	4.29	1.15	12.9	20.37	1.62
23	17	5.12	1.23	95.3	4.35	1.17	4.7	20.63	2.43
	11	7.88	1.21	87.0	4.46	1.25	13.0	30.78	0.93
WL- 5	36	8.69	1.31	83.1	4.43	1.19	16.9	29.61	1.88
WL- 3	14	11.62	1.16	71.9	6.77	1.17	28.1	24.01	1.13
	12	8.70	1.17	75.3	6.43	1.23	24.7	15.63	0.98
	2	18.04	0.79	53.9	1.72	0.91	46.5	36.81	0.64
		18.04	0.79	61.9	2.55	0.90	38.1	41.8	0.67
WL- 2	8	5.16	0.74	92.6	4.23	0.74	7.4	16.76	0.75
	15	10.96	1.51	75.5	5.12	1.56	24.5	28.95	1.38
	4	9.40	1.58	74.9	3.96	1.10	25.1	25.63	3.03
	4	11.62	1.21	88.2	4.39	1.17	11.8	11.25	1.54
	3	5.96	1.04	86.8	4.28	1.0	13.2	17.00	1.32
Total	182								
Averages		7.96	1.29	86	4.66	1.22	14	22.86	1.79

As reported by Commercial Testing & Engineering
Chicago, Illinois.

Appendix B-2

J. M. BLACK, P. ENG. PH. D.
CONSULTING GEOLOGIST

6026 Carnarvon Street
Vancouve r 13, B. C.
June 4, 1969

The Manager
Northern Coal Mines Ltd.

Dear Mr. Garraway:

Re Cleaning Tests on Coal Core

Core from DD holes 20, 21 & 23 and from WL holes 2, 3 & 5, was sent to Chicago and was tested by Commercial Testing & Engineering Company. The samples had an average ash content of 7.96%.

All but one sample were first put in a medium with a sp. gr. of 1.40 and then, successively into denser mediums of 1.50, 1.60 and 1.90 respectively. One sample from a thin seam in WL hole #3 was first tested in a medium of sp. gr. of 1.35 and then in the denser mediums.

A synopsis of the results in the 1.40 medium is attached. An average of 86% floated in this medium. This float had an average ash content of 4.66%, showing an ash reduction of 41.4%. The sink (the reject) had an ash content of 22.86%.

In the heavier mediums, of course, more float was obtained but it was dirtier. From these tests, it would appear that a medium of between 1.4 and 1.5 would be suitable for cleaning this coal because it would recover a high percentage (about 90%) with an ash content of about 5% to 6%. This is appreciably better than the average American recovery, which is about 80%.

The core and the float and sink from each sample, was assayed for sulphur. The results are included in the synopsis.

The core before cleaning averaged 1.29% sulphur, which is higher than most samples from the seams. The float averaged 1.22 and the sink 1.79% sulphur. This is only a small reduction and is fairly typical of results generally obtained from this method of cleaning.

Yours truly,

J. M. Black, P. Eng.

Appendix B-4

Canadian Northern Coal

基礎試験書

Test Report

株式会社大阪造船所
研究部
44. 4. 3
田川製作所

昭和　　年　　月

Osaka Shipbuilding Co.

株式会社 大 阪 造 船 所
田 川 製 作 所

TAGAWAMACHINERY M. F. G. CO. LTD.

kind of coal

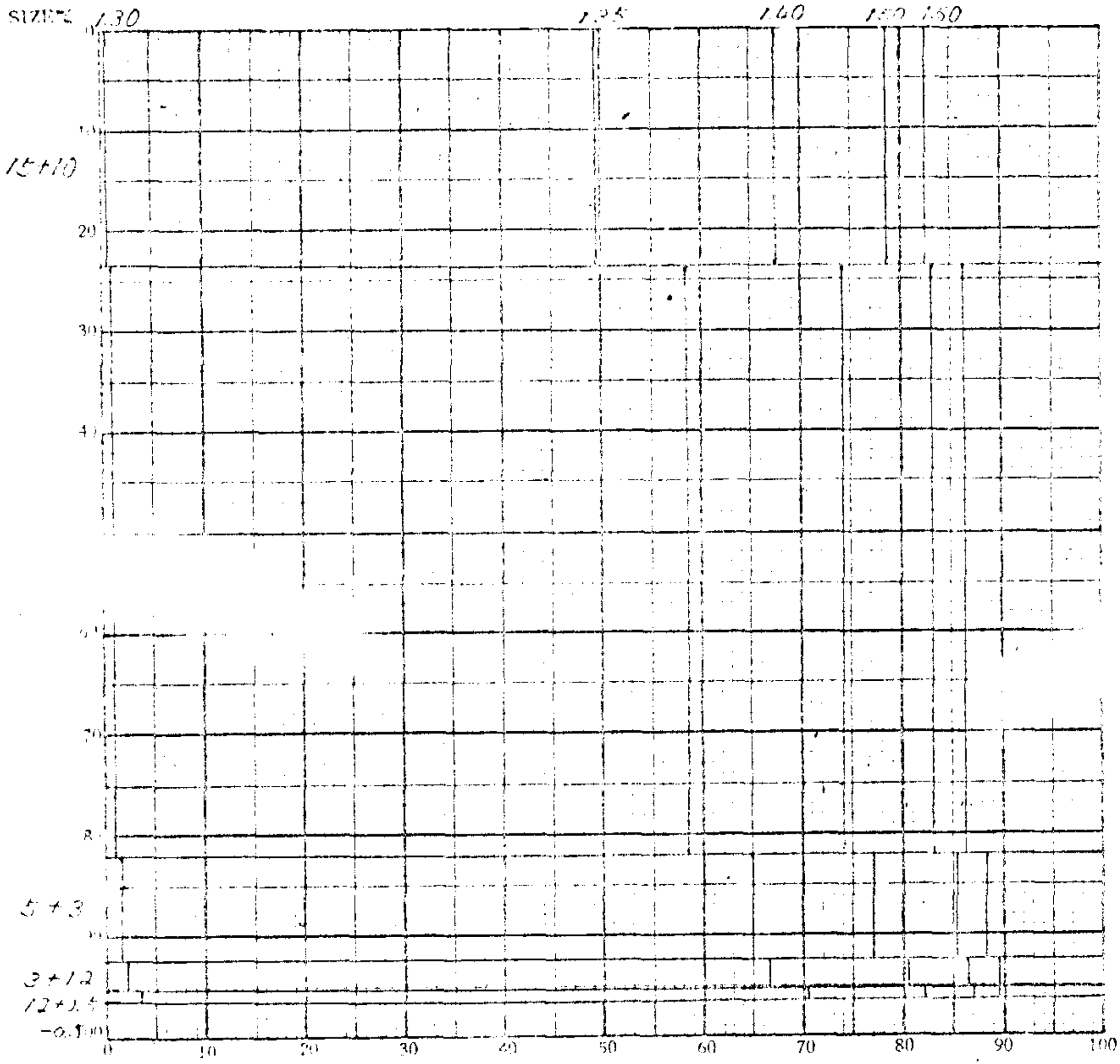
date. Apr. 2nd '69

炭名 Canadian Northern Coal

CHRISTOPHER DIAGRAM

~~田川製作所（[illegible]）~~

44 年 4 月 2 日



SIZE	mm	15+10		10+5		5+3		3+1.2		1.2+0.5		-0.5		Total			
Wt	%	237		56.2		10.6		20		1.5		3.4		100.			
Ash	%	16.8		14.3		12.4		12.4		10.4		14.1		14.6			
SP.Gr ← 比重	Wt Ash %	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A
1	-1.30	0.4	3.7	1.0	3.5	1.5	3.3	21	3.0	3.6	3.0						
2	1.30-1.35	49.0	4.3	57.6	4.2	63.4	4.1	64.6	3.6	66.6	3.4						
3	1.35-1.40	18.2	8.2	15.6	8.3	12.0	8.5	.139	8.6	11.9	8.6						
4	1.40-1.50	111	18.3	8.4	172	8.7	16.4	6.2	170	4.8	17.4						
5	1.50-1.60	3.7	29.4	3.7	29.4	2.8	28.0	2.8	28.2	2.4	29.0						
6	+1.60	17.6	57.1	13.7	58.3	11.6	58.0	10.4	58.2	10.7	59.0						
7																	
8																	
9																	

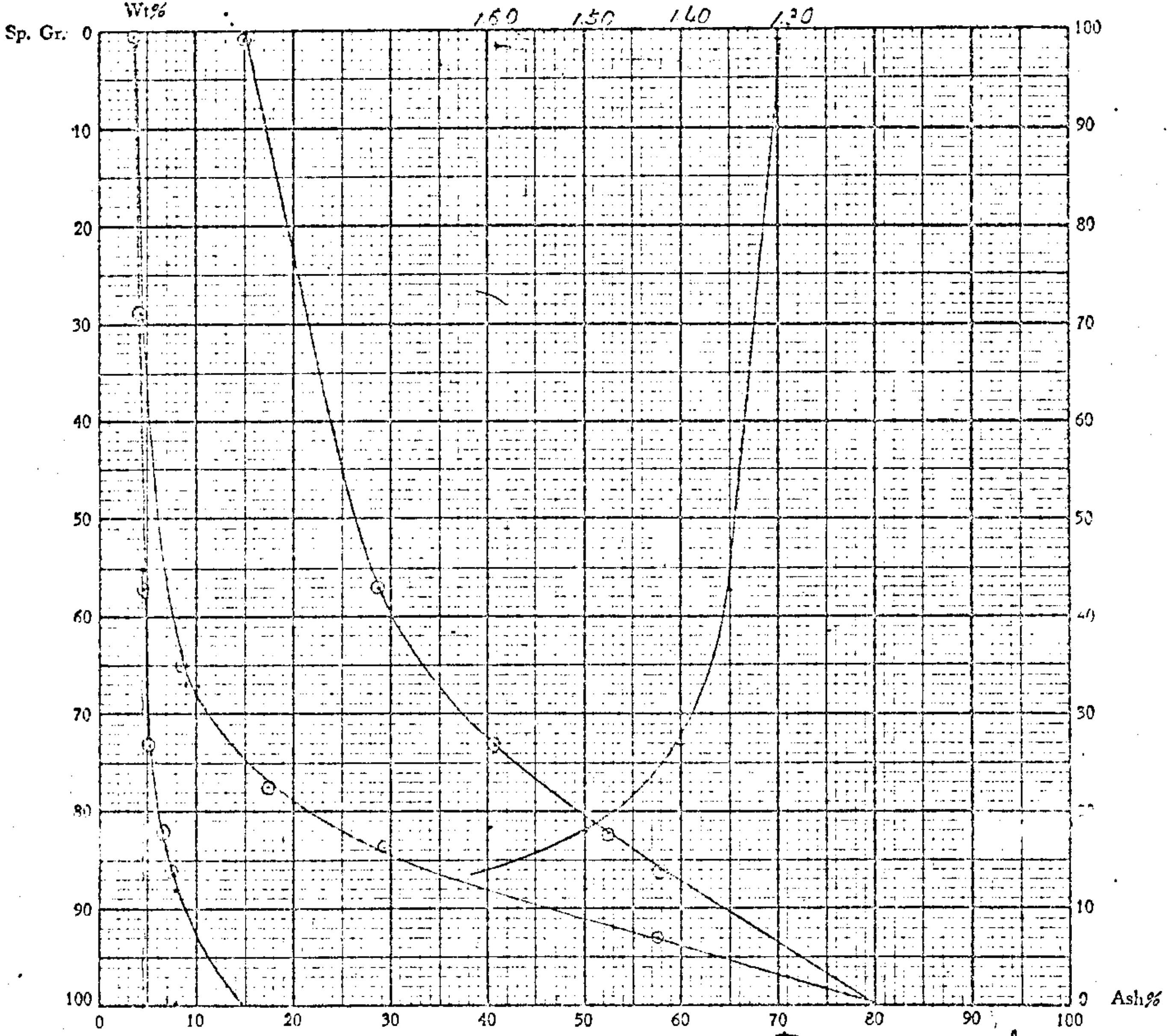
Place.　　　　　　　　JUSK SAMPLE

WASHABILITY CURVE

産地 Canadian Northern Coal　~~名称~~　粒度 15+1.5"

~~採炭年月日　年　月　日~~　試験年月日 昭和44年3月31日　報告年月日 昭和44年4月2日

Test. Date March 3. '69　　Reported on 2nd April '69



Float　　　　Sink

No.	Sp. Gr.	W	A	AW	ΣAW↓	ΣAW↑	浮 W	灰 A	~~[illegible]~~	沈 W	灰 A
1	-1.30	1.0	3.4	3.40	3.40	1466.96	1.0	3.4	~~0.8~~	100.	14.6
2	1.30 -1.35	56.2	4.2	236.04	239.44	1463.56	57.2	4.2	~~[illegible]1~~	99.0	14.8
3	1.35 -1.40	15.8	8.3	131.14	370.58	1227.52	73.0	5.1	~~[illegible].0~~	42.8	28.7
4	1.40 -1.50	9.0	17.4	157.50	518.08	1096.38	82.0	6.3	~~[illegible]~~	27.0	40.6
5	1.50 -1.60	3.6	29.2	105.12	623.20	938.88	85.6	7.5	~~83.8~~	18.0	52.2
6	+1.60	14.4	57.9	833.76	1456.96	833.76	100.	14.6	~~92.8~~	14.4	57.9
7											
8											
9											
10											

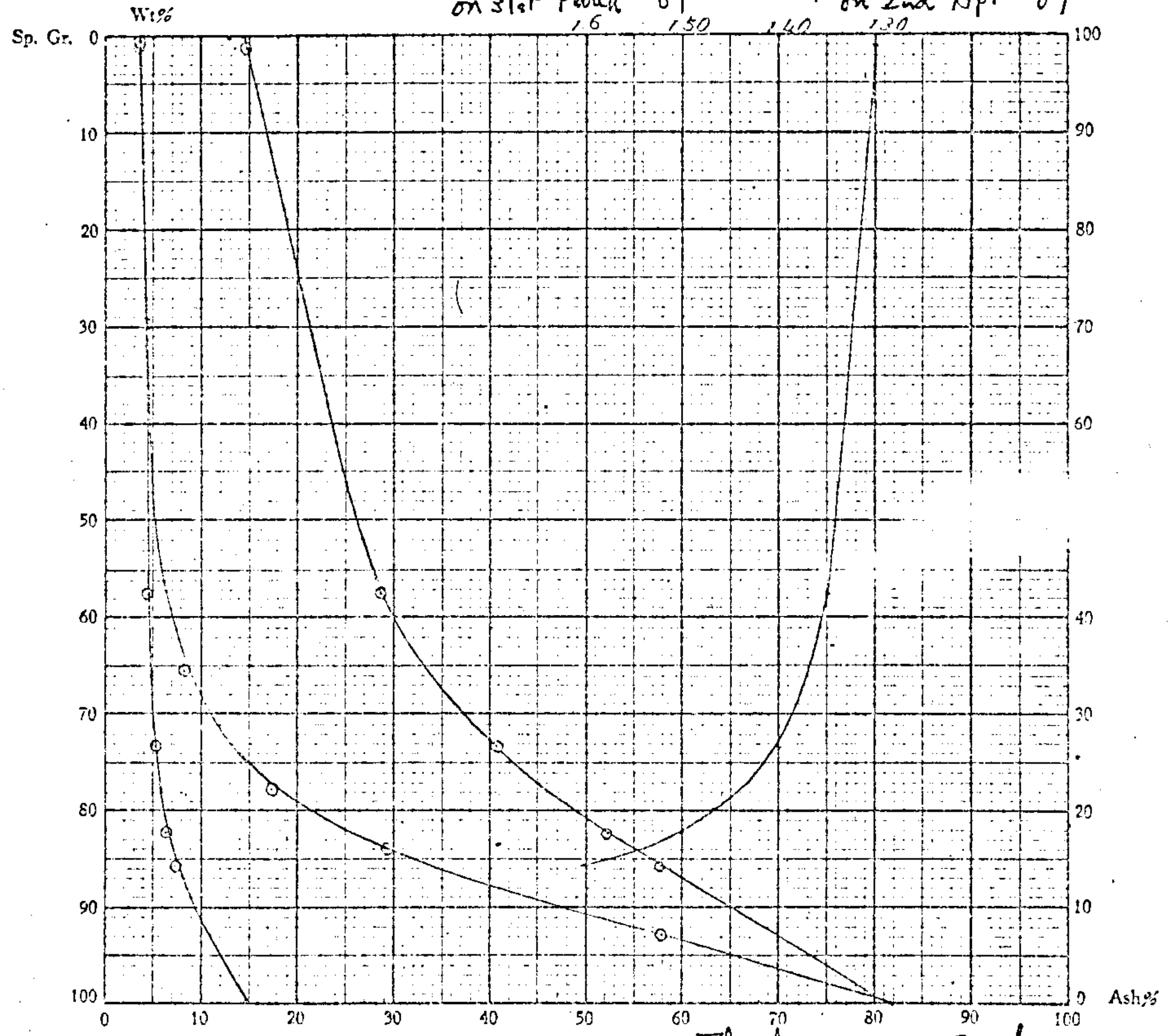
[illegible]

WASHABILITY CURVE

place 産地 [illegible] ~~名称 粒度~~ 15+0.5 粍

採取年月日 昭和 年 月 日 試験年月日 昭和44年3月31日 報告年月日 昭和44年4月2日

Tested on 31st March '69 Reported on 2nd Apr '69



Float Sink

No.	Sp. Gr.	W	A	AW	ΣAW↓	ΣAW↑	浮 W	灰 A	~~中点浮のW~~	沈 W	灰 A
1	-1.30	11	3.4	3.74	3.74	1460.20	1.1	3.4	0.6	100	14.3
2	1.30-1.35	56.3	4.2	236.46	240.20	1456.46	57.4	4.2	29.3	98.9	14.7
3	1.35-1.40	15.7	8.3	130.31	370.51	1220.00	73.1	5.1	65.3	42.6	28.6
4	1.40-1.50	90	17.4	156.60	527.11	1089.69	82.1	6.4	77.6	26.9	40.9
5	1.50-1.60	36	29.2	105.12	632.23	933.09	85.7	7.4	83.9	17.9	52.1
6	+1.50	14.3	57.9	827.97	1460.20	827.97	100	14.6	92.9	14.3	57.9
7											
8											
9											
10											

COAL RESINS

A. Soluble (invisible) Resin		Reference
Ventilation Slope	4.05%	B-6
	3.80%	A-2
Detailed description		B-7 C-2 C-3

B. Insoluble (Amber) Resin		Reference
Estimate locally	4 %	A-3
General description		C-2,C-3,C-4
Ocurrence noted in Bethlehem Drill Cores		

The Battelle Memorial Institute (C-3) describes detailed tests of a highly technical nature which suggest that these resins could be valuable products. A letter (C-4) from Battelle confirms their interest in continuing research.

A summary of their findings is as follows:

1. A distinction is made between two types of resin occurring in the coal
   a) Dark soluble "Refined Resin."
   b) Visible insoluble "Amber Resin."
2. All testing was done on the "Refined Resin" which was found comparable to Congo Resin for certain uses and which was priced at $0.21 to $0.28 per lb. in 1967 ($0.24 to $0.33 in 1972).
3. It was indicated that the "Amber Resin" might be the more valuable of the two, but how much more valuable is not estimated.
4. Further research is required to determine the best extraction methods for each of these types as well as their suitability for various industrial applications.

RADIOACTIVITY

The Geological Survey of Canada report radioactivity in the vicinity of the Bowron River seams of Northern Coal Mines Ltd. amounting to 10 times background value $\frac{40\ \mu\text{R/hr.}}{4\ \mu\text{R/hr.}}$. Copy of their report follows:

COAL RESEARCH

4.

RADIOACTIVITY OF TERTAIRY LIGNITES IN SASKATCHEWAN, ALBERTA AND BRITISH COLUMBIA

Project 680106

A. R. Cameron, P. A. Hacquebard, J. R. Donaldson
and T. F. Birmingham

Radioactivity measurements of Tertiary lignites were carried out with a scintillometer at about 200 stations in southwestern Saskatchewan, southeastern Alberta, and a large area of south and central British Columbia. All visible coal occurrences were checked including thin lenses, dirty coal, carbonaceous shales, etc. Readings above two or three times the background were considered significant for sampling and about 35 samples were collected. The most appropriate of these will be processed for chemical determination of the uranium content.

In Saskatchewan 73 stations were examined in the Cypress Hills district coal area. This was extended into Alberta to include the western and southern flanks of the Cypress Hills. With a background of 5 to 15 microroentgens per hour most readings ranged from 0 to 25 microroentgens above the background. However, in the vicinity of Eastend, Saskatchewan, two good readings were obtained (a) 380 µR/hr with background of 19 µR/hr and (b) 600 µR/hr and background of 31. The latter occurrence is 3/4 mile due west of a similarly good reading obtained last field season.

In British Columbia 125 stations of Tertiary coal areas were surveyed at White Lake, Princeton, Tulameen, Merritt-Quilchena, Spence's Bridge, Hat Creek, Kamloops, Chu Chua, Alexandria, Quesnel, and Bowron River. In most areas readings above or even approaching the two times background were rarely obtained, with the following exceptions; White Lake, a high of 16 µR/hr above a background of 14 µR/hr; Princeton, a high of 19 µR/hr above a background of 8 µR/hr; Chu Chua, a high of 33 µR/hr above a background of 7 µR/hr; and in the Bowron River section, a high of 40 µR/hr above a background of 4 µR/hr.

Along with the uraniferous lignite survey, column samples were collected in the following areas for coal petrographic studies: Eastend, Saskatchewan (3), Luscar, Alberta (1), and in British Columbia, at Michel (3), Hat Creek (1), and Bowron River (1). From the Blakeburn strip mine at Coalmont 21 samples were taken for the coal reflectance studies.

Kucera (A-1, p.4) states that "A scintillometer survey of rocks along the Bowron River, 500 feet south of Northern Coal camp reveals that fine-grained sandstones 5 to 10 feet below the upper coal zone are radioactive with readings up to 7 times background count (see detailed stratigraphic section)".

A notation on the strip log of D.D.H. 71-3 indicates a radioactive measurement at a depth of 290 feet as follows: " 4-5 x Background Count (285 - 290)".

There is no further reference in Kucera's report to radioactive testing and it is not known if all the drill cores were systematically tested.

Various references in the company's progress reports are made to analyses for U_3O_8, but the accuracy of these has not been verified at time of writing.

Future exploration or development should include systematic checking of radioactivity.

MINING CONDITIONS

1. Large Scale Mechanized Mining

Dips of 20° to 45° and fault dislocations indicate high mining costs which, however, may be alleviated by improvements in mining methods (hydraulic mining?, D-1) and made acceptable by increased coal prices.

A considerable amount of drilling would be required to test continuity of seams and to determine mining layouts.

2. Small Scale Mining

This would assume favourable results from technological and market research on the resins. Mining of 300 to 500 tons per day would involve a relatively low initial outlay for the mining plant and would ensure several years production from the vicinity of the present working before undertaking extensive development.

If the amber resin could be sold for 30 cents per pound and the coal for $12.00 per ton, F.O.B. mine, the gross product value is estimated at approximately $36.00 per ton.

3. Gasification of Coal In-Situ

This procedure is in an early stage of development and requires extensive research but offers considerable promise for the future (D-4). Field tests have been in progress in Wyoming since March 1973 (D-3) and results there could have an important bearing on the viability of the deposits of Northern Coal Mines Ltd.

Respectfully Submitted

L. S. Trenholme

L. S. Trenholme, M.Sc.

January 9, 1974.

L. S. Trenholme - Statement of Qualifications

This will certify:

1. That I am a graduate of the University of Saskatchewan, B.Sc., (Geology) 1936, and of McGill Unversity, M.Sc., (Geology) 1939,

2. That since graduation I have continuously (except 1942 - 1945) practised my profession in mining and exploration geology,

3. That I was in the employ of Brameda Resources Limited from May, 1968 to July, 1973 as exploration manager and staff geologist,

4. That my experience in coal exploration has been obtained through 3 years close association with the Sukunka Coal Project of Brameda Resources Limited,

5. That I have made one visit to the property of Northern Coal Mines Limited and have studied all significant reports relating to it and have been one of its directors (unpaid) since 1971 and,

6. That I do not at present own any shares or other interest in Northern Coal Mines Limited or its properties, other than an indirect interest through ownership of 1750 escrowed shares of Brameda Resources Limited, which company owns 840,000 shares of Northern Coal Mines Limited.

(Signed) L.S. Trenholme
L. S. Trenholme

January 9, 1974
6746 Marguerite Street,
Vancouver 14, B. C.

Appendix A

A-1	Report by R. E. Kucera to Bethlehem Copper Corporation, September, 1971 Less maps.
A-2	Black, J. M., Report January 31, 1967
A-3	Black, J. M., Report September 8, 1967
A-4	Letter to the Shareholders June 6, 1969 RE: Underground Progress

Appendix A-1

GEOLOGICAL REPORT

BOWRON RIVER COAL

Cariboo District, British Columbia

by

Richard E. Kucera, Ph.D.

Prepared for Bethlehem Copper Corporation Ltd.

November 4, 1971

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INTRODUCTION

Northern Coal Mines Limited holds 36 coal licenses on the lower Bowron River, extending for a distance of approximately 13 miles from Purden Creek to Grizzly Bear Creek. The area lies 35 miles east of Prince George and is accessible by gravel road south of Highway 16. The Bowron River valley in this area is flat-bottomed, 1½ to 2 miles wide, and lies at an elevation of approximately 2,400 feet: valley sides rise to summits of about 4,000 feet.

In 1971 Bethlehem Copper Corp. Ltd. investigated the stratigraphy and structure of the coal-bearing rocks and completed a programme of surface diamond drilling with 5 holes totalling 7, 474 feet. Drill cores and logs furnished by Northern Coal Mines were also studied.

STRATIGRAPHY

Most of the area is covered by 50 to 180 feet of overburden and outcrops are limited only in the banks of the river. Most of the information has been obtained from detailed mapping of isolated rock exposures for a distance of 23 miles along the river and an examination of nearly 22,000 feet of drill cores and logs.

Basement Rocks

Rocks of the Slide Mountain group (Mississippian age?) crop out along the slope above the valley floor and have been penetrated by drill holes in the Bowron River basin. They include argillite, chert, flow breccia, greenstone and some limestone. According to Campbell (1968) the Slide Mountain group in areas to the south are neither schistose nor greatly deformed. This is also true for this area, except that the steeply dipping dark grey limestone encountered on the east bank of the Bowron River at the mouth of Tenaskli Cr. is probably involved in a fault zone.

Massive grey tuffaceous sandstone cut by carbonate stringers and veins has been encountered in diamond drill holes WL-1A, WL-4, DDH-24, DDH-71-5, DDH-71-4 and DDH-71-2. Because of its intimate association with overlying Tertiary sediments, it is suggested that volcanic activity may have been contemporaneous with the initial sedimentation of coal bearing strata.

Coal-Bearing Sedimentary Series

A thick sedimentary series overlies the Slide Mountain group and has been dated by Rouse (U.B.C.) as mid-Tertiary age. Diamond drill hole 71-3, the deepest hole on the property, penetrated 2,200 feet (true thickness) of shale, sandstones, breccias and coal beds in the lower part.

Breccia

Breccias are up to 200 feet thick and consist of angular fragments of chert, green volcanics, quartzite, limestone, shale and coal fragments in a medium to coarse-grained matrix. Some of the fragments are up to 6 inches long but more commonly are 1 to 2 inches long. There is rapid and abrupt graded bedding within fine-grained breccia zones that grade up into coarse-grained sandstone, whereas some of the breccias are in sharp contact with underlying sandstone and shale units. Breccias are darker in colour below the major coal zone in DDH-71-1, DDH-71-2, DDH-71-3 than above, due to a predominance of dark limestone pebbles and shale fragments in a dark matrix.

The thick breccia sequence in DDH-71-3 at depths of 937 to 1,138 feet contain pebbles with long axes that lie in a downslope direction which suggests that the direction of transport was in an east-west direction. One foot of breccia in this drill hole at a depth of 290 feet is radioactive with readings of 4 to 5 times background count.

A detailed examination of the outcrop on the west side of the Bowron River, 500 feet south of the Northern Coal camp reveals the lenticular nature of breccia units which pinch out from 3 feet thickness to extinction in a lateral distance of 20 feet. Minor imbricate structures suggest that transport of fragments was from the south (see stratigraphic section).

Sandstone

These units are light grey to brown to dark grey, very fine to coarse-grained and contain coal partings and abundant carbonaceous stringers and streaks. Graded bedding and fine-laminations are quite common, especially at depths of 594 to 620 feet in DDH-71-3 and 967 to 1,300 in DDH-71-4. Some of the sandstones are cross-bedded below the major coal zone in

DDH-71-1 at 1,500 feet depth.

Contorted bedding in some of the drill cores is interpreted as penecontemporaneous slump structures. In some cases, the sandstones show the effect of being squeezed and slumped by impact of breccia pebbles.

A scintillometer survey of rocks along the Bowron River, 500 feet south of Northern Coal camp reveals that fine-grained sandstones 5 to 10 feet below the upper coal zone are radioactive with readings up to 7 times background count (see detailed stratigraphic section).

Shales

Shales range from gray to black and brown in colour and contain thin sandstone and breccia zones, carbonaceous stringers and coal partings. Dense and black shales are found associated with coal beds in DDH-71-1. Graded bedding within shale units is quite obvious. Shales at depths of 306 to 967 feet and below 1,200 feet in DDH-71-4 are finely laminated and appear to be cyclic in character. A thin pyrite zone occurs in DDH-71-4 at a depth of 949 feet. Slump structures occur in DDH-71-1 at 400, 432-449, 740-857 and 1067-1069 feet depth; also in DDH-71-2 at 804-815, and in DDH-71-4 at depths of 245-267, 282-304 and 335 feet.

Distinctly brown shales occur within 200 feet of the top of the major coal zone in WL-1A, WL-5, WL-7, WL-9, DDH-71-4, DDH-71-3 and DDH-71-2 and therefore can be used for correlation purposes.

Coal

Most of the drill cores show a distinct coal zone in the basal 250 feet of section with a vertical thickness ranging from 60 feet in DDH-71-4 to 200 feet in DDH-71-3. Refer to vertical sections A-A' to G-G'.

The behavior of the coal zone is quite variable. Individual coal beds and interbedded sandstones and shales do not maintain their thicknesses for any great distance. Within 1,500 feet of their first appearing, individual coal beds may have become separated by as much as 100 feet of sediment. Because of this fact, <u>individual coal seams</u> can not be traced from drill hole to drill hole.

The thickness of the coal seams and the thickness of interbedded sediments are closely related seam properties and probably was determined largely by the degree of subsidence taking place during the accumulation of peat in the Bowron River basin. Seam splitting takes place so that within the same stratigraphic limits, seams away from the basin margin become fewer in number and individually thicker with a corresponding decrease in amount of sediment (DDH-71-1). Toward the margin of the basin, seams are thin and often contain an appreciable amount of sediment (WL-3 and WL-4).

Figure 1

Major Coal Zone Penetrated by Drill Hole

Drill Hole	Depth	Dip	Combined Coal Thickness	Other Sediments	Thickest Coal Bed
DDH-71-1	1,384 - 1,453	25°	40	29	5
DDH-71-2	Upper 1140-1171	25°	12	19	5
	Lower 1258-1284	25°	17	9	4
			Upper 12 feet of lower seam contains 2 feet total shale		
DDH-71-3	Upper 2081-2146	20°	15	51	2
	Lower 2220-2261	20°	21	21	2.5
DDH-71-4	1720-1767	38°	11	36	2

The following is based on logs
by Dr. Black for Northern Coal.

WL-1A	Upper 995-1039	15°	15	29
	Lower 1097-1150	15°	21	32
WL-2	957-1102	20°	39	106
WL-3	815-881	20°	32	34
WL-5	523-559	45°	32	34
WL-6	777-809	45°	32	0?
WL-7	1778-1810	25°	24	8
WL-9	540-571	45°	26	5
DDH-11	49-91	45°	28	14
DDH-19	127-162	40°	28	7
DDH-31	221-290	35°	22	57

According to Commercial Testing and Engineering Co. the coals in DDH-71-1, DDH-71-2 and DDH-71-3 is similar to anthracite in appearance but high in volatile matter. Core DDH-71-1 contains several resin blebs from 1,435 down. The mineral matter-free BTU ranges from 13,500 to 13,900. If the coal is not oxidized its ranking according to ASTM is High Volatile B Bituminious. Residue from the volatile determination indicates the coal has caking properties but is non-swelling.

Stratigraphic Variations

The sediments are characterized by sharp, vertical, lithological variations in more than one scale. Facies change in the horizontal direction is also highly characteristic, particularly in the coarser beds. This finds its extreme development in breccias which cut fine-grained sandstone and shales.

The lower part of the sedimentary series in the southern portion of the basin is composed of shale. The shale sequence is approximately 800 feet thick in DDH-71-3 (vertical section C-C'), 1,000 feet in WL-7 (vertical section D-D') and 770 feet in DDH-71-4 (vertical section G-G' and E-E'). But even in this predominantly shale facies a wedge of breccia, 200 feet thick, occurs in DDH-71-3 and pinches out before it reaches WL-7, a distance of 2,600 feet to the southwest (vertical section G-G'). Cyclic or rhythmic laminated horizons in these shales bespeak of lacustrine deposition especially in the area south of Northern Coal camp.

The shale facies changes into coarse clastics toward the north, so that drill cores from WL-1A, WL-2, WL-3, WL-4, and DDH-71-2 are composed predominantly of sandstone and breccia (vertical section F-F' and G-G').

The breccia sequence in the upper part of the sedimentary series is approximately 800 feet thick in DDH-71-3 and 400 feet in DDH-71-1. The upper part of the sequence is not exposed and its total thickness is unknown. There is little doubt that fragments contained in the sedimentary breccia were derived from Slide Mountain rocks that outcrop on nearby slopes. A coarsening of facies in the stratigraphic record in a northeast direction suggest a principal source area in that direction. The random distribution of fragments, graded bedding, and imbricate structure suggests transportation in the form of channel deposits as well as mudflows, giving rise to turbidity currents in the deeper portion of depositional basin.

The long term subsidence of the basin must be accompanied by uplift of the supply areas and this necessarily involves crustal deformation, since the coal-forming conditions in the Bowron River basin becomes less and less obvious in upward vertical succession, while the percentage of coarse-clastics tends to rise.

Extent of Coal-bearing Rocks

Examination of outcrops along the Bowron River extending from Grizzly Bear Creek northward to Highway 16 near Purden Creek reveals that the southern portion of the area is underlain OUTCROPPING 4-5 miles E.S.E. of DDH. 71-4 by rocks of the Slide Mountain group (green volcanics, phyllites, and quartzites) and the southern limit of Tertiary sedimentary strata OUTCROP occurs along the west side of the valley ½ mile northwest of the confluence of Swamp Creek and Bowron River, approximately 2 miles south of the Northern Coal camp. Refer to the Photogeological Map. This suggests that the coal-bearing rocks in the Bowron River basin ~~is~~ are far less extensive than was previously postulated by Black (1967) and others.

The rocks exposed northwest of the Northern Coal camp at various places along the Bowron River ~~is~~ are composed dominantly of coarse breccias and sandstones. Cores from drill holes WL-1A, WL-2, WL-3 and WL-4 show not only a pinch-out of coal seams in a northwest direction but also a thinning of the sediments as the basin floor rises in the same direction (vertical section F-F'). These facts seem to discount the possibility of encountering anything but thin discontinuous coal seams at depth in areas northwest of DDH-WL-4. Unless WL-4 is situated on a local paleo-topographic high.

STRUCTURAL GEOLOGY

The Tertiary rocks occupy a linear basin oriented northwesterly, 10 miles long and approximately 1½ miles wide. In gross aspect, the structure appears to be a graben that has been downdropped in relation to Slide Mountain group rocks that crop out on both sides of the Bowron River valley. The east side of the graben is interpreted as a fault, inferred from aerial photographs by the relatively straight escarpment, composed of green volcanics, quartzite and black limestone. Throughout

NOTE: pencilled notations by L.S. Trenholme most of its length the fault line is largely buried by Pleistocene and Quaternary alluvium along the Bowron River. Eastward dipping sedimentary breccias exposed on the east side of the river, 1½ miles northwest of Tenaskli Creek ~~is~~ are thought to lie within 500 feet of the fault line. Steeply dipping limestone at the mouth of Tenaskli Creek is probably a slice of Slide Mountain group associated with the fault that lies just west of this outcrop.

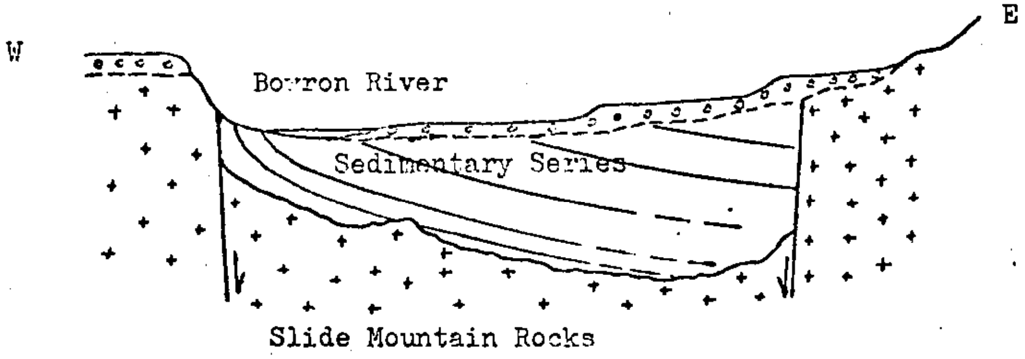
The fault contact on the west side of the Bowron River graben has been observed in only one place. In the area 1½ miles southeast of Northern Coal camp, thin-bedded dark shales are in contact with eastward dipping green volcanics of the Slide Mountain group. The shales are overturned steeply toward the west near the fault but in a distance of 100 feet, dip 50 to 60° eastward under the Bowron River. Refer to the vertical section of this fault in the Photogeologic Map. The fault can be traced to the south on the aerial photographs to a point just north of Tsus Creek, where it is completely obscurred by glacial and fluvial deposits. Toward the northwest, the fault is manifest as an exhumed fault-line scarp, especially in the area southwest of Northern Coal camp.

The Bowron River graben has been traced from Purden Creek southeastward for a distance of approximately 10 miles where it is cut off by a northeast-southwest-trending fault near the mouth of Tsus Creek (on Photogeologic Map).

Along the western edge of the graben. the sedimentary series dip from 20 to 60° eastward. A local reversal of dip does occur along the Bowron River 1 mile northeast of the mouth of Taspai Creek where breccias dip as much as 70° westward. With the exception of this one outcrop, the writer has not seen any evidence to suggest that the coal-bearing rocks within the graben reverse their eastward dip beneath the Bowron River valley.

Figure 2

Generalized Cross-Section
Bowron River Graben



Structure Contour Map

Structural contours drawn at the top of the major coal zone penetrated by drill in the Bowron River valley discloses that the sedimentary rocks dip 40 to 60° eastward in the southern portion of the area whereas the strata north of Northern Coal camp dips about 40° eastward decreasing to about 20° toward the northeast.

Figure 3

Depths to Top of Major Coal Zone

Drill Hole	WL - 1A	WL-7	DDH-71-1
	995	1778	1380
	WL-2	WL-9	DDH-71-2
	1040	540	1235
	WL-3	DDH-11	DDH-71-3
	845	50	2110
	WL-5	DDH-19	DDH-71-4
	523	128	1720
	WL-6	DDH-31	
	775	220	

Because of the elevation of the major coal zone in DDH-71-2 at 1,144 feet is not consistent with an extension of a 20° dip of the coal zone in WL-1A (1,371 feet), it is postulated that a northwest-trending fault lies between DDH-71-2 and WL-1A with the east side upthrown approximately 400 feet. Refer to the Structural Contour Map and vertical section A-A'.

CONCLUSIONS

1. Based on drill core examination and detailed mapping in the field, the limits of the coal basin are more restricted in area than was formerly anticipated.

2. Distinct facies change from shales and sandstones into breccias; this, concomitant with a rise in basement rocks northwest of DDH-WL-4, discounts the possibility of encountering anything but thin coal seams at depth in this direction. Coal-forming conditions in the Bowron River basin are less and less obvious in upward vertical succession while the percentage of coarse clastics tends to rise.

3. Because of extreme variations in thickness of coal seams and interbedded sediments, continuity of individual coal seams is not maintained at depth and their correlation has not been possible.

4. Coal-bearing rocks dip eastward at dips ranging from 60° on the west edge of the Bowron River graben to 20° in the northern part of the area. There is no evidence to suggest that these rocks reverse their dip beneath the Bowron River valley. Because of this, it is almost certain that there is no potential for large tonnages amenable to surface mining.

CERTIFICATE

I, RICHARD E. KUCERA, of 2946 West 36th Avenue, Vancouver, British Columbia, do hereby certify:

1. That I am an Associate Professor of Geology and a Consulting Geologist;

2. That I graduated as a geologist from the Ohio State University with the degree Bachelor of Science in the year 1952, and the degree Master of Science in Geology in the year 1954. I am also a graduate of the University of Colorado with a Ph.D. degree in Geology in the year 1962;

3. That I am a member of the American Association of Petroleum Geologists, a member of the Geological Society of America, a member of the Rocky Mountain Association of Geologists, a member of the American Association for Advancement of Science, and a Fellow of the Geological Association of Canada;

4. That I have no interest, direct or indirect, in the properties described in the attached report entitled "Geological Report, Bowron River Coal, Cariboo District, B.C." dated November 4, 1971;

5. That this report is based on both field and laboratory study.

Richard E. Kucera

Richard E. Kucera, Ph.D.

November 4, 1971
Vancouver, British Columbia

REPORT ON NORTHERN COAL MINES
by J. M. Black, P.Eng.
January 31, 1967

APPENDIX A-2

INTRODUCTION

This property has responded favorably to exploration and is nearing the stage where production should be considered.

Research into the qualities and uses of the resin in the coal and of possible markets for it, has been going on for many months and it is expected that in the near future it will be possible to assess the value of the resin.

A new slope is now being advanced toward a main seam in the camp area and soon it should be possible for the first time to sample this seam to determine the quality of the coal where it is unweathered. These tests can determine the coking quality of the coal.

Indicated and probable reserves are now considerable and, if the coal cokes moderately well and/or the resin has marketable value, it may be decided to proceed with plans for production.

Because of the likelihood of such a decision, this report has been prepared in order to summarize results of the work done.

CONCLUSIONS

Several coal seams over 5' thick occur in the lower part of an extensive sedimentary basin. The seams generally have been explored only by drill holes, some of which are widely-spaced. One of the seams has been followed in one working. Because of fairly rapid changes in the sediments and the seams, exact correlation of all the seams has not been possible.

Indicated reserves are 8,562,000 tons. An area surrounded on three sides by indicated reserves, is estimated to contain an additional 3,756,000 tons which are classed as probable. The total of indicated and probable reserves is 12,318,000 tons.

It is probable that these reserves can be increased because large areas have not yet been explored.

RECOMMENDATIONS

1. That exploration be continued
   a) in the area classed as a probable reserve;
   b) in the areas down-dip and along the strike from the indicated reserves.

If production is planned, additional fill-in holes will be necessary to permit definite correlation of seams and to plan location of future slopes and levels.

2. That the new slope be continued downward in order that the lower seam may be bulk-sampled at depth.

3. That information re qualities and uses of the resin be forwarded to possible purchasers to determine marketability.

LOCATION

The property is on Bowron River about thirty-five miles east of Prince George, which is a rapidly growing rail and industrial centre. The property is now reached from Prince George over a total distance of fifty miles of highway and road. It is only four miles south of a new highway constructed eastward from Prince George.

HISTORY

Coal seams outcrop in the banks of the Bowron River just above the present camp and were discovered about 1870. Some exploration was carried out just before 1914. Then very little was done until 1946. In most years since then some exploration has been done by a series of companies. In the last three years exploration has been successful in following seams for over two miles and to over 1,100' depth.

PROPERTY

The property includes one hundred thirty-three mineral claims and three coal licenses covering Lots 9591, 9592 and 9593. These cover a length of about 27,000' along the base of the sedimentary series where the coal seams occur. Of this length, only 12,000' has been intensively explored and the remainder of this length is a logical target for exploration.

GEOLOGY

GENERAL:

Most of the area is covered by overburden and seams outcrop only in the banks of the river. Most of the information has been obtained from an examination of drill cores.

A series of sediments over 1,000' thick, was laid down on volcanic rocks. On the property these are mostly agglomerates and tuffs and greenstones of uncertain origin. The contact between the volcanics and the sediments is conformable or nearly so and, in part, is gradational. Volcanic activity continued after the start of accumulation of the sediments. All the rocks are believed to be of tertiary age.

The lower part of the sedimentary series comprises predominantly dark shales and sandstones. Interbedded with these are many coal seams and some grit and conglomerate beds. This part of the series if about 350' thick near the camp and thins towards the northwest and thickens towards the southeast where it is more than 1,000' thick.

Most of the seams are less than 1' thick but several are ove r 5' thick and, in places, are as much as 24' thick. As many as three of these seams, 5' or more thick, have been cored in some holes. These thicknesses include all the coal in a sequence that may include several partings of shale or sandstone but the figures given are for the coal only. Rapid changes in the sedimentary series vertically and laterally, in short distances, make correlation from point to point uncertain and more holes will be needed before correlation is certain.

The upper part of the sedimentary series is at least several hundred feet thick and its top has not been seen. It is characterized by coarser beds than the lower part of the series. It comprises grit, conglomerate and sedimentary agglomerate, as well as sandstone and shale. It contins relatively few beds of coal and all of these that have been core d are thin.

COAL & RESIN:

The coal exposed underground and in drill cores is clean and of good appearance and has a relatively high B.T.U. content. The thicker seams have partings of up to 1 or 2 feet of shale and sandstone.

Distributed irregularly through the seams can be seen amber-colored particles up to about ¼" across of resin. Recent research suggests that other resin is present which is coal-black in color and, hence, has not been recognized in hand specimens. The results of recovering resin from bulk samples taken from the slope in the ventilation entry, averaged about 3.8% for air-dried coal. These results were based on dissolving the resin in a solvent. Battelle Research Institute reports that some of the amber resin is almost insoluble and that it is probable that the results reported earlier are incomplete and that the total resin content is greater than 3.8%.

The lower of the two seams near the camp has not been sampled because it has not been accessible. However, sections of it that have been cored, appear to contain somewhat higher proportion of resin than does the seam in the slope in the ventilation working.

The resin in the coal comprises several different types with different qualities. Some of it is characterized by a very high melting point and it is relatively insoluble. Research done shows that the resin is useful in curing rubber and in the manufacture of varnishes and lacquers, etc.

Much of the resin can be recovered from the coal by hydrocyclones after it is crushed to -¾". When the resin is removed, the quality of the coal is improved inasmuch a s the proportion of fixed carbon increases.

FAULTS:

Numerous minor faults with slight displacements can be seen underground. Evidence of faulting is seen in some cores. One fault zone of consibrable thickness is exposed underground and there is some evidence of faulting near its projected extension to the northwest. Its location and projected extension are shown on the accompanying map. Coal had not been found east of this fault until the deep wire line holes were drilled.

The seams cored in wire line holes Nos. 1,2,3 and 4, dip about 10°, much less steeply than near the margin of the basin, where the seams dip about 45°. The seams in the deep holes are at about the depth they would be if the change from steep to gentle is gradual. This suggests that the apparent vertical displacement is relatively small (see section X Y).

However, in the south, the seams cored in wire line holes 5 and 6 dip about 45°, which shows that the flattening that occurs in the north has not occurred here down to the depths tested.

Assuming that the thick seam cored in holes 5 and 6 is the same one, the apparent strike is more nearly northwest than north-northwest. If this seam is a continuation of one of those cored farther north (as is likely), then it would appear that there is a considerable horizontal displacement at the major fault, with a right hand movement.

UNDERGROUND WORKINGS

The main working, now called the Ventilation Slope, comprises a slope, a cross-cut, an entry along the upper of two seams and a slope down in it. This entry and slope start near the main fault and follow the seam northward for more than 700'.

A new slope, that is big enough to be used for production, has been started east of the camp. It is being driven westward and downward at -12° and, in the near future, should reach the lower seam. It is equipped with a tipple and hoist, compressor and mucking machine.

DRILL RESULTS

32 holes, recovering 1" core, were drilled in 1964 and 1965 and traced the upper and lower seams near the river and toward the northwest. Since then, six deep, widely-spaced holes have been drilled, recovering 1½" core. These have explored for seams much farther east than the earlier drilling and to much greater depths. They have cored coal at depths of over 1,100'. All but #4, cored one or more seams, 5' thick or more. The thicknesses are shown on the accompanying map. These holes have permitted a large increase in estimates of indicated and probable reserves.

RESERVES

INDICATED:

Area A:-

Upper Seam

The average thickness in six holes and in the Ventilation Slope is 8'. It has been followed 1,800'. The deepest point at which it was cored, is 180' and it is assumed that it continues downward half as far again, ie. to 270'. This makes a slope length of 360'.

The gross indicated tonnage is $\frac{1{,}800 \text{ x } 8 \text{ x } 360}{25} = 207{,}000.$

The tonnage above 100' is $\frac{1{,}800 \text{ x } 8 \text{ x } 125}{25} = 72{,}000.$ This is considered destroyed by erosion or weathering and this leaves a gross indicated tonnage below 100' of 207,000 - 72,000 = 135,000. Of this, it is assumed that 10% is destroyed near faults, leaving a net indicated tonnage of 122,000. All figures are rounded to nearest thousand.

Lower Seam

It has been followed along strike for 2,000'. Its thickness, based on coring it in nine holes and where it was exposed in an old working, is 10.5'. It was cored 430' below the surface and it is assumed that it continues half as far again, ie. to a depth of 650'. This is equivalent to a slope length of 850'.

The gross indicated tonnage is $\frac{2{,}000 \text{ x } 10.5 \text{ x } 850}{25} = 714{,}000.$

The tonnage above 100' is $\frac{2{,}000 \text{ x } 10.5 \text{ x } 135}{25} = 113.^{000}$ It is assumed that this has been removed by erosion and weathering. This leaves a gross indicated tonnage below 100' of 600,000. It is assumed that 10% of this is destroyed near faults, leaving a net indicated tonnage of 540,000 tons.

Area B:-

The lower seam has been followed for 1,200'. The slope length is assumed to be the same as in Area A. The average thickness in four holes, is 6.5'.

The gross indicated tonnage is $\frac{1,200 \times 6.5 \times 850}{25}$ = 265,000.

The tonnage above 100' is $\frac{1,200 \times 6.5 \times 135}{25}$ = 42,000. This leaves a gross indicated tonnage of 223,000. Of this, it is assumed that 10% is destroyed near faults and this leaves a net indicated tonnage of 200,000 tons.

Area C:-

Coal has been cored at a depth of 1,130' and is assumed to extend unchanged to a depth of 1,300'. It is assumed to extend along its strike to a point down dip from a point midway between wire line holes 3 and 4, where it is assumed to thin to less than 5'. The average thickness of coal in commercial seams in the three holes 1A, 2 and 3 is 24'. Tonnage in Area A equals the area times thickness over 25 equals $\frac{5,000,000 \text{ times } 24}{25}$ == 4,800,000 tons. Because of the slope, the actual volume of coal is greater by about 16% but it is assumed that about 16% has been eroded or has been destroyed by faults and the net indicated tonnage is considered to be 4,800,000.

Area D:-

A thick seam was cored in each of holes 5 and 6 and this is assumed to extend 250' along the strike beyond the holes. The strike is believe d to be as shown. The coal in #6 was cored at 800' and it is assumed to continue downward unchanged to 1,200'. The average thickness in the two holes is 22'. The indicated tonnage is $\frac{\text{area} \times \text{thickness}}{25}$ = $\frac{1,200 \times 2,300 \times 22}{25}$ = 2,428,000. The slope length is about 40% greater than the planned width and, therefore, the gross tonnage would be about 40% greater. But it is assumed that one half of this increase has been destroyed by erosion and by faults. Therefore, the figure given above is increased by 20% to yield a net indicated tonnage of 2,900,000 tons.

The total indicated tonnage in Areas A,B,C and D is 8,562,000.

RESERVES

PROBABLE:

Areas E and F have not been drilled but it is considered probable that coal underlies them because coal occurs up dip from Area E and the northern one third of Area F. Also, coal has been cored along the strike from both areas.

Area E:-

The thickness assumed is the thickness in C (24') plus the thickness in A (10') divided by 2 equals 17'.
Probable tonnage = $\frac{\text{area} \times 17}{25}$ = $\frac{2,330,000 \times 17}{25}$ = 1,584,000. The fact that the slope length is greater than the width on the plan, means that the tonnage as calculated is less than the tonnage contained in the volume. However, it is considered that this is offset by the amount of coal destroyed near faults and the net probable tonnage is considered to be 1,584,000.

Area F:-

The thickness assumed is the thickness in D (22') plus the thickness in A (10') divided by 2 equals 16'. The apparent probable tonnage equals

$\frac{\text{width x length x thickness}}{25} = \frac{725 \text{ x } 3,900 \text{ x } 16}{25} = 1,810,000$. It is considered that the theoretical tonnage, using the slope distance, would be about 40% greater, but one half of this is considered to have been destroyed near faults. Therefore, the net probable tonnage equals the above plus 20% or 2,172,000. This makes a total probable reserve of 3,756,000 tons.

RESERVES

TOTAL:

The total estimate of indicated and probable tonnage is 12,318,000.

J. M. Black, P.Eng.
January 31, 1967

Appendix A-3

NORTHERN COAL MINES LTD.
report by
J. M. Black, P.Eng.
September 8, 1967

INTRODUCTION

This property has been reported on many times previously. This report brings together much of the material contained in earlier reports. Since January exploration has continued successfully. Three diamond drill holes have been completed after intersecting the main seam or other commercial seams. The main slope has been advanced a total of 600' and has exposed two commercial seams. An entry has been driven 70' southeast on the upper one and from that point a short crosscut has been driven to the lower seam. Even though it is wet at this point, the swelling index of coal from here is higher than it was closer to the surface.

CONCLUSIONS

Indicated and probable reserves have been substantially increased and now are over 20,000,000 tons. The seams thicken towards the centre of the sedimentary basin. Most of the area expected to be underlain by coal remains to be explored.

The coal cokes and the increase of the swelling index at the present deepest level to 2 and 2½ from the 1 and 1½ closer to the surface, indicates that at greater depths an even higher swelling index may be expected. No gas has been detected underground.

The most direct way to obtain samples from the coal at greater depth for swelling index tests is by driving a slope down on the upper seam exposed in the main slope.

Research into the two main types of resin that occur in the seams has shown that they have useful qualities and possible markets.

RECOMMENDATIONS

1. Drive a slope from the new entry at -12° in the seam for 350' to 400', at which point it should be more than 180' below the bedrock surface and more than 200' below the surface. Presumably the coal at this point will be drier and less weathered and more representative of the reserves than any sample available till now. This slope will approach the seams exposed in the workings at the river bank but will be more than 200' deeper.

2. That a large central area now underlain by a probable reserve be explored by three deep drill holes, 1,700' to 1,800' apart.

3. That exploration be continued toward the southeast.

4. That research into separation and recovery processes for the resins be completed and markets considered.

LOCATION

The property is on Bowron River about 35 miles east of Prince George which is a rapidly growing rail and industrial centre. The property is now reached from Prince George over a total distance of 50 miles of highway and road. It is only 5 miles south of a new highway constructed eastward from Prince George, which is now being paved.

HISTORY

Coal seams outcrop in the banks of the Bowron River just above the present camp and were discovered about 1870. Some exploration was carried out just before 1914. Then very little was done until 1946. In most years since then some exploration has been carried on by a series of companies. In the last four years exploration has been successful in tracing seams for a distance of two miles and to a depth of 1,800 feet.

PROPERTY

The property includes 133 mineral claims and 3 coal licenses, covering Lots 9591, 9592 and 9593. These cover a length of about 27,000' along the base of the sedimentary series where the coal seams occur. Of this length, less than one half has been explored and the remainder is a logical target for exploration.

GEOLOGY

Most of the area is covered by overburden and seams outcrop only in the banks of the river. Most of the information has been obtained from an examination of drill cores.

A volcanic series of unknown thickness and extent underlies the coal basin. It comprises agglomerate, tuff and greenstone of uncertain origin. Some volcanic activity, resulting here in the accumlation of volcanic ash, continued after the beginning of the deposition of the sedimentary series that includes the coal. In some areas volcanic, ashy material stood up above the level of the floor of the sea in which the sediments accumulated and sediments could not accumulate in these areas. These elevations of volcanic material may have been only a few tens of feet high but were sufficiently high in at least two points around the edge of the basin to prevent the accumulation of the lower seam.

Such elevations may also have occurred centrally in the basin but it is more likely that they were most extensive and occurred as peninsulas near the margin of the basin and this is the area that has been most intensively explored.

Overlying this volcanic sequence, is a thick sedimentary series. It contains many coal seams in its lower part. This part of the series is characteristically fine-grained. It comprises chiefly dark shales and grey sandstones although coarser beds such as grit, conglomerate and sedimentary agglomerate are common, as are coal seams. Most of the coal seams are thin but as many as three are over 5' thick and in places are as much as 20' thick. A little greywacke and tuff are present. Most of the beds are thin - only a fraction of an inch thick. The thickest beds, the conglomerates and agglomerates, are only a few feet thick.

This lower part of the sedimentary series, in the vicinity of the camp, appears to be a few hundred feet thick. Towards the southeast it thickens and, also, it thickens towards the centre of the basin and at Wire Line Hole #7 it is more than 1,000' thick and, possibly, is more than 1,200' thick. Coal seams are found only in the lower 200' or 300' of it.

Overlying this finegrained sequence is a sequence that comprises predominantly coarse members such as grit, conglomerate and sedimentary agglomerate. Shales and sandstones occur in this sequence also but are a minor part of it. The beds in this sequence also are thin. Coal is practically absent. The upper part of this sequence is not exposed and its total thickness is unknown. In the southeast, it is at least 550' thick and possibly is over 700' thick and in the northwest it is also 700' thick or more.

The thinness of the beds suggests seasonal deposition and the many coarse beds suggest that the basin was a lake or sea close to the mountains.

Fragmentary fossil leaves found in the coal some years ago indicated a Tertiary age for the series. However, the sediments are only slightly younger than the volcanic series and not separated from it by any significant interval. Also, the unknown but considerable thickness of the combined volcanic-sedimentary series (probably several thousand feet) and the folding which has occurred, makes it appear that the entire series can more likely be correlated with a <u>Cretaceous series</u> than any know Tertiary one.

<u>COAL & RESIN</u>

Most of the work done so far has been on seams 7' to 12' thick. The coal is bright and of good appearance. It is a high volatile, bituminous, coking coal. Clean coal contains generally 6% to 12% ash, 30% to 40% volatiles and 45% to 55% fixed carbon and, generally, between 11,500 and 13,500 B.T.U.'s per pound.

The only seam exposed for a considerable distance is the one in the ventilation slope which has been followed for over 600'. Some of this seam was bulk sampled and found to contain close to 4% soluble resin. This resin has been named "Canadian" by the Battelle Institute and reports from that institute compared favorably with "Congo" resin which has a well-established place in world markets. In addition, the Institute reports that in some samples, visible, insoluble resin is almost as abundant as soluble resin.

In the two seams most recently exposed, the visible resin is as abundant as in any exposure previously seen. The upper seam is 8' to 10' thick and the lower one is 6' to 7' thick.

DRILLING RESULTS

In the last 3½ years, 42 holes have been drilled from the surface (a total of about 18,000') and one underground. The last eight holes from the surface have been drilled with a wire line and, generally, have been much deeper than the earlier holes. These holes have explored the coal basin along one margin for a length of 2 miles and a width of about ½ mile and to a depth of 1,900'. Most of these holes and one from earlier drilling, are shown on the accompanying plan.

Wire Line Hole #7, completed in July, is the deepest drilled to date. In its upper part, it cored coarse, friable beds which tended to slough into the hole and caused the drilling to be done very slowly. Measurements of the inclination of this hole, showed that near the bottom it was 8° from vertical. A section CD through it shows this inclination and on the plan is shown the point at which the main seam was intersected more than 100' from the collar of the hole.

Underground hole #1 was drilled to explore the ground ahead of the slope. It cored a 6' seam near the collar and, at 80', entered volcanics, showing that here the sedimentary series was interupted by volcanic rock, part of a ridge or island, projecting above the floor of the sedimentary basin. The relationships are shown on Section AB.

STRUCTURE

The seams so far exposed and cored, dip northeastward. In the southeast they dip as much as 65° to 70° and, in the central area, at about 45° and in the northwest somewhat less. These are the attitudes near the margin of the basin. Closer to the centre of the basin, the seams dip less steeply(perhaps only 10° to 20°) and, towards the northeast, probably flatten out. On the northeast margin of the basin they may dip towards the southwest. In detail, the attitude is not uniform and is complicated by minor rolls and some faults.

A major fault is exposed in the ventilation slope and crosscut and its probable location near there is indicated by some drill holes. It dips steeply. Within this fault zone, which is 50' to 60' wide, the seams are broken and mixed with the other sediments so they cannot be mined. No information is available as to the continuation of this fault but it is shown on the accompanying figure as if it continued indefinitely maintaining its attitude.

The alignment of seams on opposite sides of the fault, suggests that there has been a considerable movement to the right along it. The results of the drilling near the ventilation workings, suggest also that the block northeast of the fault has moved downward relative to the block southwest of it. The extent of the two movements is unknown and may not be uniform throughout the length of the fault.

Section AB has been prepared, showing no vertical movement at the fault, because the coal intersections as shown are consistent with no movement but the structure is probably more complex.

Some faults that probably are branches from this major fault, are exposed in core from holes drilled near the fault.

In the ventilation slope some minor faults strike northeastward and dip steeply northwest. On these there has been a left hand movement of about 10'.

SURFACE WORK

A new, larger air line was installed in the main slope. A new compressor house was built and occupied. A leading hopper was built into permit trucks to be loaded directly from the tipple without the use of a front end loader.

The property has been surveyed and the location and elevation of workings and drill holes have been established.

RESERVES

These have been calculated as indicated or probable. Indicated reserves are based on drill core intersections plus information where available from seams exposed. Probable reserves are in areas without an exposure or a drill hole but which are believed to be underlain by coal because a coal seam or seams extend under adjoining ground, either along the strike (as in area A) or down the dip and along the strike (as in area B), on at least two sides.

One area is exceptional inasmuch as it has had some holes drilled in it but these (possibly not deep enough) did not core coal. This area is up dip from Possible Reserve A and between indicated reserves 7 and 6. For present estimates, it has been assumed to contain no coal, although it is probable that further exploration will find coal in it.

The area explored is about one square mile and several square miles are not yet explored. Only coal more than 100' below the surface and outside of the fault zone has been included in the estimates. The reserves are calculated by determining the area of the seam or seams within the limits under the discussion by multiplying the strike length by the slope length and getting the area in square feet. This is multiplied by the thickness assumed for the seams in the area, which gives the number of cubic feet of coal. This product is divided by 25 (the approximate number of cubic feet in a ton of coal) to give the reserve in tons. Calculations are rounded to the nearest thousand.

Indicated Reserves

No. 1 $\frac{1525 \times 2050 \times 21}{25} =$ 2,626,000 tons

No. 2 $\frac{1060 \times 1850 \times 29}{25} =$ 2,213,000 tons

No. 3 $\frac{1425 \times 1200 \times 6.5}{25} =$ 444,000 tons

No. 4 $\frac{1400 \times 650 \times 8}{25} =$ 291,000 tons

No. 5	$\frac{1000 \times 440 \times 14}{25} =$	246,000 tons
No. 6	$\frac{1700 \times 210 \times 9}{25} =$	129,000 tons
No. 7	$\frac{2370 \times 3600 \times 19}{25} =$	6,211,000 tons
	Gross total:	12,160,000 tons

Note re indicated reserve #4. This reserve is calculated on the lower seam as if it extended over the whole area. However, it is absent in an area which is outlined on the accompanying figure. But within an area that is approximately as large, are one or two other seams which together contain more coal than the lower one would if it were present. However, because of uncertainty about the limits of the three seams in this area, the reserve has been calculated as if the lower seam only were present, though it is probable that this particular estimate is low.

Probable Reserves

A	$\frac{5700 \times 2250 \times 19}{25} =$	9,747,000 tons
B	$\frac{1740 \times 1150 \times 6.5}{25} =$	520,000 tons
	Gross total:	10,267,000 tons

Gross total, indicated and probable: 22,427,000 tons

However, a deduction must be made from this to allow for islands or ridges on the floor of the sea that may have prevented accumulation of coaly material, also for coal that may have been destroyed at unknown faults or by erosion. It is assumed that 10% is a sufficient allowance for these unknown factors. This amounts to 2,242,000 tons which, deducted from the gross figure above, leaves a net total of indicated and probable reserves of 20,185,000 tons.

J. M. Black, P.Eng.
Consulting Geologist
September 8, 1967.

MINE: PRINCE GEORGE RADIO
"GARRAWAY MINES"

MINE OFFICE:
3 – 1330 THIRD AVENUE
PRINCE GEORGE, B. C.
PHONE: 564 - 5816

Northern Coal Mines Ltd.

(Appendix A-4)

June 6, 1969.

LETTER TO THE SHAREHOLDERS

The last letter to the shareholders was dated January 26, 1968. At that time the Coal Slope, which was being driven downwards in the 11 feet coal seam at a gradient of -12 degrees, was at Station 70 feet.

Until the present time there was very little news to report except that the Coal Slope was being slowly advanced as funds became available.

In August 1968 the Coal had been advanced to Sta. 296 feet, but we thought it impossible and unfair to ask the shareholders for assistance for the second time. We now know this was a mistake. Undoubtedly the shareholders would have given us their unanimous support as with the share offering in January 1968.

The Slope was completed by means of loans from your directors and the invaluable assistance of a few major shareholders.

Your board of directors are pleased to report that on December 18, 1968 the Coal Slope had reached it's objective of 400 feet and had been levelled off for some 20 feet in preparation for a Landing.

The Upper – 11 feet – Coal Seam

The Slope passed through the Zone of Oxidation at Station 325 feet or some 225 feet down the full pitch of the seam from surface.

The Landing at the bottom of the Slope is under more than 200 feet of solid backs – Shales and Sandstones – and some 280 feet down the pitch of the seam from surface.

The coal at the Landing is extremely dry and dusty but no Methane has been detected.

As the Coal Slope was advanced below the Zone of Oxidation there was a gradual improvement in the Coke Button Index and a reduction in the percentage of Volatile Matter.

Numerous analysis of samples taken during the driving of the last 75 feet of the Slope proved we had an extremely low ash coking coal of from 2.6 to 4.0 per cent ash.

Systematic testing has proved that when our coal is crushed to minus 1/2" and then passed over a 1/4" screen between 80.0 and 90.0 per cent of the resins and some of the ash passes through the 1/4" screen with the fines. The 1/2" X 1/4" coal then tests as low as 1.2 per cent ash. The elimination of a high percentage of resin is reflected in the reduction of Volatile Matter.

The Lower – 8 feet – Coal Seam

This seam is exposed in the river bank where it is 4 feet thick and contains 36 per cent Volatile Matter, 6.5 per cent ash, 2.5 per cent sulphur and has a Coke Button Index of 2 1/2. Diamond drilling indicated the thickness increased with depth and in all deep holes the seam was at least 8 feet thick.

Three cross-cuts have been driven to this lower seam. One, off the Entry at the top of the Coal Slope – 100 feet vertically below surface –, the second at 200 feet and the third at 250 feet down the Coal Slope. In each of these cross-cuts the seam is 8 feet thick with a good roof and a very hard floor. The seam is clean and the coal, in place, is very hard and strong. The coal has improved with depth and samples from the last cross-cut, in the Zone of Oxidation, contained 28.6 per cent Volatiles, 1.6 to 4.0 per cent ash and 1.5 per cent Sulphur. We can expect better results when the coal is tested below the Zone of Oxidation and there is a very good possibility that the sulphur per centage will be reduced to a level acceptable to the steel makers. This seam is approximately 35 feet horizontally from the Landing at the bottom of the Coal Slope and below the Zone of Oxidation.

When the Japanese visited your mine, between May 15 and 19 last, they were disappointed that the lower seam was not exposed for their examination at this lower elevation. They were of the opinion that provided the sulphur percentage was reduced, in the lower seam, that both seams should be mined at the same time.

During the period from the time the Coal Slope was completed on December 18, 1968 until after the Japanese visit on May 19 last, we had been unable to employ a full crew necessary to carry out any development work.

Although we have what is considered a dry coal mine, in order to comply with the Rules & Regulations of The Coal Act, we had to employ three men to keep the slopes unwatered at all times.

Results of the testing of samples shipped to Japan and Chicago in January 1969 were not received until May last.

Appendix B - Coal Testing

B-1	Sink - Float Analysis of Drill Cores - 1969
B-2	Black, J. M., Letter Report on Cleaning Tests June 4, 1969
B-3	Proximate Analysis - by Superintendence Company (Canada) Ltd. Nov. 19,1968 Mines sample from "Main Slope" at 400 feet.
B-4	Washing Test - Osaka Shipbuilding Co. April 2, 1969 Bulk Sample, "Main Slope" at 200 feet.
B-5	Proximate Analysis - "Main Slope" at 200 feet by Nippon Kaiji Kentei Kyokai April 6, 1968
B-6	Proximate Analysis - No. 1 Seam "Ventilation Slope" by Coast Eldridge January 28, 1964
B-7	Petrography G. S. C. Technical Report 93-H-13W-1 1972

Certificate of Analysis

GENERAL TESTING LABORATORIES DIVISION
SUPERINTENDENCE COMPANY (CANADA) LTD.

ANALYTICAL AND CONSULTING CHEMISTS

BULK CARGO SPECIALISTS — SURVEYORS — INSPECTORS — SAMPLERS — WEIGHERS

MEMBER:
AMERICAN SOCIETY FOR TESTING MATERIALS
THE AMERICAN OIL CHEMISTS' SOCIETY
AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.
CANADIAN TESTING ASSOCIATION

1001 EAST PENDER STREET
VANCOUVER 6, B.C.
CANADA

REFEREE AND/OR
OFFICIAL CHEMISTS FOR:
VANCOUVER MERCHANTS EXCHANGE
NATIONAL INSTITUTE OF OILSEED PRODUCTS
THE AMERICAN OIL CHEMISTS' SOCIETY

OFFICIAL WEIGHMASTERS FOR:
VANCOUVER BOARD OF TRADE
VANCOUVER MERCHANTS EXCHANGE

21

November 19, 1968

Mr. Ross,
1282 Chartwell Crescent
West Vancouver, B.C.

No. [illegible]

Appendix B-3

WE HAVE TESTED a submitted sample of coal, received on November 18, 1968 and report as follows:-

ANALYSIS: 400 ft down Coal Slope

Moisture (air dried) 2.02% 1.38%

The following analysis is on an air dry basis:--

Moisture 1.98% 3.24

Volatile Matter 36.50% 38.6

Ash 2.77% 3.35

Fixed Carbon .... 58.31% 52.

Calorific Value (B.T.U./lb) 12,590

Sulphur .... 0.95% .71

Free Swelling Index 2½ 2 1/2

GENERAL TESTING LABORATORIES DIVISION
SUPERINTENDENCE COMPANY (CANADA) LTD.,

per

W.B. Sizer - Chief Chemist

holes

1	2 1/2	1 1/2	2 1/2
2	2	1 1/2	2
3	4	2 1/2	3 1/2
4	2 1/2	1 1/2	2 1/2.

58.04 52.
33.3% 32

KAIJI BLDG., NO. 5, 1-CHOME,
NISHI-HATYOBORI, CHUO-KU,
TOKYO, JAPAN

PHONES: TOKYO (03) 552-0141
CABLE ADDRESS: KAIJIKENTEI TOKYO
CODE BENTLEY'S 2ND USED

BRANCHES
ALL PRINCIPAL PORTS IN JAPAN

JAPAN MARINE SU ASSOCIATION
LICENSED BY JAPANESE GOVERNMENT

NIPPON KAIJI KENTEI KYOKAI
FOUNDED IN 1913

MINATO-KU, TOKYO,
JAPAN
PHONES: TOKYO (03) 452-4458, 4459

OSAKA OFFICE:
NO. 2-CHOME, SANJO-DORI
MINATOKU, OSAKA,
JAPAN
PHONE: OSAKA (06) 573-5505

17

Tokyo

(Ref. K T, K U)
TRIPLICATE

Analysis Certificate

Date April 6, 1968.
Certificate No. Y 89/68

Applicants: Messrs. Kanematsu - Gosho, Ltd.

Description of Sample: Canadian Coal
Quantity on B/L or Invoice: -

(Appendix B-5)

Name of Vessel: -
Sample ~~taken from:~~ presented by the Applicant.

Taken by: -
Taken on: -
(Refer to our Inspection Certificate No. - issued at - Branch)

Result of Analysis: (Result obtained from the sample rendered)

200 FT DOWN COAL SLOPE

1. Inherent Moisture 5.7%
2. Ash 4.0%
3. Volatile Matter 39.1%
4. Fixed Carbon 51.2%
5. Total Sulfur 0.8%
6. C. B. I. 1

(Last Item)

N.B. Method of Analysis : JIS M 8801, 8812, 8813.

We hereby certify that above is the result of analysis made faithfully by us upon request.
Application No. Kon. 21

NIPPON KAIJI KENTEI KYOKAI
Physical & Chemical Research Dept.

C. TSUKADA, MANAGER

(42. 11. 200×250 O)

COAST ELDRIDGE
ENGINEERS & CHEMISTS LTD.
125 EAST 4TH AVE., VANCOUVER 10, B.C.
TELEPHONE: TRINITY 6-4111
CABLE ADDRESS: "ELDRICO"

REPORT OF: Chemical Testing

AT: Vancouver Laboratory (Appendix B-6)

ORDER NO.

PROJECT: Coal Analysis

DATE: January 28, 1964

REPORTED TO: Northern Coal Mines Ltd.,
1347 Sussex Street,
Victoria, B.C.

FILE: C.3-N.2-64 10055

We have tested 2 samples of coal submitted by you on January 13, 1964 and we report as hereunder :

SAMPLE IDENTIFICATION

No. 1 Bone Sample
No. 2 Coal Sample

N° 1 Seam 9 ft coal

RESULTS

No. 1

Sulphur Wt. Percent -- 0.95 %

No. 2	Air Dry	Oven Dry
Moisture Wt. %	0.4	-
Volatile Matter Wt %	43.0	43.2
Ash Wt. %	9.8	9.9
Fixed Carbon Wt. %	46.8	46.9
Sulphur Wt. %	0.80	0.82
Resin Wt. % (Benzene, Isopropyl Alcohol and Acetone Solubles)	4.05	-
Coking Characteristics	3	-
B.T.U./lb	11,070	-

COAST ELDRIDGE

J. G. Smith
CHIEF CHEMIST

/ni

(Appendix B-7)

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

GEOLOGICAL SURVEY OF CANADA

TECHNICAL REPORT NO. 93-H-13W-1

PETROGRAPHY OF THE COAL FROM THE GARROWAY MINE IN THE BOWRON RIVER COAL AREA, BRITISH COLUMBIA

-(NORTHERN COAL MINES LTD.

BY

J. ROGER DONALDSON

OTTAWA
1972

PETROGRAPHY OF THE COAL FROM THE GARROWAY MINE IN THE BOWRON RIVER COAL AREA, BRITISH COLUMBIA.

ABSTRACT

A petrographic study was carried out on coal from the Garroway Mine in the Bowron River Coal area in British Columbia.

The seam studied is of Tertiary age and the examination was part of a larger investigation on Canadian Coals of Tertiary Age.

Though the coal is reported as being a coking coal, stability predictions based on the chemical composition as determined by proximate analyses, reflectance (R_o) indices and maceral composition indicated otherwise. Results showed that the reactive-inert imbalance predominantly favoured the reactive components. These constituents contribute good swelling characteristics to a coke but lack of an optimum amount of the inert or dull coal components result in a coke that is weak.

The coal is reported to be high in percentage of the maceral resinite. Visible resin nodules were observed in the coal during sampling. The subsequent microscopic analysis did not substantiate this observation because this type was not observed during the analysis. Resin of the invisible type, due to vitrinization, could be treated only as a vitrinoid.

Though this coal would not produce a coke of good quality by itself it could be used possibly as a blend to mix with a coal which has good strength contributing properties and a lack of good swelling characteristics.

INTRODUCTION

The existence of coal on the Bowron River in British Columbia has been known for the last 100 years. Dawson noted in 1871 that coal was reported by Dewdney on the banks of the Bear River - later known as the Bowron River.

The seam sampled is from the Northern Coal Mines Ltd., Garroway Mine (see Fig. 1) which is located on the west bank of the Bowron, about 35 miles east of Prince George - a rapidly growing rail and industrial center. The mine is only five miles south of a newly paved highway that has recently been constructed from Prince George.

Due to the increased interest in B.C. coking coals, considerable development work has been done in the Bowron River area. Petrographic studies have been undertaken to determine the nature of the coal and its suitability for coking. The coal is reported to have a high resin content and the present company set out to mine the coal solely for the resin and have the coke as a low priced by-product. Favourable indications from swelling tests coupled with the mine's favourable location in respect to the Japanese market reversed this policy.

GENERAL GEOLOGY

The Bowron River valley is almost entirely covered with overburden and therefore the coal seam outcrops can only be observed along the banks of the river and along the creeks.

The rising ground on the valley-sides and a few points along the river itself are underlain by a group of largely green-coloured volcanic rocks and include fine tuffs, breccias and lavas. The only intrusives seen are several small dykes which intrude dark argillite near the north of Purden Creek (Holland 1948).

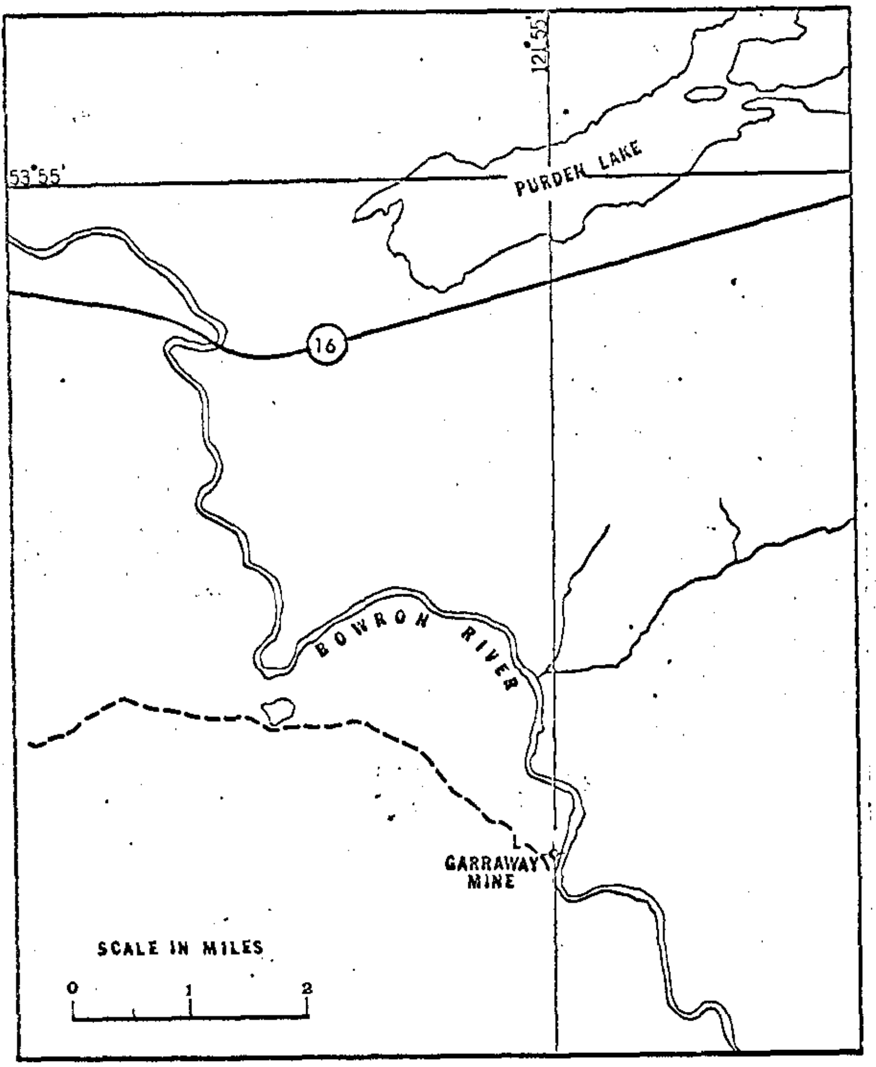


FIGURE 1. SAMPLE LOCATION MAP, BOWRON RIVER, B.C.

The coal is found in a series of sandstones, shales and conglomerates that outcrop along the river. It is possible that the coal-bearing series may outcrop farther to the northwest and southeast but the formation has not been traced farther in those directions.

The coal formation comprises grey and buff sandstones inter-bedded with light to dark soft shales and sandy shales, some of which are carboniferous, as well as several beds of conglomerate. The conglomerate contains cobbles of green volcanic rock as much as 10 inches in diameter proving that the volcanics are the older. Several beds, as much as 15 feet thick, of grey conglomerate outcrop along the river. The distribution of coal-bearing outcrops suggests that the formation underlies the Bowron River valley forming a belt 1½ to 2 miles wide and about 7 miles long.

Holland (1948) reported that a collection of fossilized plant remains was submitted to the late Dr. W.A. Bell for identification who reported, "the fossil plants from the Bowron River area are poor indeed.....but....I consider the age to be Tertiary". In 1968 Dr. Bell, in an unpublished report stated, "the evidence, unsatisfactory as it is, favours a time interval in the Upper Cretaceous, within the limits of Campanian-Maestrichtian and particularly a Campanian one".

From the foregoing it is obvious that dating the Bowron River measures is very difficult, the problem being compounded by the lack of good fossil material.

MacKay (1946) noted that the coals of the Bowron area are of Tertiary age, and at least 3 of the coal seams are of commercial interest. He also states that the coals have been classed by the Provincial Government as bituminous in rank.

In 1969, Dr. G.E. Rouse of the University of British Columbia, Dept. of Botany, reported, "I am reasonably sure that the Bowron suite is Tertiary in age; most likely between Middle Paleocene and mid Eocene, with a chance of early Paleocene". Dr. Rouse made his age determinations on fossil pollen grains. He felt that the collection of more megafossils, especially plants, would aid in fixing the age of the measures more precisely.

Though the age of the measures is in doubt due to the lack of good fossil evidence, it is generally considered that the coals found in the Bowron River area are of Tertiary Age.

Sample Preparation and Megascopic Examination

A column sample was taken from the upper seam of the productive part of the coal measures from the Garroway Mine, stated to be 10 ft. thick.

The sample represents 7 feet of coal exposed at face of prospect slope. The column was taken to the laboratory cut into smaller, more manageable blocks and mounted in Paraplex - a plastis mounting medium.

After mounting, these blocks were labelled as to their relative position in the column and oriented with respect to top and bottom.

The blocks were then polished on a Buehler polishing lap using a standard acceptable procedure. They were then examined megascopically using a hand lens and a very low power stereoscopic microscope (X5).

In general appearance, the coal examined is a normal banded coal composed almost entirely of the bright components vitrain and clarain. Subordinate amounts of shaly coal, coaly shale and shale also occur. The coal has a high lustre and is hard and dense.

The megascopic profile of the seam is reproduced in figure 2, which shows that the seam is split by four distinct partings. The pure coal, contained between these partings was divided into nine petrographic intervals based on the relative proportions of the entities present.

The resulting breakdown showed that intervals I and V are composed mainly of the shale-rich entities while the remaining 7 are of clean coal which differs only in the vitrain to clarain ratio. Vitrain exceeds clarain in interval II, IV and IX while the reverse is true in intervals III, VI, VII and VIII. Throughout these bright intervals the shaly impurities occur in minor percentages.

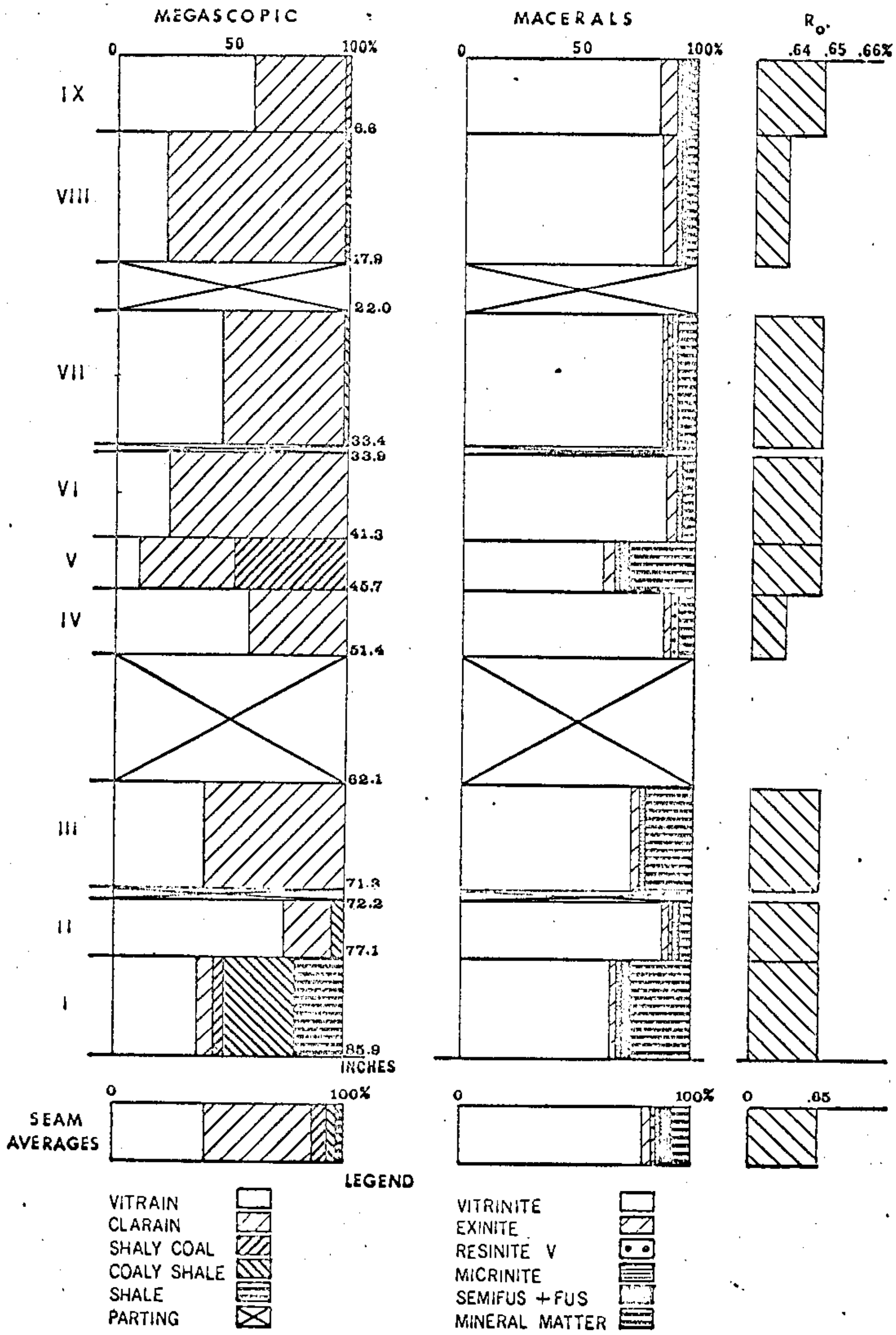


FIGURE 2. PETROGRAPHIC COMPOSITION AND R_o. INDICES OF THE UPPER SEAM, BOWRON RIVER, B.C.

Microscopic Examination

Coal from the megascopically determined intervals was then prepared for microscopic examination.

The coal representing each interval was crushed to -20 mesh and riffled to yield a representative sample. A grain mount was prepared from each interval and polished on a Buehler Automet polishing lap. The polished grain mounts were then used for reflectance measurements and maceral determination. Reflectance measurements are normally made on vitrinite, the most abundant constituent in most coals. Measurement of this parameter is a petrographic way of expressing rank. An increase in rank is accompanied by an increase in reflectance and this can be measured quite precisely. Such measurements on a given coal are usually reported in two ways:

1. An average of a number of readings may be calculated and the rank of the coal expressed by a single reflectance index.
2. The reflectance data also may be used to subdivide the vitrinite into so-called "V" types. These are designated by number as V6, V7, etc. These numbers signify a reflectance range. Thus V6 means vitrinite with a reflectance range between 0.60 and 0.69% in oil, while V7 has a range between 0.70 and 0.79%.

Reflective indices were determined with a Leitz microscope fitted with a photometer. This is a similar arrangement to that which is generally accepted and used by other petrology laboratories. The instrumentation and its standardizations are described in the "Third Draft, Equipment and Procedures for Determining Microscopically the Maximum and Mean Minimum Reflectance of the Organic Components in Polished Specimens of Coal, ASTM Designation D5 Subcommittee XVIII Petrographic analysis of Coal" by J.L. Bayer. It is described also by Schapiro and Gray (1960).

The results of the reflectance study are shown on figure 2 in the right hand column headed R_o. These show that the mean maximum reflectance of the vitrinite component is almost constant from the top to the bottom of the seam.

That there is little variation in the consistency of the vitrinite is shown by the fact that the reflective index of the various intervals only fluctuates from 0.64 to 0.65 which is within the range of the statistical error encountered in the work. The average reflectance for the entire seam is calculated to be 0.65.

A further indication as to the lack of variety in the vitrinite is shown by the fact that there were only 4 vitrinite types in evidence in the entire nine intervals which ranged from V4 to V7. The vitrinite type V6 accounted for 66 per cent of these reflectance readings.

The rank of the coal was determined chemically using the method outlined in the A.S.T.M. standards on coal and coke (1962). The coal was found to be of high volatile B bituminous rank. Rank as determined by reflectance was in accord with the A.S.T.M. method.

The grain mounts used in the above R_o study were repolished and re-examined to determine the maceral content of the coal. Macerals are the basic constituents of coal and are analagous to the minerals of inorganic rocks. The ones identified in the present study are vitrinite, exinite, resinite, micrinite, semifusinite and fusinite. Mineral matter also was determined. Definitions of the macerals as well as the method followed in determining their quantity conform to those suggested in the International Handbook of Coal Petrology (1963). The results of this examination are shown graphically in the center column of figure 2 and numerically in table I. During the analysis the macerals semifusinite and fusinite were considered separately but these later combined to produce the column in figure 2 because they appear to represent stages in a genetically related group. The fact that the combined total of these two macerals does not exceed 5 per cent in any interval facilitated plotting.

As previously stated the seam in the Garroway Mine is very bright, hard and has a high lustre. The maceral analyses of the various petrographic intervals substantiates this initial impression.

Table I

Interval	Height Inches	Vitrinite %	Exinite %	Resinite %	Micrinite %	Semifusinite %	Fusinite %	Minera Matter
IX	6.6	84	7	—	1	4	1	3
VIII	11.3	85	6	—	1	1	—	7
VII	11.4	85	2	1	1	—	—	11
VI	7.4	88	4	—	2	—	—	6
V	4.4	61	4	—	1	3	1	30
IV	5.7	90	3	2	—	—	—	5
III	9.2	73	3	—	1	—	—	23
II	4.9	90	2	1	1	—	—	6
I	8.8	65	1	—	1	2	1	30
Seam Average	69.7	80.2	3.6	0.4	1.0	1.1	0.3	13.4

Maceral Content of the IX Petrographic Intervals of the Upper Seam, Bowron River Area

The seam is composed almost entirely of the bright coal component vitrinite. This maceral is the major entity of all nine intervals reaching a high of 90 per cent in interval IV, the brightest unit and dropping to a low of 61 per cent in interval V, which is the dullest interval. The monotony of the column is broken by the three intervals I, III, and V which have higher amounts of mineral impurities. The mineral pyrite and various shale minerals account for the mineral matter. The other maceral components are present only in minor percentages.

The seam under study has been noted for its relatively high resin content. Black reports on two types of resin, namely soluble or "Canadian" resin and insoluble resin. The former is reported to compare favourably with "Congo" resin which has a well-established place in world markets. This resin was named "Canadian" by the Batelle Institute (Black 1967). This "Canadian" or soluble resin was reported to amount to 4 per cent in this coal. In contrast to the above "soluble resin" which is invisible, megascopically the insoluble resin is visible and is said to be present in the coal in an amount equal to the "soluble resin" (approximately 4%).

During the visit to the mine to collect the sample studied, the visible resin was observed in the coal. The resin appeared as small (±1 inch), elongated, amber-yellow nodules randomly distributed throughout the seam.

The invisible, soluble resin was assumed to be so only in a megascopic examination, but would be visible during the microscopic phase. The resulting low percentages actually observed during the microscopic examinations therefore were disappointing.

A fragment of the visible resin, hand-picked from the seam, was examined in oil under reflected light and showed a distinct brownish red-orange colour and therefore appeared as a readily identifiable component. During the subsequent analysis, none of this type was observed in the coal. The small percentages of resinite evident ranged from light to dark grey in colour.

by Black and the paucity of resin found by the present analysis could be attributed to "vitrinization". Stach (1968) reports that the elliptical resin bodies can lose their resinous characters by polymerisation and may be transformed into grey vitrinite. Such resinous material in a petrological examination would have to be assessed as vitrinite or, more strictly, as semi-vitrinite. Thus it would appear that through this process of polymerisation the resinite loses its original optical properties and assumed the same colour as vitrinite. It is conceivable that in this process the resin loses some of its "exinitic" properties and takes on more vitrinitic characteristics.

COKE STABILITY

The present mine operators found that the coal near the top of the slope produced a coke button with a swelling index of 1 and that it increased as the mining proceeded down the dip of the seam.

Coke stability can be predicted with an accuracy of 94 per cent (Berry, et al.,1967) if the maceral content and the reflectance data of the seam are known. The method followed in the present study was that described by Schapiro, Gray and Eusner (1961) and the calculated stabilities for the petrographic intervals and a composite of the entire seam were compiled. The method considers the macerals as belonging to two groups, namely those which are reactive (vitrinite, exinite, resinite, 1/3 semifusinite) and those which are inert (fusinite, micrinite, 2/3's semifusinite, mineral matter). The method further assumes that for maximum coke strength there is an optimum ratio of reactives to inerts and that this ratio varies with rank.

The results of the stability determinations for the Bowron coal are shown in Table II.

Table II

Interval	I	II	III	IV	V	VI	VII	VIII	IX	Seam Average
Stability	6	0	0	0	23	0	0	0	0	9

Predicted Coke Stabilities of the Petrographic Intervals and Seam Average of Upper Seam, Bowron River Area.

These results show that all intervals with the exception of intervals I and V have a calculated predicted stability of 0. The remaining intervals, I and V have stabilities of 6 and 23 respectively. The predicted stability for the entire seam was 9 as compared with a stability of 50-60 for known coking coals.

The resulting low stability factor can be almost solely attributed to the lack of the so-called inert macerals such as the semifusinite, fusinite and micrinite.

As can be seen from figure 2, the seam is composed of almost 80/ per cent of the reactive components vitrinite and exinite. These are the macerals that contribute the swelling properties to the coke. As previously stated, resinite behaves in a manner similar to exinite and this adds considerably to the swelling characteristics. Coal that contains 5/ per cent resinite is considered a high resinous coal and therefore the 8/ per cent reported by Black puts the seam under study in this category. This overabundance of swelling reactives would yield a favourable coke button but not necessarily a strong coke.

On the other hand, a coal that would be considered a good coking coal would have a predicted coke stability of from 50 to 60. The reason that this coal has such poor predicted stability is due to the paucity of the inert macerals which impart strength to the coke. The calculation of stabilities is based on the ratio of reactive entities which in general produce the swelling characteristics to the inert components which give the coke its strength. It is, therefore, unlikely that this coal would produce a good coke. The coal could, however, be used as a blend to mix with a low volatile coal that has a high inert maceral content. Further study would be required / to determine the suitability of this coal for blending.

SUMMARY AND CONCLUSIONS

The upper seam of the productive part of the coal measures in the Bowron River area is composed of a clean-looking coal with a very high lustre. The coal is dense and hard and contains small amber-yellow resin nodules dispersed through it.

The coal is a high volatile bituminous coal by A.S.T.M. standards and this was borne out by the mean maximum reflectance index of 0.65.

The coal has yielded a coke button with a free swelling index of 1 near the top of the slope and 3 at the face. The operators predict a button of 5 as they procedd down dip. This is not over-optimistic as the coal is composed mainly of those macerals that contribute volatiles and hence swelling of the coke. The lower indices of 1 and 3 obtained on the samples mentioned above may be due to oxidation of coal collected relatively near the outcrop.

This abundance of reactives is detrimental to the process of coke making with this coal since the inert macerals which give strength to coke are present in very small proportions. It is the lack of this inert component that gives a predicted coke stability of only 9 for the seam even though one of the established petrographic intervals gave a figure of 23. This was the highest figure obtained and, when weighed against the 50-60 stability index produced by good coking coals, indicates a coke of inferior quality. The coal possibly could be used as a blend with a coal which is low in reactive macerals.

There was little petrographic indication of the high (8%) resin content attributed to this coal. This lack could be attributed to the amount of bitrinization undergone by the resin or by the superiority of a chemical analysis to determine the resin content of this coal.

REFERENCES

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Stach; Basic principles of coal petrology: macerals, microlithotypes and some effects of coalification - coal and coal bearing strata; Murchison, D.C., and Westall, T.S.; 1968; p. 7.

Appendix C - Resins and Radioactivity

C-1	"Radioactivity of Tertiary Lignites . . . ." G. S. C. Project 680106	
C-2	Battelle Memorial Institute Report on Refind Resins	November 30, 1966
C-3	Battelle Memorial Institute Summary Report on Resins	February 28, 1967
C-4	Battelle Columbus Laboratories Letter and Attachments	November 29, 1972

COAL RESEARCH

4.

RADIOACTIVITY OF TERTAIRY LIGNITES IN SASKATCHEWAN, ALBERTA AND BRITISH COLUMBIA

Project 680106

A. R. Cameron, P. A. Hacquebard, J. R. Donaldson
and T. F. Birmingham

Radioactivity measurements of Tertiary lignites were carried out with a scintillometer at about 200 stations in southwestern Saskatchewan, southeastern Alberta, and a large area of south and central British Columbia. All visible coal occurrences were checked including thin lenses, dirty coal, carbonaceous shales, etc. Readings above two or three times the background were considered significant for sampling and about 35 samples were collected. The most appropriate of these will be processed for chemical determination of the uranium content.

In Saskatchewan 73 stations were examined in the Cypress Hills district coal area. This was extended into Alberta to include the western and southern flanks of the Cypress Hills. With a background of 5 to 15 microroentgens per hour most readings ranged from 0 to 25 microroentgens above the background. However, in the vicinity of Eastend, Saskatchewan, two good readings were obtained (a) 380 µR/hr with background of 19 µR/hr and (b) 600 µR/hr and background of 31. The latter occurrence is 3/4 mile due west of a similarly good reading obtained last field season.

In British Columbia 125 stations of Tertiary coal areas were surveyed at White Lake, Princeton, Tulameen, Merritt-Quilchena, Spence's Bridge, Hat Creek, Kamloops, Chu Chua, Alexandria, Quesnel, and Bowron River. In most areas readings above or even approaching the two times background were rarely obtained, with the following exceptions; White Lake, a high of 16 µR/hr above a background of 14 µR/hr; Princeton, a high of 19 µR/hr above a background of 8 µR/hr; Chu Chua, a high of 33 µR/hr above a background of 7 µR/hr; and in the Bowron River section, a high of 40 µR/hr above a background of 4 µR/hr.

Along with the uraniferous lignite survey, column samples were collected in the following areas for coal petrographic studies: Eastend, Saskatchewan (3), Luscar, Alberta (1), and in British Columbia, at Michel (3), Hat Creek (1), and Bowron River (1). From the Blakeburn strip mine at Coalmont 21 samples were taken for the coal reflectance studies.

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November 30, 1966

(Appendix C-2)

Mr. David A. Ross
Northern Coal Mines Ltd.
1296 Kings Avenue
West Vancouver, British Columbia
Canada

Dear Mr. Ross:

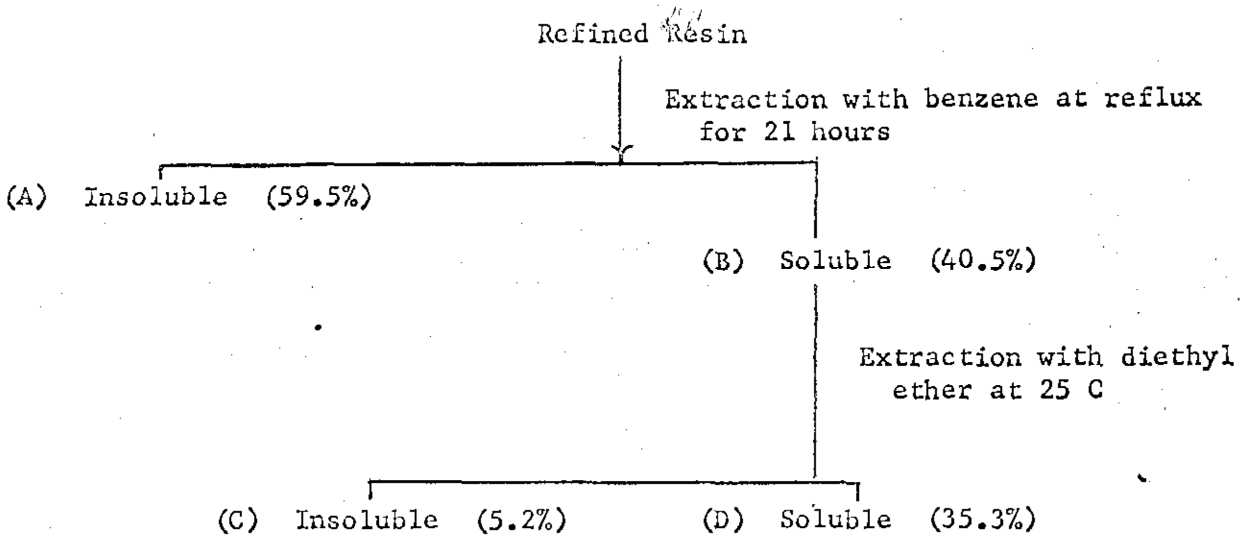
This letter summarizes the work done on our study of the composition of Northern Coal Mines' resin from Coal from June 1, 1966, until November 1, 1966. Since the ten-pound sample of Refined Resin arrived only recently, the evaluation studies in rubber and in coatings have just been started and will be reported upon at a later date.

Characterization of Refined Resin

Chromatographic and spectral data indicate that the Refined Resin is a complex mixture of some 40 - 50 components having hydroxyl, carboxylic, and ester functionality. In my letter of June 15, 1966, it was indicated that no aromatic components were present in the Refined Resin. More recent studies now indicate that the Refined Resin is predominantly a mixture of condensed ring aromatics with aliphatic substitution on the rings.

The Refined Resin is very resistant to hydrolysis. The resin could not be completely hydrolyzed by treatment for a period of 2 - 3 days with a 20 percent solution of sodium hydroxide in either water or a water-ethylene glycol mixture at temperatures up to 200°C. Only a small amount of hydrolytic products was obtained from these treatments of the resin. These products appeared to be a more complex mixture of materials than the original resin and no attempt was made to characterize them.

More informative data were obtained by solvent fractionation of the Refined Resin according to the scheme shown below and examination of the resulting fractions.



The infrared spectra of the various fraction were similar to one other and to the original resin. These data indicate that: (1) the resin is probably a mixture of materials of a single class or family of chemical compounds rather than a mixture of different chemical classes, and (2) the various fractions obtained by the solvent fractionation represent different molecular weight species present in the resin.

The diethyl ether soluble fraction (D), 1.96 g, from the above fractionation was partially hydrolyzed by treatment for 16 hours with a 3.2 percent solution of sodium hydroxide in a 10:10:1 mixture of dimethyl sulfoxide, ethyl alcohol,and water. An acidic fraction was obtained which contained some ester carbonyl as shown by infrared examination. However, no neutral alcoholic fraction, i.e. material containing hydroxyl, but no carboxylic acid functionality, was obtained.

The acidic fraction of D was esterified with diazomethane and then fractionated by thin-layer chromatography (TLC) on Silica Gel G using a 10 percent v/v solution of acetone in diethyl ether as developing solvent. Five fractions of materials were obtained. Infrared examination indicated that each fraction consisted of a mixture of materials. The infrared spectra of four of the fractions having R_f values* in the range 0.03 - 0.95 were similar and showed hydroxyl and ester carbonyl functionality. The fifth fraction, having an R_f range of 0.95 - 1.00, was a neutral material, i.e., contained no hydroxyl or ester functionality, and was aromatic in nature.

The fact that no neutral material containing hydroxyl functionality was recovered from the hydrolysis of fraction D suggests that the precursors of the resin are hydroxy acids. Hence, the ester carbonyl of the resin may arise from, (1) intraesterification to produce a lactone, or (2) interesterification to produce a normal ester. Some evidence in support of these hypotheses is found in the nuclear magnetic resonance spectrum of the resin which shows two types of esters to be present in the resin.

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* The R_f value of a component is the distance that component has moved on the TLC plate divided by the distance which the solvent front has moved.

A sample of the Refined Resin was reduced to hydrocarbons by distillation with zinc dust. Examination of the reduced product by infrared, nuclear magnetic resonance spectroscopy and gas liquid chromatography showed it to be a complex mixture of hydrocarbons consisting predominantly of aromatic or condensed-ring aromatics with alkyl substitution on the rings. The infrared spectrum of the reduced material resembles the spectra of coals and asphalts, especially in the aromatic substitution region of 950 - 650 cm^{-1}.

On the basis of the above date, it is believed that the Refined Resin is a mixture of condensation products of a complex aromatic hydroxy acid highly substituted on the ring(s) with alkyl groups. Because of the complexity of the resin no attempt was made to determine whether the hydroxylic functionality was aliphatic or phenolic in nature, or a mixture of both types.

Because of the complexity of the resin, a considerable amount of work would be required to do a complete elucidation of its structure, and at present, further effort in this direction does not seem to be warranted.

Comparison of Amber Resin and Refined Resin

Very early in this program some incongruities in the properties of Amber Resin and Refined Resin were observed. Amber Resin is the amber-colored clear material which can be picked out of the coal by hand. Refined Resin is the dark-colored material obtained by the extraction process which was employed to obtain the ten-pound batch of resin recently received.

As reported in my letter to Mr. Ross of June 15, 1966, the following differences were observed.

1. Infrared spectra indicate that the Amber Resin is principally ester, whereas Refined Resin is a mixture of ester and carboxylic acid. The composition of Refined Resin seems to lie between that of Amber Resin and the original coal.

2. Amber Resin is, for all practical purposes, completely insoluble in chloroform, benzene, or pyridine. By contrast, Refined Resin is completely soluble in pyridine and soluble in varying extents in a number of other solvents.

3. Refined Resin softens at ~ 200 C. Amber Resin does not soften at temperatures even at 400 C. A differential thermal analysis (DTA) in nitrogen, indicates that Amber Resin does not melt until ~ 450 C, at which temperature it is volatilized (probably with decomposition).

Further consideration of these points has led to speculation about the separation being achieved by the solvent extraction process. Accordingly, samples of the various fractions involved in the separation were obtained from Northern Coal Mines Ltd. and analyzed by infrared spectrometry and examined microscopically.

The microscopic studies together with the infrared spectra showed conclusively that the Amber Resin is not being removed by the extraction process. It remains in the extraction residue. Figure 1 is a photomicrograph of Amber Resin picked out of coal by hand. The sharp edges and conchoidal fracture pattern are especially important. (The black material is coal which remained stuck to the resin.) Figure 2 is a photomicrograph of Refined Resin. These particles are of an entirely different character than the fragments of Amber Resin. None are transparent, and even those that are translucent are reddish brown rather than light amber as in the case of Amber Resin. Figure 3 is a photomicrograph of the residue left after the extraction process by which the Refined Resin is obtained. There are many clear, light-amber particles which are obviously the original Amber Resin, along with some coal residue. These clear particles still have the conchoidal fracture pattern, which indicates that they have not been affected by the solvent extraction.

I understand that the commercial plant to make resin will use an air classification process. Our work demonstrates rather conclusively that the extraction process simply dissolves the more soluble coal fractions. By contrast, the air separation process will function on an entirely different basis -- relative particle densities. The air separation process thus may give a product rich in Amber Resin, and if so it would be vastly different from the present Refined Resin.

We are currently attempting to isolate as much of the Amber Resin as possible to study its properties further. Included will be an attempt to use air classification on the five pounds of extraction residue we received some time ago.

It has been some time since you visited Battelle, and I believe another visit in the near future to discuss the current status of the project would be helpful.

Sincerely yours,

Maynard B Neher

Maynard B. Neher
Associate Chief
Structural Organic Chemistry

MBN:KR

Enc. (3)

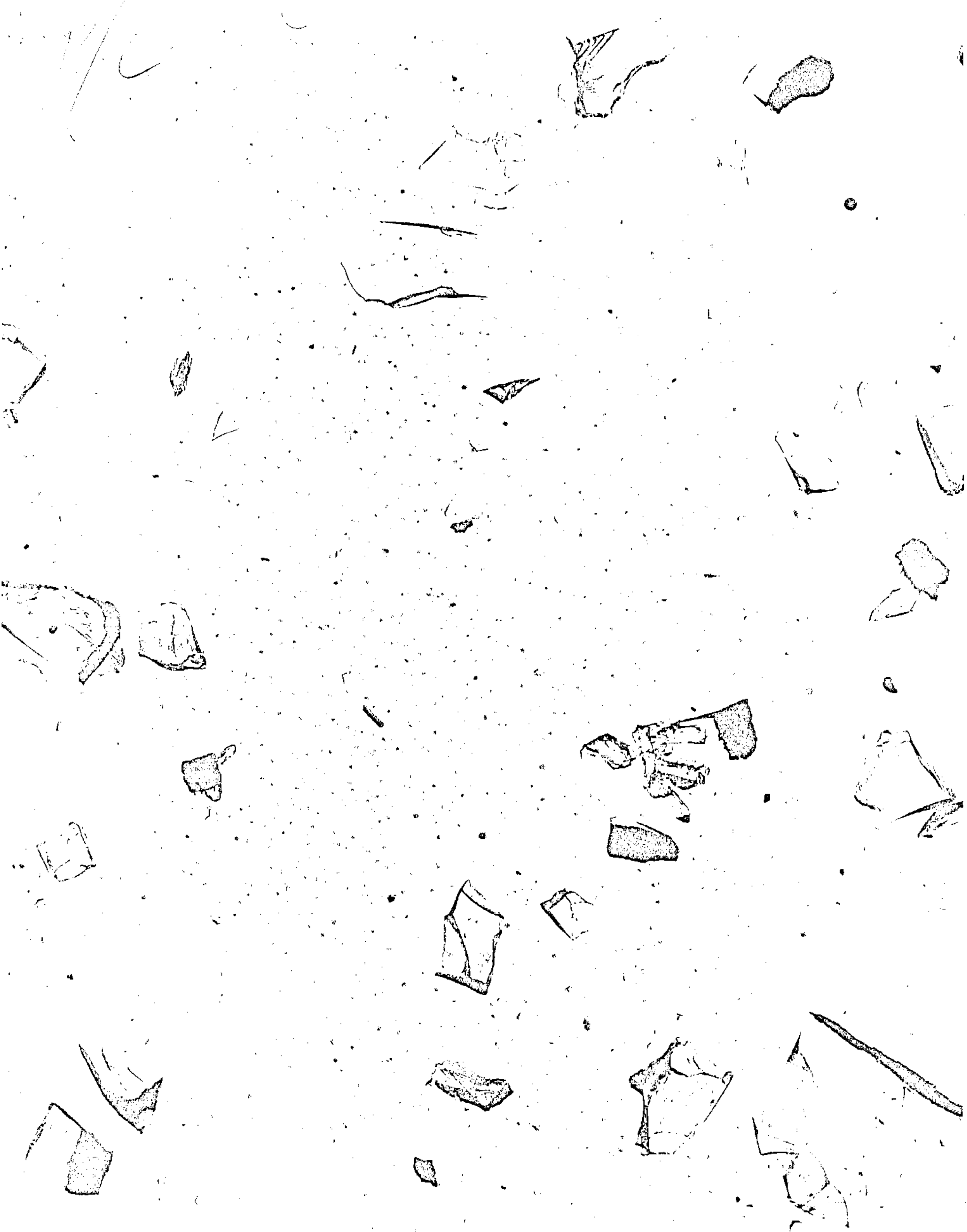

FIGURE 1. AMBER RESIN (62X)

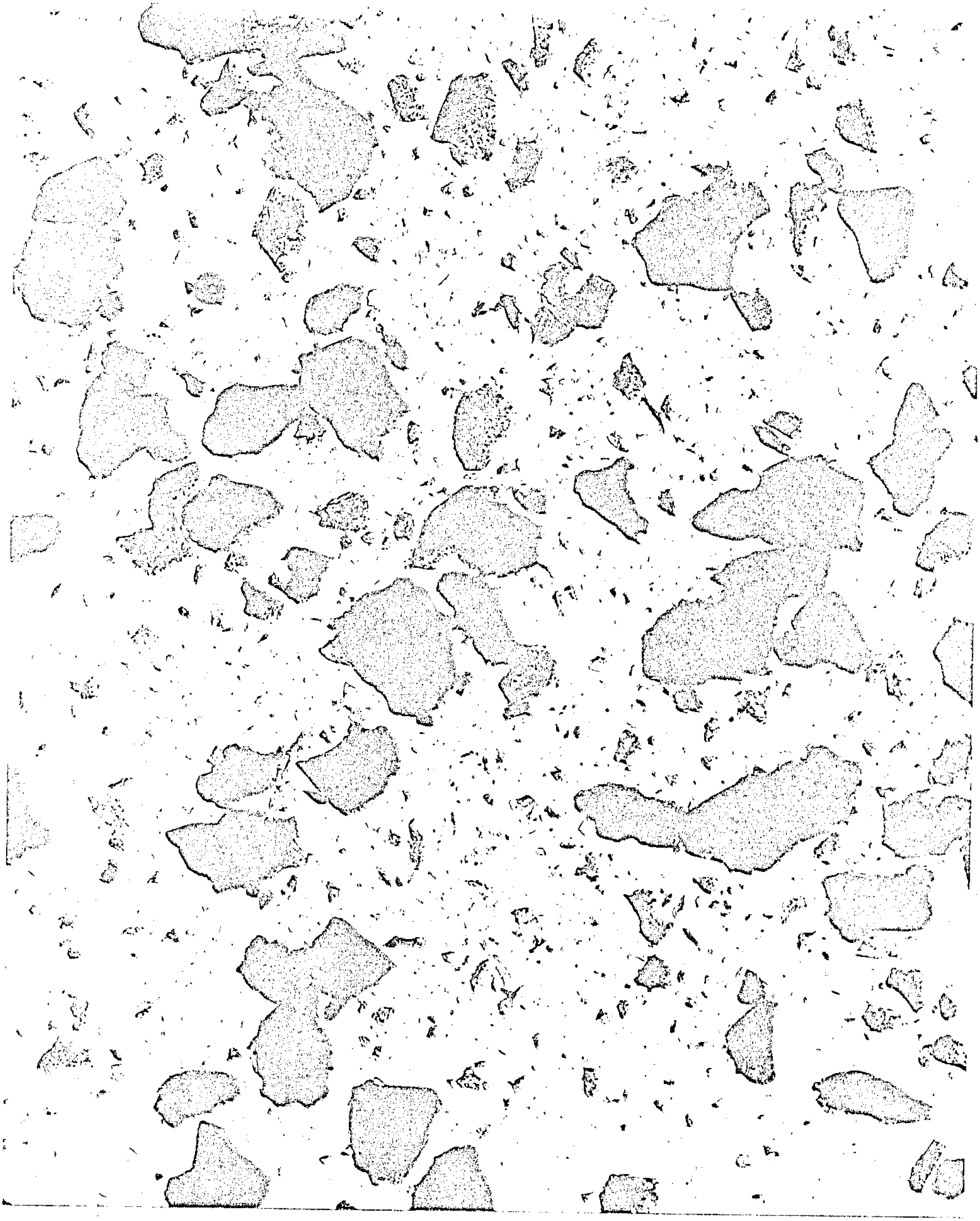

FIGURE 2. REFINED RESIN (62X)

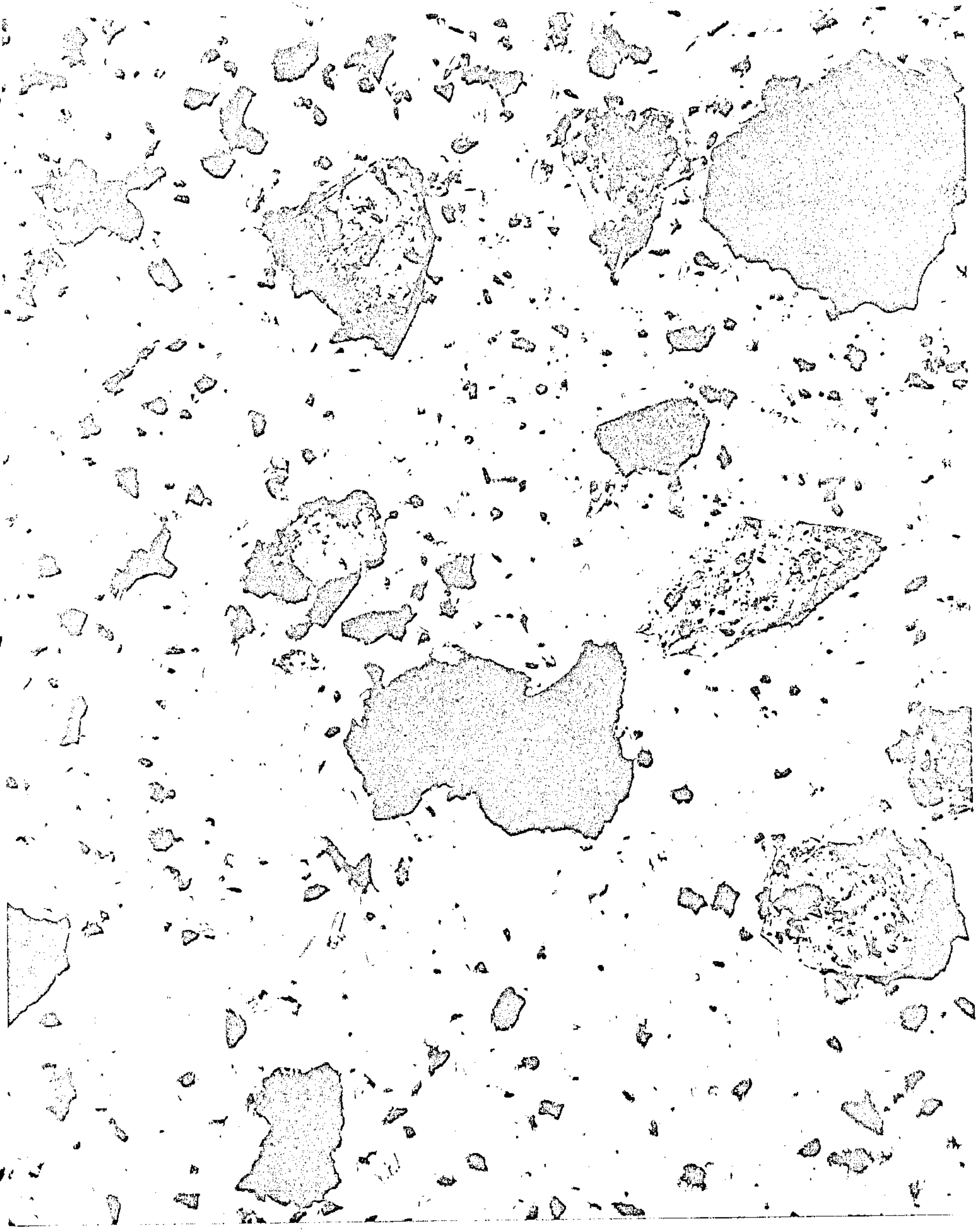

FIGURE 3. EXTRACTION RESIDUE (62X)

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February 28, 1967

(Appendix C-3)

Mr. David A. Ross
Northern Coal Mines, Ltd.
1296 Kings Avenue
West Vancouver, British Columbia
Canada

Dear Mr. Ross:

We have now completed the work so far agreed upon in our investigation of "Refined Canadian Resin in Coatings and in Rubber Compositions". The enclosed report covers this phase of the work.

The results indicate promise for the refined resin, both in oleoresinous varnishes and as a low-cost extender in certain rubber compositions, but further work will be required in both applications. At least some of the additional work should be deferred until a product more representative of the ultimate commercial product is available.

However, I believe that you should give serious consideration to the separation process. We have shown that the solvent extraction process leaves the "Amber" resin behind, and we believe that this may be the most valuable part. We would certainly like to get enough to evaluate it in coatings.

If you can arrange to visit Battelle in the next month or so, I believe that it would be worthwhile to discuss the results obtained so far and to decide the course of future work.

Sincerely yours,

Maynard B. Neher
Associate Chief
Structural Organic Chemistry

MBN:ja

Enc.

SUMMARY REPORT

on

STUDY OF REFINED CANADIAN RESIN IN COATING AND RUBBER COMPOSITIONS

to

NORTHERN COAL MINES, LIMITED

February 28, 1967

by

M. B. Neher, G. F. Cremeans, and W. J. Mueller

BATTELLE MEMORIAL INSTITUTE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

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STUDY OF REFINED CANADIAN RESIN IN COATING AND RUBBER COMPOSITIONS

M. B. Neher, G. F. Cremeans, and W. J. Mueller

INTRODUCTION

During 1966, a preliminary study of the chemical and physical properties was undertaken of a fossil-type resin found in the Sponsor's coal deposit. This evaluation included a cursory study of potential applications of the resin in coatings and in rubber compositions.

This preliminary study indicated potential markets in both the coating and rubber fields. These results, along with the results of the chemical characterizations, were summarized in a letter report from M. B. Neher, dated November 30, 1966.

All of the work described in the present report was performed using the resin obtained by solvent extracting the fraction of coal that floats on a CCl_4/Varsol mixture with a specific gravity of 1.25. The sample was supplied by Dr. Visman. This fraction has been described as "Refined Resin", and is referred to as such throughout this report.

SUMMARY AND CONCLUSIONS*

The Refined Resin was evaluated in rubber compositions for use as (1) a filler and extender, (2) as an ingredient to improve abrasion resistance, and (3) as an antioxidant. The results indicate some potential for use as a low-cost extender, but little or no potential in the other areas.

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*The work reported here is recorded in Battelle Laboratory Record Books #23043, pp. 1-11; #24497, pp. 10-30.

The Refined Resin was evaluated in oleoresinous varnishes of the type that normally employ fossil resins (e.g., Congo resin). The Refined Resin appears to have potential application in these coatings. The experimental coatings made from Refined Resin are harder but darker than those made from Congo resin. However, the "Amber" resin picked out of the coal by hand appears potentially more valuable than the Refined Resin.

EVALUATION OF REFINED RESIN AS A COMPOUNDING INGREDIENT IN RUBBER

Refined Resin was evaluated as a compounding ingredient selected rubbers in three areas. These were (1) filler and extender, (2) antioxidant, and (3) ingredient to increase abrasion resistance. These areas were selected on the basis of preliminary evaluations in rubber, and the chemical properties which have been established for Refined Resin.

Filler and Extender

Large quantities of many materials are used as fillers in rubber compounding. These materials are normally added to improve certain properties, and they range over a wide area with respect to particle size and cost, depending upon the requirements of the products. Extenders are often added to supplement the fillers. These are usually low-cost materials which have little effect on properties, either good or bad, and are used primarily to increase the compound volume and decrease its cost.

The results of a preliminary examination of the Refined Resin in Neoprene W are shown in Table 1. SRF Black was used as the control since large quantities are used in this polymer for general-purpose applications. The SRF Black increased the modulus and tensile strength, while decreasing the elongation. The SRF Black also increased the minimum viscosity and decreased both the scorch (Δ5) and cure (Δ35) times. The major effect of using the Refined Resin as a filler (Composition 12) was a large decrease in tensile strength and an increase in elongation and minimum viscosity. The effects on other properties were not large. The effect of supplementing SRF black with a small amount of Refined Resin (Composition 13) was a further increase in the stiffness of the composition as shown by the increases in modulus and minimum viscosity; also, decreases were noted in the scorch and cure time at 250 F.

Comparable data obtained with nitrile rubber are shown in Table 2. With this polymer, the control filler was MT black, which can often be used where high product quality is not required. The use of the Refined Resin as the filler resulted in a vulcanizate with very low tensile strength. On the other hand, the compositions (16 and 17) in which the Refined Resin was used as an extender for the MT black did show the most promising results. The effect on the minimum viscosity was much less than was observed with the Neoprene W composition, possibly indicating greater compatibility of the resin with the nitrile rubber. When used as an extender, the Refined Resin increased the scorch time (Δ5) at 250 F, but had little effect on the cure time or rate at 302 F.

The results of this study with the two polymers suggest little possibility for the use of Refined Resin as a filler, but indicate that

TABLE 1. REFINED RESIN AS A FILLER AND EXTENDER IN NEOPRENE W

		Composition Number			
		10	11	12	13
Mooney Scorch and Cure Data at 250 F					
Minimum Viscosity		32	73	66	90
Δ5, min		8.4	6.7	9.7	6.0
Δ35, min		15.2	11.9	16.1	10.5
Δ35-Δ5, min		6.8	5.2	6.4	4.5
Mooney Scorch and Cure Data at 307 F					
Minimum Viscosity		34	85	59	101
Δ5,min		3.1	2.0	2.9	2.6
Δ35, min		5.0	3.4	5.1	3.7
Δ35-Δ5, min		1.9	1.4	2.2	1.1
	Cure, min. at 307 F				
100% Modulus, psi	10	Nil	660	120	860
	20	80	830	220	900
	30	Nil	620	220	900
300% Modulus, psi	10	130	2840	370	2820
	20	210	-	380	-
	30	220	-	400	-
Tensile Strength, psi	10	1990	3010	1040	2820
	20	2430	2920	980	2700
	30	2600	3000	1000	2920
Elongation, percent	10	850	320	700	300
	20	730	240	620	230
	30	760	280	640	270
Hardness, Shore A-2	10	75	81	72	75
	20	72	75	75	76
	30	76	80	77	80
Ingredients:					
Neoprene W		100	100	100	100
SRF Black		-	50	-	50
Refined Resin		-	-	50	5
Zinc Oxide		5	5	5	5
Magnesium Oxide		4	4	4	4
Stearic Acid		1	1	1	1
Phenyl-β-naphthylamine		2	2	2	2
2-Mercaptoimidazoline		0.5	0.5	0.5	0.5

TABLE 2. REFINED RESIN AS A FILLER AND EXTENDER IN A BUTADENE-ACRYLONITRILE COPOLYMER (HYCAR 1041)

		Composition Number			
		14	15	17	18
Mooney Scorch and Cure Data at 250 F					
Minimum Viscosity		37	47	33	43
$\Delta 5$, min		49.5	72.0	62.0	57.0
$\Delta 35$, min		57.5	88.0	71.0	66.0
$\Delta 35-\Delta 5$, min		8.0	16.0	9.0	9.0
Mooney Scorch and Cure Data at 302 F					
Minimum Viscosity		26	22	22	21
$\Delta 5$, min		8.8	12.4	9.2	8.7
$\Delta 35$, min		10.3	14.3	10.5	10.2
$\Delta 35-\Delta 5$, min		1.5	1.9	1.3	1.5
	Cure, min. at 302 F				
100 percent Modulus, psi	10	220	Nil	200	240
	20	290	200	290	300
	30	300	220	300	350
300 percent Modulus, psi	10	600	Nil	520	420
	20	1010	250	970	840
	30	1100	300	1040	920
Tensile Strength, psi	10	2080	320	1900	1510
	20	1730	800	1720	1570
	30	1780	620	1660	1380
Elongation, percent	10	720	>1000	780	780
	20	500	710	510	540
	30	490	560	480	430
Hardness, Shore A-2	10	62	60	65	69
	20	65	66	64	69
	30	66	70	66	70
Ingredients:					
Hycar 1041		100	100	100	100
MT Black		50	-	50	50
Refined Resin		-	50	5	20
Zinc Oxide		5	5	5	5
Stearic Acid		1	1	1	1
Sulfur		2	2	2	2
Benzothiazyldisulfide		1.5	1.5	1.5	1.5

it may have some merit as a low-cost extender. Further work would be required to establish this point. At the same time, we would need to have a fairly accurate estimate of the planned selling price for the resin, so that materials could be selected as controls against which it would probably be competing.

Improvement of Abrasion Resistance

Earlier studies at Battelle have shown that the abrasion resistance of some nitrile rubber compositions can be significantly improved by the addition of a phenolic resin. The nitrile compositions which are so affected are those which contain a low-cost carbon black which provides a low degree of reinforcement. To determine whether the Refined Resin was able to function similarly, the compositions shown in Table 3 were evaluated. Composition 24, containing a phenolic resin, Durez 12687, showed only 14 percent as much abrasion loss as Composition 23 (no additive); whereas Composition 25, containing Refined Resin, showed three times as much abrasion loss as the additive-free composition.

These results clearly show that the Refined Resin does not provide the abrasion resistance afforded by the phenolic resin.

Antioxidant

The characterization study on the Refined Resin reported in a letter of November 30, 1966, by M. B. Neher, indicated that the resin had hydroxyl funtionality, although it was not established whether this was aliphatic or phenolic in nature. Presently, several hindered phenols and diamines are used as rubber antioxidants. The phenols are used where

TABLE 3. REFINED RESIN AS AN ADDITIVE FOR IMPROVING ABRASION RESISTANCE

	Composition Number		
	23	24	25
100 percent Modulus, psi	400	1180	460
300 percent Modulus, psi	1880	2980	1280
Tensile strength, psi	2640	2980	1880
Elongation, percent	410	300	450
Hardness, Shore A-2	70	86	80
Pico Abrasion Loss, cc	0.022	0.003	0.063
Ingredients:			
Hycar 1041	100	100	100
HMF Black	40	40	40
Refined Resin	-	-	30
Durez 12687	-	30	-
Zinc Oxide	5	5	5
Stearic Acid	1	1	1
Sulfur	2	2	2
Benzothiazyl disulfide	1.5	1.5	1.5

TABLE 4. REFINED RESIN AS AN ANTIOXIDANT IN NATURAL RUBBER

	Composition Number				
	18	19	20	21	22
Unaged Properties					
100 percent Modulus, psi	200	140	200	190	170
300 percent Modulus, psi	1560	1480	1460	1400	1210
Tensile strength, psi	2930	3100	2720	2550	2220
Elongation, percent	480	500	460	450	440
Hardness, Shore A-2	56	56	54	56	55
Properties After Aging 4 Days at 212 F					
100 percent Modulus, psi	370	400	350	360	350
Tensile strength, psi	1520	2280	1180	1230	1170
Elongation, percent	230	310	210	210	220
Hardness, Shore A-2	61	64	59	62	63
Ingredients:					
Smoked Sheet	100	100	100	100	100
SRF Black	45	45	45	45	45
Zinc Oxide	5	5	5	5	5
Sulfur	2.5	2.5	2.5	2.5	2.5
Stearic Acid	1	1	1	1	1
Benzothiazyl Disulfide	1	1	1	1	1
Phenyl-β-naphthyl Amine	-	2	-	-	-
Refined Resin	-	-	2	5	10

staining and discoloration cannot be tolerated, while the diamines are used in other applications because of their better performance.

To determine whether the Refined Resin has any antioxidant activity, a study was made with natural rubber, using phenyl-β-naphthylamine (PBNA) as a control antioxidant. Property determinations were made on unaged compositions and on compositions aged for four days at 212 F, following standardized aging procedures. Antioxidant activity was judged by the differences in tensile strength and elongation between the unaged and aged compositions.

Table 4 shows that Composition 19 containing the PBNA had a much higher aged tensile strength and elongation than any other composition. The three compositions comtaining the Refined Resin were no better, and possibly a little poorer, than the Composition 18 containing no added antioxidant. Thus, the results clearly show no antioxidant activity for the Refined Resin.

EVALUATION OF REFINED RESIN IN COATINGS

In general, the physical and chemical properties of oils and resins used in the preparation of a varnish carry over into the finished vehicle. The primary reasons for adding hard resins to drying oils are:

(1) To increase the hardness of the film

(2) To improve water and chemical resistance

(3) To improve the gloss

(4) To shorten the drying time.

These improvements are normally attributed to the fact that the hard resin added is usually hard, glossy, and inert to acid, bases, and water.

The trend in the past twenty years has been to use synthetic "hard" resins in the varnish-making trade to replace the fossil resins that were once used almost exclusively. The reasons for this are primarily: (1) uniformity of product, (2) increased production capacities for synthetics, and (3) synthetic resins are competitive with fossil resins in price. However, fossil resins are still being used to prepare nominal amounts of oleoresinous varnishes, with Congo resin being one of the most popular. This material sells for \$0.21 to \$0.28 per pound, depending on quality and type.

It was initially decided to compare Refined Resin directly with Congo resin in similar coatings formulations. This involved a thermal degradation of the resin until it became soluble in a fatty acid triglyceride. For this program, linseed oil was chosen. In addition, other type formulations (resin-esters) were tried and other means of incorporating the Refined Resin into polymeric vehicles were used. The solubility of the Refined Resin in rosin derivatives was also established.

The degree of difference between a linseed oil film and a modified linseed oil film naturally depends on the hard resin content of the coating. The varnish trade refers to short-, medium-, and long-oil varnishes. This terminology indicates the gallons of oil used per 100 pounds of resin and the following definitions are used:

(1) Short-oil, 6-18 gallons oil/100 pounds resin

(2) Medium-oil, 18-30 gallons oil/100 pounds resin

(3) Long-oil, 30-60 gallons oil/100 pounds resin.

In general, hardness and chemical resistance decrease as the oil length increases, but flexibility of the film is proportional to the oil content. For the purpose of this study, varnishes having oil-length values of 10, 20, and 40 were used.

Oleoresinous Varnishes

The normal procedure for incorporating Congo or other insoluble hard fossil resins is to heat the resin at 330 to 345 C until oil solubility is attained. Congo resin is usually brought to 335 C in successive heats, each requiring about 1.5 hours. During this time, a 20 percent weight loss occurs, with the acid number of the resin decreasing from 112 to about 85.

The degree of heating required to degrade the Refined Resin was determined before any effort was made to incorporate it into a coating. To do this, 200 grams of Refined Resin was heated in a stainless steel beaker under a carbon dioxide spurge. The temperature of the resin was raised to 330 C and small samples removed at 30-minute intervals and tested for oil solubility. In addition, weight-loss data were obtained. The results of this experiment are summarized in Table 5. These data show that considerable degradation has to occur before the resin becomes readily soluble in linseed oil. Nevertheless, it was found that if the resin is heated to 327 C and held for 30 minutes (in a nitrogen atmosphere), the resulting processed resin can be dissolved in linseed oil by heating the oil and the resin for about three hours at 230 C. Congo resin, when thermally processed until a 20 percent weight loss occurs, will dissolve in less than one-half hour under similar conditions. However, since the thermal processing of Congo resin rarely results in a loss greater than 20 percent weight, it was decided to use

TABLE 5. THERMAL PROCESSING OF CANADIAN AMBER RESIN NECESSARY TO OBTAIN AN OIL SOLUBLE PRODUCT

Processing Time under CO_2 at 327 C, Minutes	Weight Loss, percent of Initial Resin	Solubility in Linseed Oil	
		100 C for 5 Min	Heating at 230 C Until Solubility is Attained
0.0 (no thermal processing)	0.0	Insoluble	Insoluble after 5 hr
1.0(1)	-	Insoluble	Insoluble after 5 hr
30.0	20	Insoluble	Soluble after 3 hr
60.0	29	Insoluble	Soluble after 2 hr
90	-	Insoluble	Soluble after 1 hr
120	40	Soluble(2)	Soluble in less than 1 hr(2)

(1) A 30-minute heating time was used to raise the temperature of the resin from 25 C to 327 C.

(2) The resin at this point consisted of two materials--a carbonacious foam on top and a liquid resinous mass in the bottom of the reactor. The solubility of the resinous mass is reported.

Refined Resin also thermally decomposed until a 20 percent weight loss was observed. It is recognized that many economic factors will determine whether or not the Refined Resin will compete with Congo resin or similar resins to the varnish industry. The cost criterion that will be used by a manufacturer of varnishes is the production cost of the final coating. This will include pounds of faw resin, required to produce one gallon of varnish, as well as the kettle time required to produce the final product.

Accordingly, three basic linseed varnish formulations were prepared having oil lengths of 10, 20, and 40, using the thermally processed Refined Resin and Congo resin (supplied by O. G. Innes Corporation). Coatings were deposited on steel and tinplate panels and cured at either ambient temperature (25 C for 1 week) or elevated temperature (30 minutes at 177 C). The Refined Resin coatings were compared with the control coatings, Congo-linseed varnishes, and linseed oil coatings for resistance for 40 percent nitric acid. In addition, hardness and flexibility measurements were made on all of the coatings.

The evaluation data are shown in Tables 6 and 7. All of the baked coatings had excellent resistance to methyl ethyl ketone, while the coatings cured at ambient temperature were dissolved in one to two minutes. As shown in Tables 6 and 7, the varnishes prepared using the Refined Resin compare favorably with the Congo controls. The Refined Resin imparts slightly more hardness to the linseed oil varnish while not harming its flexibility. However, the coatings formulated using the Refined Resin are considerably darker than the coatings prepared using the Congo resin.

TABLE 6. COMPARISON OF LINSEED OIL VARNISH FILMS PREPARED USING CONGO AND REFINED RESIN AND CURED BY BAKING AT 177 C FOR 30 MINUTES

Resin	Oil Length,(1) gal	Film Properties(2)		Resistance to 40 Percent Nitric Acid, hr until failure
		Flexibility(3)	Sward Hardness(4)	
Congo	10	Failed 1 in.	60	5.5
Canadian	10	"	69	5.8
Congo	20	Passed 1/8 in.	44	2.3
Canadian	20	"	49	3.8
Congo	40	"	12	1.3
Canadian	40	"	21	1.3
Linseed Oil Control		"	4	0.5

(1) Number of gallons of linseed oil per 100 pounds of resin.

(2) All of the films were about 0.8 mil thick ± 0.1 mil.

(3) Figure represents the smallest diameter of a rod that the coating on tinplate can be bent over through 180 degrees without breaking the coating.

(4) Compared to plate glass having a hardness of 100.

TABLE 7. COMPARISON OF LINSEED OIL VARNISH FILMS PREPARED USING CONGO AND REFINED RESIN AND CURED AT 25 C FOR ONE WEEK

Resin	Oil Length,(1) gal	Film Properties(2)		Resistance to 40 Percent Nitric Acid, hr until failure
		Flexibility(3)	Sward Hardness(4)	
Congo	10	Failed 1 in.	32	5.5
Canadian	10	"	65	5.5
Congo	20	Passed 1/8 in.	21	3.5
Canadian	20	"	37	2.3
Congo	40	"	7	1.3
Canadian	40	"	11	1.3
Linseed Oil Control		"	2	0.5

(1) Number of gallons of linseed oil per 100 pounds of resin.

(2) All of the films were about 0.8 mil thick ± 0.1 mil.

(3) Figure represents the smallest diameter of a rod that the coating on tin-plate can be bent over through 180 degrees without breaking the coating.

(4) Compared to plate glass having a hardness of 100.

Attempts to Use Refined Resin in Coatings Without Thermal Degradation

Early in this program it was observed that the unprocessed Refined Resin had an acid number of about 55 and is soluble in linseed fatty acids and insoluble in linseed oil. It was felt that perhaps on heating in the presence of litharge, an ester interchange would occur between the Refined Resin and linseed oil. An experiment was carried out by heating 12.0 g of Refined Resin with 20.0 g of linseed oil containing 0.3 g of litharge at 230 C. This mixture jelled after 3 hr of heating and never became homogeneous.

Next, 10.0 g of Refined Resin was added to 16.0 g of linseed fatty acids, and the whole mixture reacted with 1.3 g of pentaerythritol at 232 C for about 3 hr. The product was a dark resinous material soluble in toluene. Coatings prepared from this material gave air-dry and baked coatings with Sward hardness values of 20 and 30 and having excellent flexibility and adhesion.

In addition, an attempt was made to degrade the Refined Resin by adding it to a refluxing 5 percent solution of sodium hydroxide. The resin was kept in contact with the refluxing basic solution for six hours and then acidified with hydrochloric acid. The product was still insoluble in drying oils and could not be used to prepare an oleoresinous varnish without further processing.

The Refined Resin appears to be comparable to Congo resin for use as the hard resin component in varnishes. The varnishes made with Refined Resin give films that are darker than those prepared with Congo resin, but have slightly higher hardnesses with no apparent sacrifice in flexibility. The results also indicate that film-forming materials can be prepared if Refined Resin-linseed oil mixtures are esterified with a polyol such as pentaerythritol. Otherwise, it appears that the Refined Resin will have to be thermally degraded prior to using it in the preparation of oleoresinous varnishes.

RECOMMENDATIONS FOR FUTURE WORK

This study indicates that the Refined Resin may find application as a low-cost extender in rubber. Further work will be required to establish this point.

This study also indicated that the Refined Resin gives oleoresinous coatings with physical properties equal or superior to coatings made with Congo resin. This study should be expanded to include a more comprehensive evaluation of co-esters of the Refined Resin with various polyols and drying oil fatty acids. In addition, a brief study should be made to establish the parameters of processing variables (both thermal degradation and varnish preparation) required with the Refined Resin. The Refined Resin should also be studied as a modifier for low-cost alkyds where color is not of primary importance.

However, the "Amber" resin which is not being extracted is potentially even more useful than the Refined Resin which was used in the current study, because of its lighter color and lower ash content. Any future work should include study of this material.

Thus, serious consideration should be given to the process used to separate "resin" from "coal". As recorded in the last report (November 30, 1966), the Refined Resin is in reality a soluble fraction of the coal, and the "Amber" resin remains in the extraction residue.

It is believed that this "Amber" resin probably represents a more valuable product than the Refined Resin obtained by the present extraction process.

Further, we understand that the material which will be produced in the ultimate plant will be obtained by an air classification process. In light of our observation that the "Amber" resin is completely unaffected by the solvent extraction, it is probable that the commercial product will be different. Future work plans should include study of a product more representative of the ultimate commercial material than the Refined Resin.

Battelle has had considerable experience in ore and mineral extraction, and we would be able to bring this background to studying separation of the "Amber" resin from raw coal. The sample of extraction residue currently on hand could be a starting point.

DEC 4 - 1972

Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151
Telex 24-5454

November 29, 1972

(Appendix C-4)

Mr. L. S. Trenholme, Director
Northern Coal Mines, Ltd.
7th Floor, Board of Trade Tower
1177 W. Hastings Street
Vancouver 1, B. C., CANADA

Dear Mr. Trenholme:

As you know, your letter of November 3, 1972, addressed to Battelle Memorial Institute was given to Mr. Neher because of his past research connections with your company. Mr. Neher's letter of November 13, 1972, gave brief reply and indicated that answers to your questions would be forthcoming. Since then, we have discussed your past research program, and how we might proceed in the future.

Research on your resin in coatings, rubbers, and plastics applications would now fall in the Division of Polymer and Paper Technology, of which I am a member. Therefore, I have taken the liberty of replying to your letter.

The minimum weight of material desired for a new research program is estimated as that quantity necessary to produce about 10 pounds of resin. If you know the percent resin in the coal, you can readily calculate the quantity of coal needed. If the research is at all extensive, 25 pounds of resin would be a more reasonable amount to work with.

At this time we cannot give an estimate of cost of a new research program. It will be necessary to plan the program carefully, and prepare a research proposal before we can give a cost estimate. In this respect, it would be very helpful to us to have you visit our Battelle-Columbus Laboratories to discuss possible research approaches.

There is an outstanding indebtedness of $3,943.75 for prior research carried out for Northern Coal Mines, Limited. This research terminated in 1967. In our last attempt to submit an invoice for this indebtedness it was returned to us because address of company was unknown.

Enclosed is a Xerox copy of a page from a recent issue of American Paint Journal, which gives prices for some of the natural resins. However, synthetic resins might provide more competition for your resins than would be experienced from the natural resins. The paint industry went through a period many years ago when synthetics largely replaced the natural resins. More recently, alkyds, and then the water-based resins replaced most of the oleoresinous varnish in paints. Enclosed is a selected tabulation of imports of some natural resins, which you should find very interesting.

Please let us know if you have any additional questions.

Very truly yours,

LJ Nowacki

Louis J. Nowacki
Polymer and Paper
Technology Division

LJN:gm

Enclosures

THE MARKETS

Barrels one cent more.

•Varnish—				
Orange, 4-lb. cut	gal.	..	—	..
5-lb. cut	gal.	..	—	..
White, 4 lb. cut	gal.	..	—	..
5-lb. cut	lb.	..	—	..

---

‡F.o.b. New York.

F.o.b. New York and Chicago for 50-gallon barrels. 4 bbls. or more 5 cents less.

Varnish Gums and Resins

Natural Resins

Asphaltum—				
Gilsonite, selects 100-lb. bags. F.o.b. Craig, Colo.	ton	$61.60	—	..
Ex-Warehouse, bags N.Y. or N.J.	ton	$145-165	—	..
•Congo—				
No. 1	lb.	..	—	..
No. 2	lb.	.29	—	.33
No. 3	lb.	.24	—	.27
•Damar—				
Singapore No. 1 Bags	lb.	.29	—	.33
Singapore No. 2	lb.	.27	—	.30
Singapore Dust	lb.	.17	—	.21
•East India—				
Pale Nubs	lb.	.22	—	.25
Pale Chips	lb.	.16	—	.19
Black Bold Scraped	lb.	.17	—	.20
Black Nubs and Chips	lb.	.13	—	.16
Black Unscraped	lb.	.14	—	.17
Batu Bold	lb.	.16	—	.19
Batu Nubs and Chips	lb.	.11	—	.14
•Pontianak—				
Nubs	lb.	.36	—	.38
Chips	lb.	.22	—	.25
•Manila—				
Loba C	lb.	.30	—	.35
DBB	lb.	.23	—	.26
LAS	lb.	.21	—	.24
MA	lb.	.19	—	.22
Philippine Pale Bold	lb.	.34	—	.37
Philippine Pale Chips	lb.	.24	—	.27
Philippine Sorts	lb.	.19	—	.22
•Elemi	lb.	..	—	..
Yacca	lb.	.12	—	.15

•Ex-warehouse or dock New York.

Synthetic Resins

Chlorinated Rubber f.o.b. Parlin and Bayonne, N.J.				
20 cps., t.l.	lb.	.61¼	—	..
125 cps., t.l.	lb.	.71¼	—	..
Epoxy, Liquid, 100% solids basis, tanks, deliv.	lb.	.41	—	..
Ester Gums—Ordinary—delivered.				
C.l., drums	lb.	.22½	—	..
L.c.l., drums	lb.	.24	—	..
Ester Gums, PE C.l., drums,				
f.o.b. customer's siding	lb.	.22½	—	..
L.c.l., drums	lb.	.24	—	..
Styrene Butadiene Copolymer Resins, f.o.b. Akron, O., or Gary, Ind., min. frt. ppd. —100-240 secs, 33⅓% in xylol.				
T.l.	lb.	.49	—	..

Organic Acids

Fumaric Acid Delivered, E. of Rockies.				
C.l., bags, 50 lbs.	lb.	.21	—	..
C.l., drums, 250 lbs.	lb.	.22	—	..
L.c.l., bags, 50 lbs.	lb.	.22½	—	..
L.c.l., drums, 250 lbs.	lb.	.23½	—	..
Isophthalic Acid, f.o.b. shipping point, freight equalized with Richmond, Calif.; Joliet, Ill., and Port Newark, N.J.				
C.l. & t.l., bags, 50 lbs.	lb.	.16½	—	..
L.c.l., bags	lb.	.17½	—	..
Maleic Anhydride Delivered, E. of Rockies.				
Tanks	lb.	.18	—	..
C.l., drums, 250 lbs.	lb.	.21½	—	..
C.l., bags, 50 lbs.	lb.	.20½	—	..
L.c.l., bags, 50 lbs.	lb.	.22	—	..
Phthalic Anhydride, f.o.b.				
Tanks	lb.	..	—	.08¼
C.l. or t.l., bags, 50 lbs.	lb.	..	—	.11¼
L.c.l., bags, 80 lbs.	lb.	..	—	.12¼

Polyhydric Alcohols

Glycerine, tanks dlvd.				
High Gravity, natural	lb.	.21½	—	..
CP USP 99% Natural	lb.	.21¾	—	..
Synthetic anhydrous 99.5%	lb.	.22	—	..
All bulk natural has one per cent trade allowance				
Methyl Glucoside, f.o.b. Argo, Ill., carloads, 100-lb. bags.	lb.	.20	—	..
Pentaerythritol, technical, dlvd., E. of Rockies.				
C.l.	lb.	.19	—	..
L.c.l.	lb.	.20	—	..
Mono grade				
C.l.	lb.	..	—	..
L.c.l.	lb.	..	—	..
Sorbitol, liquid 7%, tanks f.o.b.	lb.	..	—	..
Resin grade, pellets, 100% solids, c.l., drums, f.o.b. wks.	lb.	.25¾	—	..
Trimethylolethane, technical, f.o.b. works—				
C.l., bags	lb.	.27½	—	..
L.c.l.	lb.	.28½	—	..
Trimethylolpropane, deliv., c.l., 2 t.l., Zone 1	lb.	.275	—	..

Latex Paint Vehicles

		Wet Basis		Dry Resins Basis Solids
Acrylic Resin Emulsion—				
Interior Grade				
44½% solids, tanks	lb.	.13½	—	..
Exterior Grade				
46% solids, tanks	lb.	.14¾	—	..
50% solids, tanks	lb.	.16¼	—	..
65% solids, tanks	lb.	.21	—	..
Wet Weight Min. frt. alld.				
Add 01/Dry lb. W. of Rockies.				
Butadiene Styrene—				
48% solids, tanks	lb.	.1210	—	.26
Dry Basis, Min. frt. alld.				
Add 01/Dry lb. W. of Rockies.				
Polyvinyl Acetate Homopolymer Emulsion—				
55% solids, tanks	lb.	.16	—	..
Wet Weight Min. frt. alld.				
Emulsion—				
55% solids, tanks	lb.	.16	—	..
65% solids, tanks	lb.	.18¾	—	..
Wet Weight Min. frt. alld.				

November(?) 1972

IMPORT DATA FOR NATURAL RESIN[(a)]

Year	Total Imported from Indicated County, pounds Malaysia	Indonesia	Congo	Total Import, pounds
1970	292,320	377,960	365,388	1,035,688
1971	464,494	196,580	285,370	946,444
1972[(b)]	259,359	82,635	---	341,994

(a) These resins are listed under U.S. Imports for Consumption under the heading "Gum, Damar, Copal, Kauri, Sandarac, Varnish Gums, and Congo.

(b) The figures are for the first six months only.

Appendix D - Mining and Coal Gasification

D-1	Hydraulic Mining in East Kootenay, B. C. C.I.M. Bulletin	January, 1974
D-2	"Status Report: the AGA/OCR Coal Gasification Program" Coal Age	January, 1973
D-3	Underground Gasification Coal Age	September, 1973
D-4	"Gasification of Coal Research Needed" Berkowitz, Edmonton Journal	November 9,1972
D-5	"Preliminary results....Wyoming in situ gasification test" Coal Age	December,1973

Status report: the AGA/OCR coal gasification program

Edward Goodridge, Assistant Editor, Coal Age

IN 1971, the American Gas Association (AGA) and the Office of Coal Research (OCR) agreed to co-sponsor a $120-million, 4-yr program aimed at accelerating research on coal gasification processes through the pilot plant stage and selecting the best process—or combination of processing steps—for design of a demonstration plant. The funding is $80 million from the government and $40 million from AGA.

The multiple-process research effort is necessary to ensure that at least one economically sound process is developed before the termination of the research program in mid-1975. Hopefully, the program will result in a demonstration plant design of semi-commercial size by the end of that year. As now conceived, this facility would have a daily capacity of 80 million cu ft of high-Btu gas produced from 5,000 tons of coal. More importantly, the operation will generate the engineering data required for the construction of a commercial-scale plant, which should be ready by 1980.

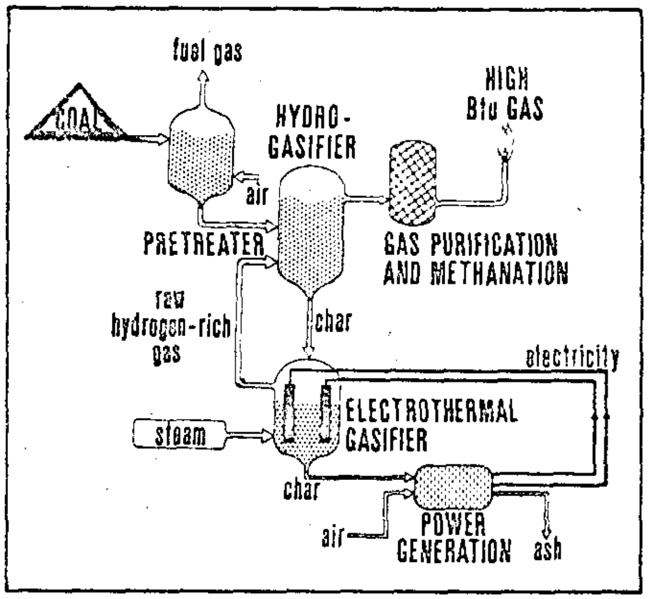
The gasification process for the demonstration plant will be selected after thorough evaluation of at least seven candidate processes. These processes are given below, with the corporation or research group responsible for their development shown in parentheses:

HYGAS process (Institute of Gas Technology),

CO_2 Acceptor process (Consolidation Coal Co.),

BI-GAS process (Bituminous Coal Research Inc.),

Agglomerated Ash process (Union Carbide Corp. and Chemical Construction Corp.),



Schematic flow sheet of the HYGAS process, with the hydrogen supplied from electrothermal gasification of residual char.

Synthane process (Bureau of Mines),

Lurgi process (Lurgi Mineraloltechnik GmbH),

ATGAS process (Applied Technology Corp.).

Additional processes suitable for use in a synthetic natural gas (SNG) plant will come under consideration a they are developed. (OCR also has a separate program for processes yielding low-Btu fuel gas for powe plants—see *Coal Age,* Nov. 1972, p 34.)

The HYGAS and Acceptor processes are in the pilo plant stage, and are undergoing start-up tests. The Agglomerated Ash, Synthane, and BI-GAS processes should reach pilot plant operation by 1974. A decision to build an ATGAS plant will be made after evaluation of further tests.

All of the processes, with the exception of the Lurgi and Synthane, are receiving funds under AGA/OCR contracts. The Synthane process is being financed and developed entirely by the Bureau of Mines, and the Lurgi process is already in commercial operation.

The Fourth Synthetic Pipeline Gas Symposium, sponsored by AGA and OCR at Chicago in October, 1972, provided an up-to-date account on each of the candidate processes.

The following is a summary description of each process and its current status:

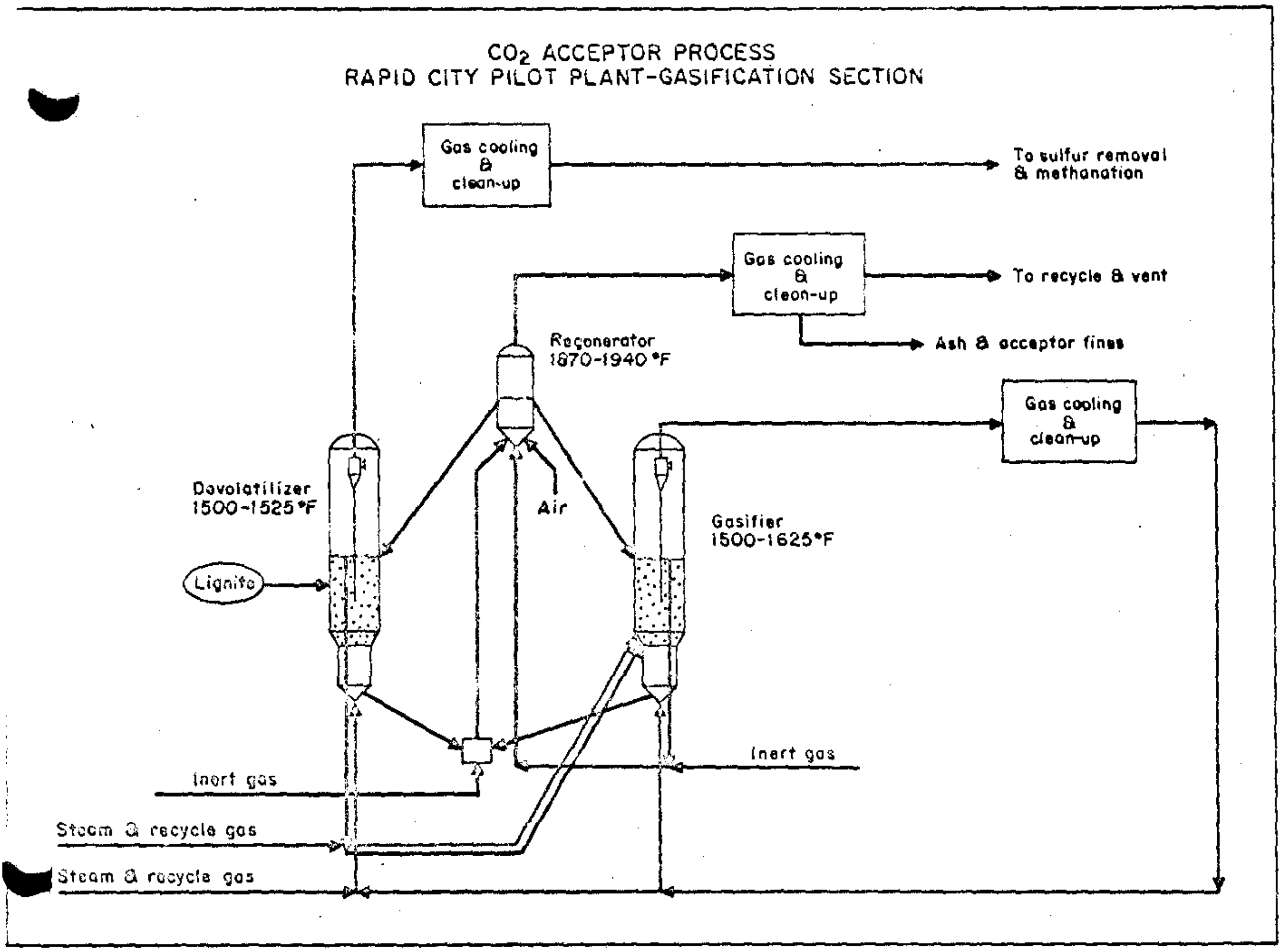
HYGAS is the most advanced U.S. process

Coal hydrogenation—the reaction of coal with hydrogen at high temperature and pressure to produce methane—is the key step of the HYGAS process. Hydrogenation takes place in a specially designed hydrogasifier, which has two stages: a low temperature stage (1300-1500 F) to obtain a high-methane yield from the volatile material in the coal, and a high-temperature stage (1700-1800 F) which generates hydrogen by steam-carbon reaction.

Of the coal feed, about one-half is gasified in the two stages. The other half, in the form of char, goes to hydrogen generation, using one of three methods now under development. The remaining steps of the HYGAS process—gas purification and methanation—yield the final high-Btu product.

The HYGAS process has its advantages. All coal types are acceptable fuels, although caking coals must be pretreated to destroy their agglomerating properties. The hydrogasifier yields an offgas relatively high in methane, thereby minimizing the need for further methanation. Finally, the process, from gasification through methanation, operates at pipeline pressure (1,000 psi). The final product can thus enter a pipeline without additional compression.

HYGAS is the most advanced American coal-to-gas conversion scheme under development. The Institute of



Consol's CO_2 Acceptor process is undergoing trial tests at Rapid City, S.D. Extensive preliminary checks led to five start-up runs since April.

Gas Technology, under the sponsorship of AGA, carried out research on the process for 18 yr prior to OCR sponsorship in 1964.

A HYGAS pilot plant has been built by Procon, Inc. at a cost of over $7 million and has a daily capacity of 80 tpd of coal, or 1.5 million cu ft of pipeline-quality gas. Plant construction began in 1969 and was completed in early 1971. Presently, the hydrogen source is a commercial natural gas reformer unit. The first gasification test was run in October, 1971 using Montana lignite as the reactor feed.

The HYGAS process will ultimately produce its own hydrogen from residual char. Three methods for generating hydrogen are under consideration: electrothermal, steam-oxygen, and steam-iron.

In the electrothermal approach, a high-pressure, steam-fluidized-bed reactor (similar in design to the hydrogasifier) is heated by electrical resistance to a temperature high enough to initiate the steam-carbon reaction. The hydrogen-rich offgas goes to the hydrogasifier. In a commercial plant design, the remaining char from the electrothermal gasifier would fuel a steam-turbine generator, thereby supplying the necessary electricity.

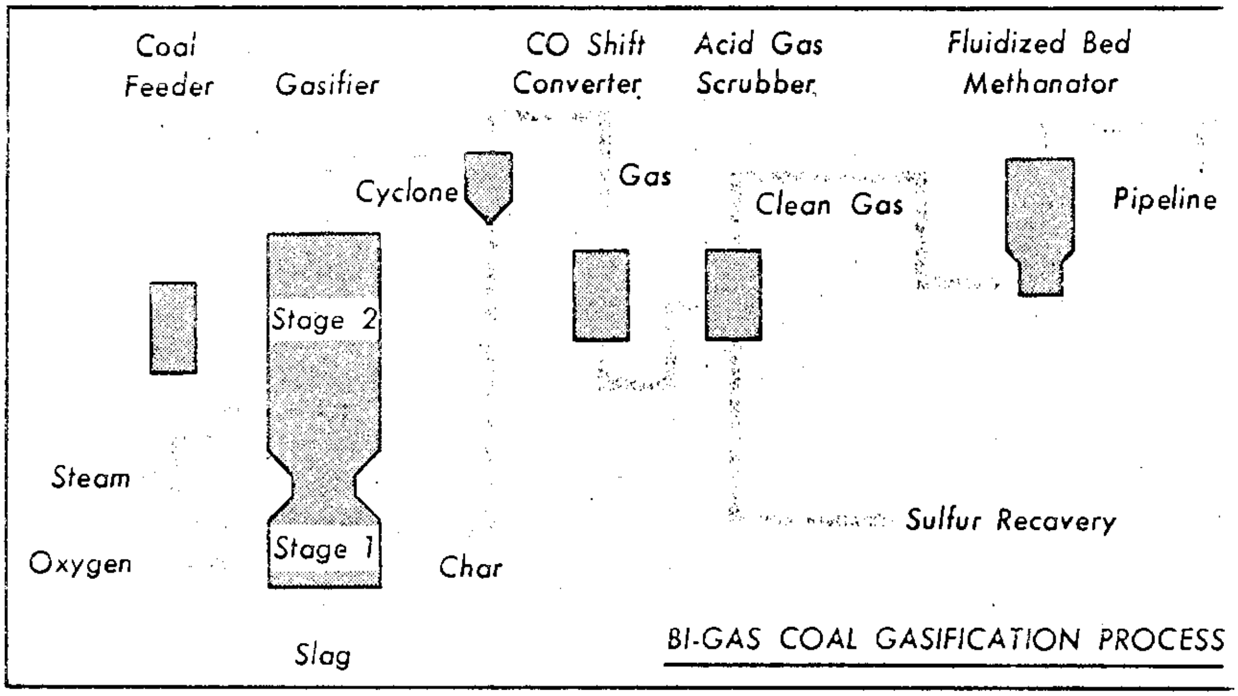
The steam-oxygen approach also utilizes a high-pressure, steam-fluidized-bed reactor to produce hydrogen. But in this case, pure oxygen rather than air is blown into the reactor. This alternative is under consideration because it could supply hydrogen at a cost lower than that for electrothermal generation.

In the steam-iron approach, hot char is gasified with air. The gas, with steam added, is passed over iron in a cyclic oxidation and reduction action that yields hydrogen.

As of August, 1972 the HYGAS pilot plant had been through seven gasification tests. The most recent run, lasting two weeks, operated the hydrogasifier at full pressure, with indications that methane formation was taking place as designed.

Thus far, only minor problems have been experienced in the coal preparation and pretreatment steps. In general, all high-pressure pumps handling slurry material had severe erosion problems. A number of solutions have been found, but the study of this problem is continuing. The package hydrogen plant, after a number of changes, is performing well, and the control of solids flow through the hydrogasifier is satisfactory. The equipment in the gas quench and purification section is operating properly, and the methanation section is ready to be put on-stream.

Electrothermal gasification is the first char-based hydrogen generation method scheduled for testing. Procon completed the unit last June at a cost of $2.4 million. The reactor vessel has been pressure-tested, and the electrical system is now being extensively tested. It is



A prototype BI-GAS plant is under construction and will be operational in January, 1974.

anticipated that start-up operations with the hydrogasifier and package hydrogen generator sections will be completed by this spring, and then operation of the electrothermal gasifier can begin.

A contract now is being negotiated for the design of a large steam-oxygen gasifier compatible in size with the HYGAS reactor. The estimated construction cost for this section is about $2.5 million, with a completion date scheduled for mid-1974. This will coincide with the final runs on the hydrogasifier-electrothermal combination. The steam-iron process is also ready for large-scale testing, but no decision has been made as to when to build this section of the pilot plant. Ultimately, however, one of the three methods for generating hydrogen will be incorporated in a commercial-scale design.

CO_2 Acceptor process moves ahead at Rapid City

Consolidation Coal Co.'s CO_2 Acceptor process is a two-stage, fluidized-bed gasifier system. The coal feed is converted to a char in the first stage, then gasified by the steam-carbon reaction in the second stage.

The unique feature of the process is the method for supplying heat for the gasification reaction. Calcined dolomite (a magnesium-calcium oxide) is circulated through the fluidized bed of char under gasification conditions. The reaction of dolomite with CO_2, one of the gaseous reaction products, liberates the heat required for the carbon-steam reaction. The removal of CO_2 leads to improved hydrogen content in the offgas and thereby increases the ultimate methane yield. The spent dolomite is calcined in a separate regenerator using char as fuel.

Among its advantages, the Acceptor process does not require an oxygen source, thereby eliminating the need for an expensive oxygen plant. It also operates in the relatively low-pressure range of 150-300 psi. However, the process as now conceived is limited to using low-grade, highly reactive western coals which gasify
tively low temperatures (1500-1575 F).

Consol started bench-scale testing of the pro
1964. Construction of the Rapid City, S.D. pilo
(see *Coal Age,* Oct. 1972, p 145) began in Januar
and was completed in November, 1971. The b
Stearns-Roger Corp., now is operating the $9-
plant, which has a capacity of 40 tpd of coal,
equivalent of 400,000 cu ft of pipeline-quality g
day. The plant consumes 3 tpd of dolomite when
capacity.

Start-up operations began in early 1972. Five st
attempts were made in the last year. Each run w
minated due to mechanical problems which have
subsequently solved. These problems included: (
cessive loss of inert gas in the purge system, (2) cl
of pressure measurement devices in the gasifie
regenerator, and (3) attrition of dolomite, with
clogging the spray towers of the quench system.

In the last two runs, char was successfully trans
into the regenerator and burned with air at ope
pressure and temperature. In the final start-up, thi
cess was carried out for five hours and the dolomit
fully calcined.

Another serious problem arose in the refractor
tems of the gasifier and regenerator. It was found
fluidized gases were bypassing the refractory ma
and causing severe erosion, leading to the total fa
of the refractory. By the middle of this month a
pletely new refractory system will have been install
the regenerator and extensive changes made in the
fier refractory system. The new refractory material
low permeability and better abrasion characteristics

There also has been difficulty in maintaining the
sity of the fluid beds and uncertainty about the real
dition of the fluids present in the pressurized ves
Tests are under way to better define the relation
tween pressure measurements and the state of the f

ized bed. Hopefully, this work will soon find a way to fully stabilize the beds and maintain a sharp interface in the gasifier. Solution of the density problem appears to be the only barrier to a full gasification test in early 1973.

The design of the purification and methanation sections was scheduled for completion last month, with a decision to construct the methanation facility following in early 1973. Construction will take about 11 months.

This year, runs will be made with char and North Dakota lignite as fuel. A switch may be made to a local limestone, instead of the Ohio dolomite now used.

Consol's Library, Pa. office is working on the preliminary design of commercial versions of some critical components of the Acceptor process. The South Dakota School of Mines is conducting studies of dolomite sources and environmental aspects of the process.

BI-GAS is another alternative

The present design of the BI-GAS process hinges on a two-stage, super-pressure, oxygen-blown gasifier. Operating pressures are very high—1,000 psi or more.

In this process, coal is introduced into the upper section (Stage 2) of the gasifier, where it comes in contact with a rising stream of hot synthesis gas produced in the lower section (see accompanying digaram). The coal is partially converted into methane and synthesis gas. The residual char entrained in the raw product gas is swept upward and out of Stage 2. The char is separated from the gas stream and recycled to the lower section, where it is completely gasified with oxygen and steam. This reaction produces synthesis gas and the heat required in Stage 2. The high temperatures in the lower section melt the ash, which is removed from the bottom as a molten slag. Finally, the raw product gas from the upper section is purified and methanated.

Caking coals do not require pretreatment in the BI-GAS process. All of the feed coal is consumed in the two stages, leaving no residual char. Most importantly, the reactor offgas is high in methane, higher than in other direct-blown gasifiers. However, BI-GAS operates at high temperatures (over 1700 F in Stage 2), and requires oxygen.

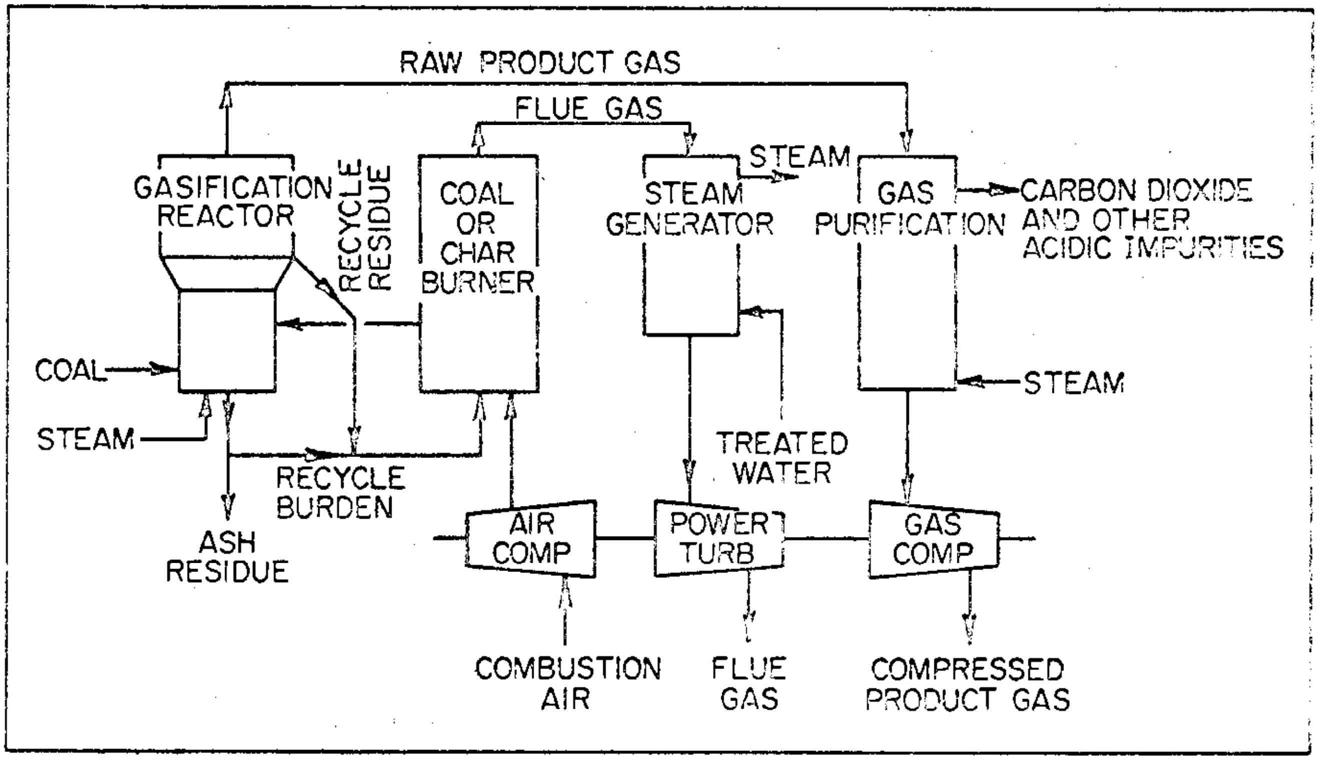
BI-GAS research has come a long way since its beginning in 1963 at Bituminous Coal Research, Inc. (BCR). The Homer City, Pa. pilot plant (see *Coal Age*, Sept. 1972, p 92) represents 9 yr of accumulated experience. BCR's initial design of the plant was carried out in cooperation with the Koppers Co. The contract for detailed engineering, construction and operation went to Stearns-Roger, Inc. in July, 1972. The Stearns-Roger design calls for a 5-tph-capacity gasifier, having a maximum operating pressure of 1,500 psi.

At a future date, two additional types of gasifiers will be built tnd evaluated: an air-blown, medium-pressure, two-stage gasifier; and a low-pressure, multistage, fluidized-bed gasifier. End products will include high-Btu pipeline gas; sulfur-free, low-Btu fuel gas; industrial gases; and fuel gas for Magnetohydrodynamic (MHD) power generation. Extra space is also provided for future installation of special equipment for preparation of enriched gasifier feedstock.

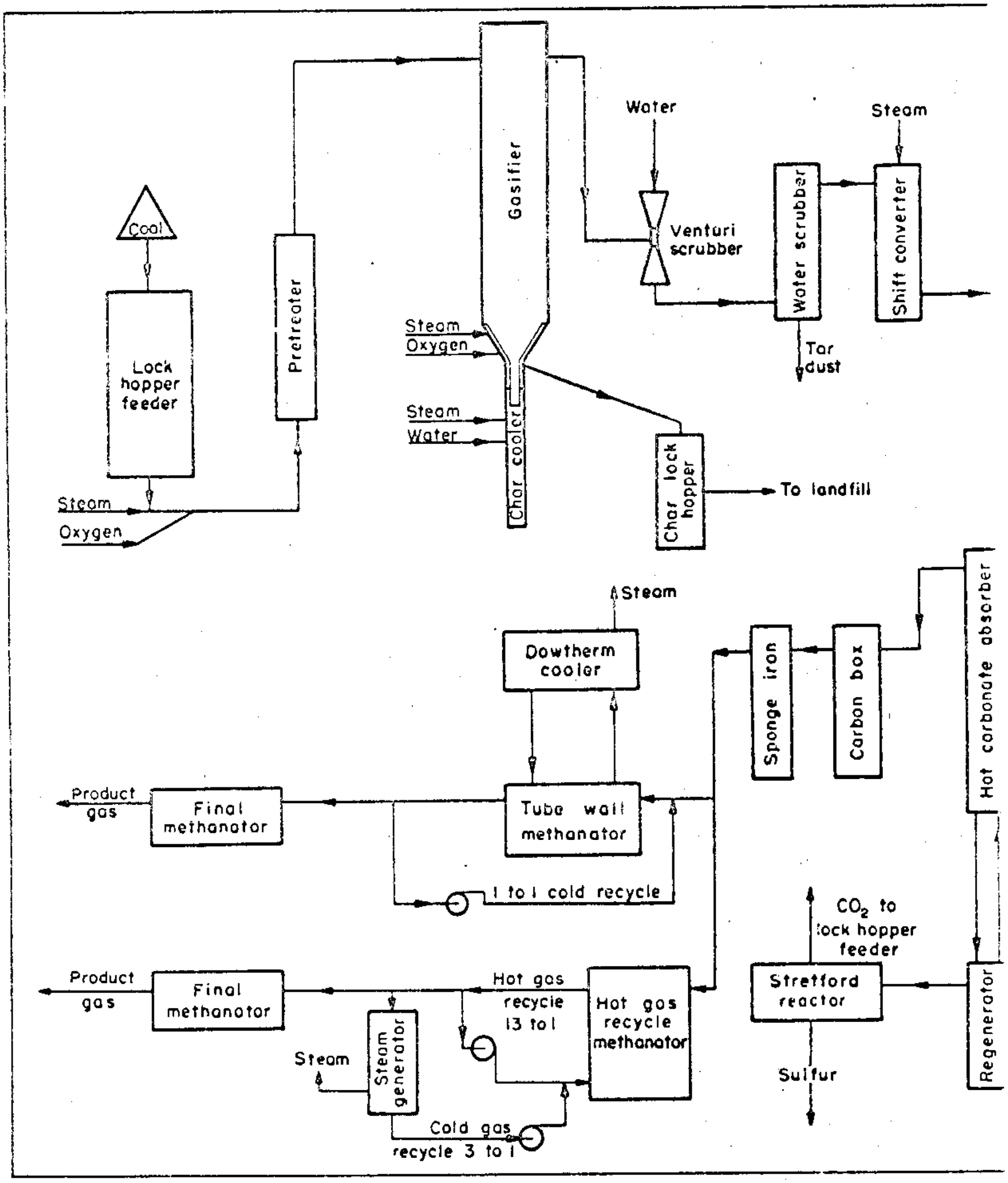
Initial start-up is scheduled for January, 1974. By mid-1975, BCR should have enough data to complete the design of a larger-scale plant.

Union Carbide offers Agglomerated Ash process

Originally developed by the Union Carbide Corp., the Agglomerated Ash process gasifies coal in a bottom-fed,



Flowsheet Illustrates the major steps of Union Carbide's Agglomerated Ash process.



The Lummus Co. designed a 75-tpd pilot plant to demonstrate the USBM's Synthane process. Construction will begin at the B lab in 1973 and completed by 1974. Two methanation systems developed by the Bureau—the tube-wall reactor and the hot-gas r tor—are included in the design.

steam-fluidized-bed gasifier. Coal is injected near the base of the gasifier into a bed of hot, sintered ash agglomerates. As the coal flows up through the bed, it is heated to the carbon-steam reaction temperature and converted to char and gas. The char concentrates at the top of the unit, where some additional gasification takes place. The gas is piped off for purification and methanation. The agglomerates enter the gasifier just below the top of the char bed, at a temperature of about 2,000 F. The gasification reactions cool this material to about 1,000 F by the time it is withdrawn at the bottom. An "agglomerating bed combustor" reheats the agglomerates, using the residual char as fuel. The cha produce an essentially ash-free flue gas as t This gas is cleaned and fed to an open-cyc compressor for energy recovery.

The process is said to have substantial ca savings over single-stage systems requiring a plant, and over systems with char-fed steam g facilities. In addition, caking coals are not p and the relatively "clean" product gas elimina sive water treatment of raw gas scrubber efflue

Columbus Laboratories of Battelle Memo tute is preparing a pre-engineering design for pilot plant, to be built in West Jefferson, Ohio in mid-1973. The present scope of the program, however, excludes the purification and methanation steps, but a complete set-up incorporating these specific steps is a future possibility.

In August, 1972 Chemical Construction Corp. (Chemico) received a license for the Union Carbide gasification technology. Chemico's commercial version of the Ash Agglomerating process would supply low- or medium-Btu gas to a high-efficiency, combined-cycle power plant. Although not under AGA/OCR sponsorship, Chemico's work should substantially aid the development of the process.

The Synthone process is USBM's entry

In the prototype Synthane design, coal is decaked in a steam-oxygen, fluid-bed pretreater. The pretreated coal then undergoes carbonization and steam-oxygen gasification in a fluidized-bed gasifier. The coal feed enters at the top of the gasifier, while ash and unburned char are removed through a bottom hopper. The product gas derived in the process will be subjected to CO-shift conversion, purification and methanation.

The Synthane gasifier operates at a temperature of about 1,800 F. Approximately 65% of the carbon in the coal feed is converted to gas, with more than half of the ultimate methane yield being made directly in the gasifier, a definite process advantage.

The Bruceton, Pa. laboratories of the USBM developed this process, and also conducted the first bench-scale tests. Now the Lummus Co., under a Bureau contract, is designing a 1,000-psi, 75-tpd pilot plant for installation at Bruceton, with construction to be completed in 1974. The plant will demonstrate the main steps of the process but is not designed to solve the problems of water treatment and char combustion. The final process step—methanation—will contain both of the Bureau's methanation systems, the tube-wall reactor and the hot-gas recycle reactor.

Lurgi is the only commercial process available

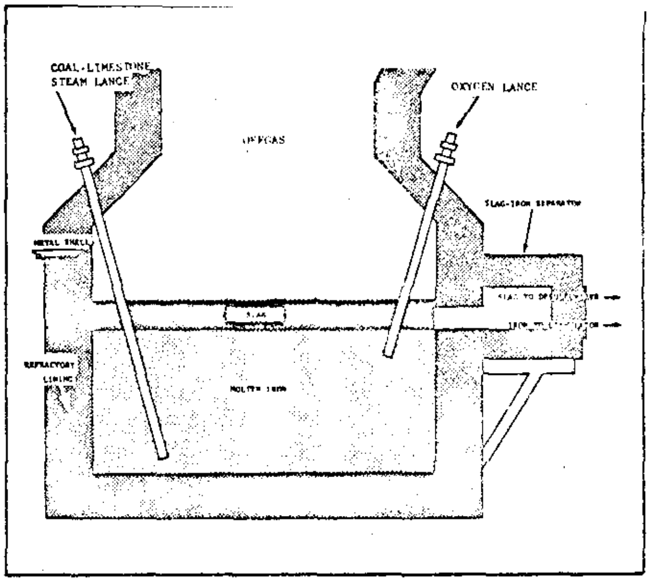
The Lurgi process uses an oxygen-fed, low-pressure (28 atm), fixed-bed gasifier. The product gas is cleaned in a scrubber, then purified and methanated. A commercial Lurgi facility also calls for a Phenosolvan plant for gas liquor treatment, and supporting plants for supplying oxygen, steam, electric power and water.

American experience with Lurgi technology is in its infancy. Conoco Methanation Co., a wholly owned subsidiary of Continental Oil, is building a full-scale commercial test facility in cooperation with the British Gas Council and the Scottish Gas Board. Operation is scheduled to begin in 1973, and will last one year.

The only U.S. commercial venture, the El Paso project, at Four Corners, N.M., will further American knowledge of the process. The M. W. Kellogg Co. also is making an economic feasibility study of the Lurgi process for Panhandle Eastern Pipeline Co. and Peabody Coal Co.

ATGAS—a novel approach using an old idea

Applied Technology Corp. (ATC) is developing the ATGAS process for coal gasification. ATGAS is based on the molten iron gasification concept in which coal is injected with steam into a molten iron bath. Steam dissociation and thermal cracking of coal volatile matter generates hydrogen, carbon monoxide and methane. The coal sulfur is captured by the iron and transferred to a lime slag from which elemental sulfur is recovered as a byproduct. The fixed carbon of the coal is dissolved in the iron from which it is removed by oxidation to carbon monoxide, with oxygen injected near the molten iron surface. The product gas is treated by conventional shift conversion and methanation.



This conceptual design of the ATGAS process is not as futuristic as it looks, since much of the required technology already exists in the iron and steel industry.

Much of the technology pertinent to the process already exists as discreet commercial steps in the iron and steel industry. However, the combination of these steps into simultaneous ones remains to be demonstrated on a large scale.

In the past, the primary research objective was an ATGAS unit capable of producing low-Btu gas for use in power-plant boilers. In pursuit of this objective, the Environmental Protection Agency (EPA) supported an experimental development program over the last 3 yr. This program is continuing under EPA sponsorship.

In the EPA program, an induction melting furnace was selected to simulate a commercial gasifier because it is a convenient means of preparing molten iron. The furnace (27 in. I.D.) can melt and hold 6,000 lb of metal. Maximum practical injection depths for coal, limestone and steam are about 30 in. below the surface of the molten iron. All of the work completed to date used air as the gasifying agent. However, the data are applicable with proper conversion factors to coal gasification using pure oxygen.

A process engineering study is now being devoted to the oxygen-steam approach for ATGAS. The product gas will be upgraded in subsequent steps to pipeline quality. Because the evaluation of the technical and economic feasibility of this process has shown it to be attractive, a proposal was submitted to AGA/OCR for funding. Work on this effort is continuing, and a decision to build a pilot plant is undecided. ■

UNDERGROUND GASIFICATION BURNING ALONG, PRODUCING GAS.

The radical concept of producing clean-burning fuel gas by fracturing coal underground and igniting it is coming along successfully, the Bureau of Mines revealed. A site near Hanna, Wyo., was prepared for the experiments by drilling boreholes 400 ft. down from the surface into a 30 ft. thick deposit of low sulfur coal owned by Rocky Mountain Energy Co. The firm is a subsidiary of Union Pacific Corp., which is cooperating with the Bureau in the research effort. To provide heat for the gasification process, the coal was ignited in March, 1973. Combustion and gasification have been controlled since then by regulating the flow of air pumped down the boreholes. Produced gas is being withdrawn through other boreholes at a rate of about 0.75 million cu.ft/day. Main fuel constituent of the gas is carbon monoxide, therefore its energy content is relatively low compared with natural and bottled gases used in household gas appliances. However, it is good fuel for such industrial purposes as generating electric power.

.... Coal Age
September, 1973.

SCOTLAND PLANT HOPES TO FIND MISSING LINK IN COAL-TO-GAS PROCESS

One of the problems resulting from the conversion of coal to natural gas, that of upgrading the Btu, or heat content, may be solved with the startup of a pilot plant in Scotland, funded by American money and managed by a Continental Oil subsidiary. All coal gas requires a methanation step to increase its Btu value to pipeline quality gas (from about 350 Btu per cu. ft. to 950 Btu per cu. ft.). The well publicized German Lurgi process which is being proposed in this country has yet to be used to make a pipeline quality gas. In fact, the only big Lurgi plant operating today is in South Africa, and this produces a low Btu gas. The methanation concept to be tried out in Scotland is under wraps - Lurgi engineers are very secretive about details - and it's interesting to see if the project will provide the only missing link in the commercial chain of processes necessary to convert huge coal reserves to gas.

.... Coal Age
November , 1973.

EDMONTON JOURNAL, Thursday, Nov. 9, 1972

Gasification of coal research needed—Berkowitz

Canada should seriously consider undertaking research into the underground gasification of coal, says Dr. Norbert Berkowitz, head of fuel sciences at the Research Council of Alberta.

The conventional coal gasification process is to treat coal at high temperatures with steam and oxygen to produce the synthetic gas. For the process the coal must be mined and pulverized before entering the processing plant.

In situ gasification would work somewhat like the process currently being examined to take oil from Alberta's deeply buried oil sands.

Steam and oxygen would be forced into the deep coal formation through drill holes while the coal seam is fired to create the high temperatures necessary for converting the coal into gas.

"This concept was researched to a great extent in Russia and in the United States from 1945 to 1952 when it was abandoned."

This research program used air instead of oxygen and the resulting gas, which included a high nitrogen content from the air, proved to have only a low heat content.

"My view is today we are fully justified in re-examining this process because we now have large volumes of industrial oxygen available at acceptable prices for injection and have a great deal more knowledge about formation fracturing thanks to the oil and gas industry," Dr. Berkowitz said.

"The concept is worth researching because it should produce synthetic natural gas at prices below that in surface plants and would make energy extraction possible from thin, deeply buried coal seams where mining is not economic.

"This research would be costly and would have to be done on a large scale," he said and suggested it might be undertaken as a joint venture through the federal government and the three coal rich Western provinces.

Dr. Berkowitz said this kind of research might also assist in extraction of a gas from deeply buried oil sands which might not otherwise be extracted by current mining or oil sands in situ techniques.

"A gas from the oil sands might be used to supplement natural gas or as a feedstock for the petrochemical industry."

ppendix

ppendix D-5

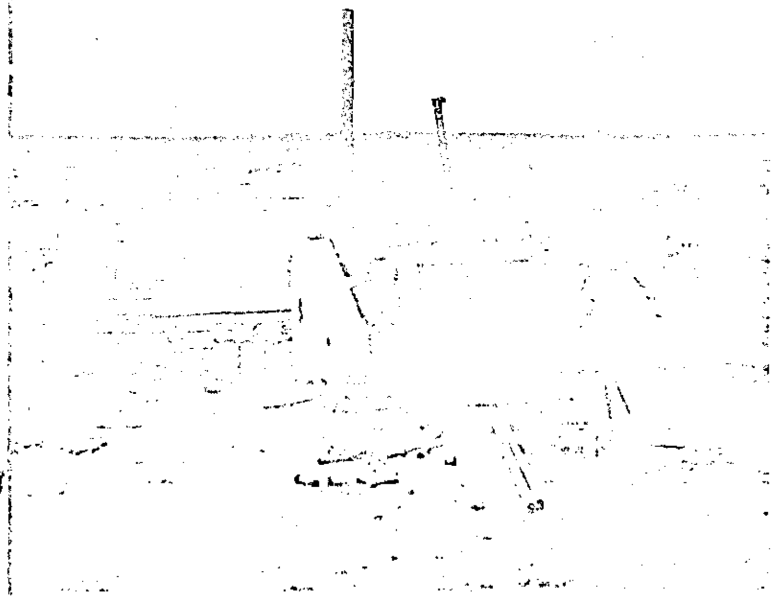
Preliminary results released for Wyoming in situ gasification test

Leo A. Schrider, US Bureau of Mines, Laramie Energy Research Center
J. Pasini III, US Bureau of Mines, Morgantown Energy Research Center

RESEARCHERS HAVE LONG BEEN TANTALIZED by the problem of gasifying coal underground. As experiments over the past 100 years have shown, in situ gasification is technically feasible but not economically competitive with other fuel sources. But this might change now. According to the Bureau of Mines, present-day economics and technology might turn underground gasification into a commercially feasible energy source, a source that would supplement conventional methods of coal extraction.

In situ gasification has its attractions: Plentiful supplies of nonpolluting fuel gas are generated, without the environmental disturbances of surface mining and without exposing workers to the hazards of underground coal mining. From an environmental standpoint, it is likely that H_2S rather than SO_2 will be the predominate form of sulfur produced. These small amounts of H_2S can be removed by hot carbonate scrubbing, whereas no effective commercial-scale treatment for SO_2 currently exists.

The technology for underground gasification is based on worldwide activity, particularly in Great Britain, the Soviet Union, and the United States. Poland, Italy, Belgium, Czechoslovakia, and Morocco have also been in volved with this process. No appreciable technological breakthroughs have been reported since 1965, when the Soviets apparently ceased production of in situ gas.



Southwest view of Hanna test site shows compressor used for air injection, Well 3 (right), and Wells 7, 5, and 8 (left).

In the fall of 1972, the Bureau of Mines began an experiment to investigate the technologic, economic, and environmental feasibility of underground gasification of a western subbituminous coal. The gasification site is near the town of Hanna, Wyo., approximately 70 miles northwest of Laramie. Land for the pilot test was provided by the Rocky Mountain Energy Co., a subsidiary of the Union Pacific Railroad. Hanna No. 1 seam, near the base of the Hanna Formation, was the coal bed selected for gasification.

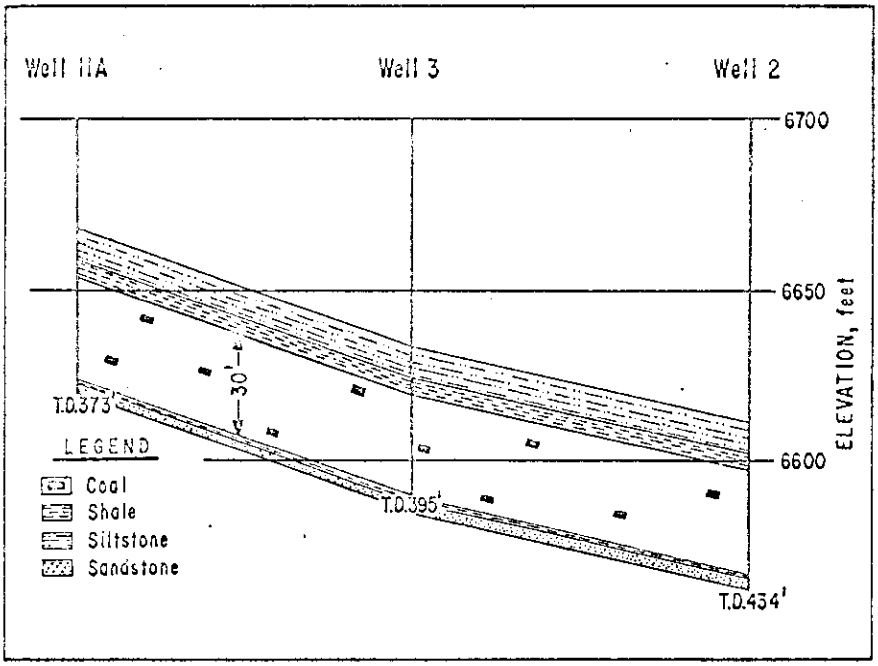
The Hanna Basin covers about 1,000 square miles and is bounded on the south by the Medicine Bow Mountains, on the west by the Rawlins Hills, and on the north by the Shirley-Ferris Mountain complex. To the east, the basin coalesces with the northern end of the Laramie Basin. Hanna Basin contains an accumulation of 35,000 ft of sediments of which up to 28,000 ft may have intermittent coal-bearing strata. Because of considerable tectonic activity, numerous structural anomalies exist within the Basin. The area of the experiment lies about ⅛-mile northwest of the axis of one of the small synclines created by the tectonic movement.

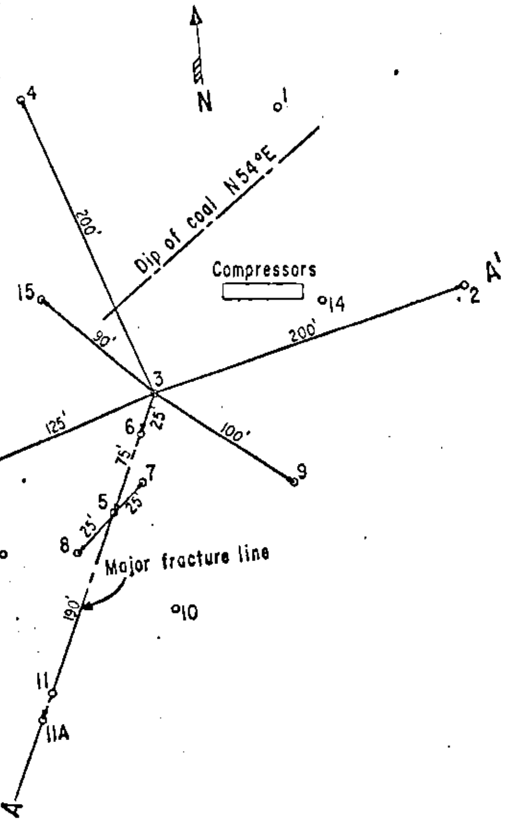
As part of the delineation studies performed prior to gasification, the Bureau cored part of the first well drilled at the test site. Of the 114 ft cored, the upper 65 ft are interbedded gray siltstone and shale, with 15 ft of shale above the coal. The 30-ft-thick Hanna No. 1 coal bed was found about 400 ft below the surface, with 4 ft of shale and sandstone immediately below. In November 1972, the Hanna No. 2 Well was drilled and a 3-in. oriented core was taken from 11 ft above the coal to a point 8 ft below. In the spring of 1973, an additional oriented core was taken 1,000 ft northeast of Well No. 2. To date, 16 wells have been drilled over an area of about 4 acres.

The oriented cores were studied for directional properties to determine the dominant direction of gas flow. Knowledge of preferred flow directions is important to gas capture. Since the directional flow properties of the coal are governed by a number of interacting physical properties, several types of measurements were made on the oriented core. These measurements determined the orientation of coal cleats, directional permeability, directional tensile strength, point-load induced failure, and directional sonic velocity of the coal. The directional permeability and joint trends taken from the two core holes indicated a preferred northeast-southwest flow direction.

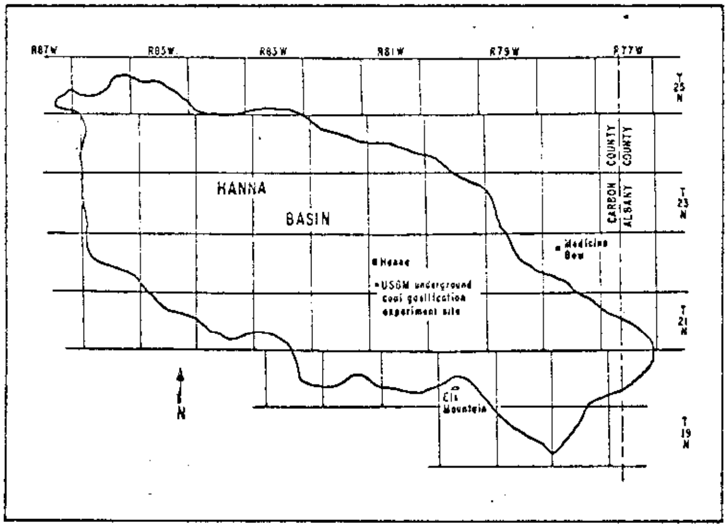
To establish subsurface communication of gases and

Presented at A.G.A./OCR Fifth Synthetic Pipeline Gas Symposium, Chicago, Ill., October 30, 1973.





The Hanna experiment lies on the flank of a comparatively narrow syncline plunging to the northeast. Strike of the coal bed is NW-SE; dip is generally N 54 E at 6 to 7°. Cross-section (left) corresponds to AA' (below).



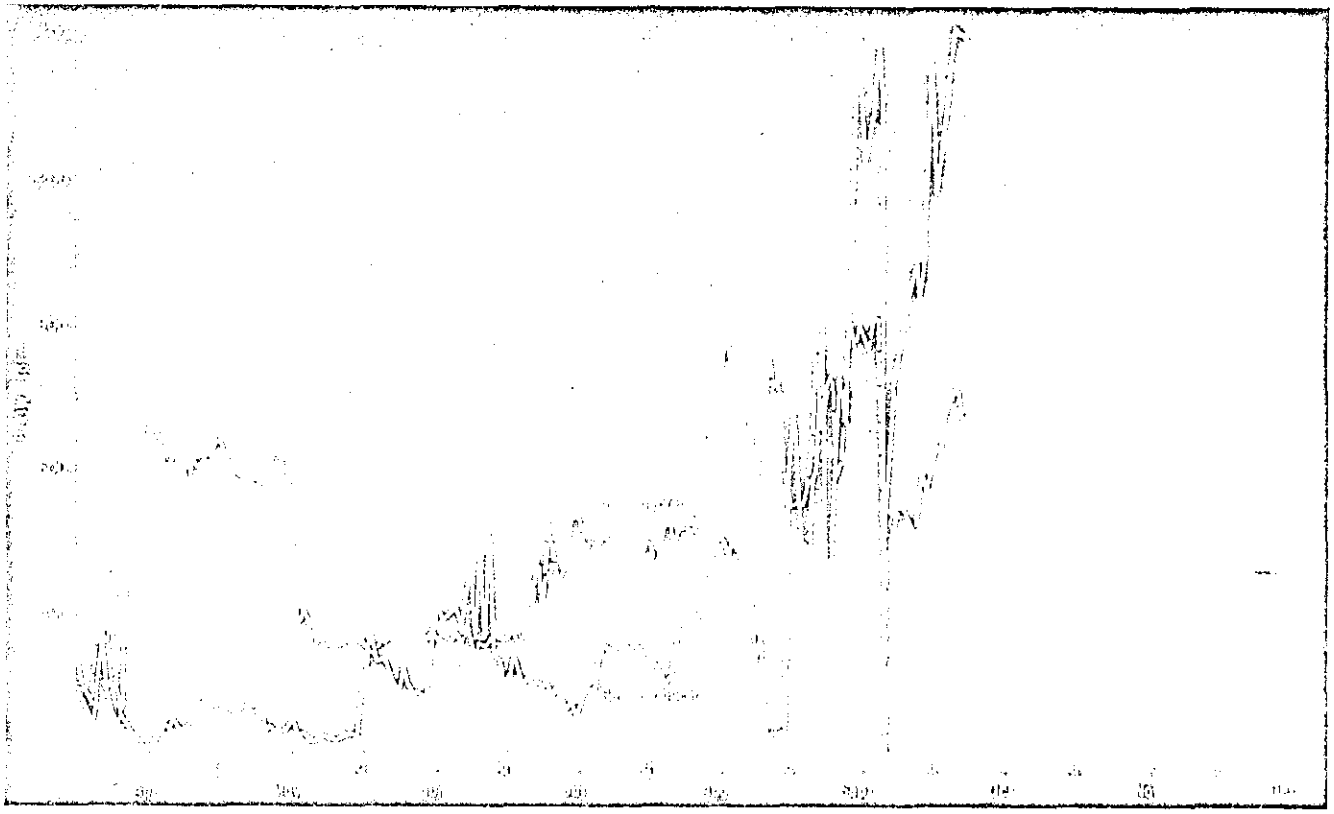
Hanna No. 1 seam is part of massive Hanna Basin.

fluids, hydraulic fracturing of the coal bed using the "sand-frac" process was initiated to increase permeability. Using Well 3, the coal was stimulated at the rate of 1,300 gpm with 32,000 gal of gelled water containing 16,000 lb of sand. The formation accepted the material with no apparent breakdown. After fracturing, an impression packer run found four vertical fractures in the wellbore. The major fracture was 1.3 in. wide, leaving the borehole at S 25° E. Air injection tests showed that the air acceptance of the coal was increased fivefold. Major flow was to the southwest, supporting the oriented core studies indicating preferred flow in that direction.

Ignition of the wells

The coal in Well 3 was ignited with a propane burner in late March. A forward burning technique in the direction of the major fracture trend was used in an attempt to originate gas production in Wells 5 through 8. (In forward burning, the "flame front"—the hottest area, where gasification reactions occur rapidly—advances in the same direction as the gas flow.) Air injection into Well 3 was continued for about 2 months, and product gas was collected from surrounding wells. Within a few weeks after initiation of air injection, it became apparent that about 90% of the air was not being recovered from any of the producing wells. This air was bypassing the coal and reappearing through wells which were drilled but not completed with casing and cement. The borehole casing in Well 3 also probably burned off, permitting direct communication of air to the silty sandstone above the coal.

Unusually severe winter weather conditions prevented cementing trucks and equipment from entering the site to remedy the situation. After several weeks the well locations became accessible and, upon sealing all wells, air bypassing was considerably reduced. At this point, May 30, it was decided to switch injection to Well 5. This drew the combustion zone from Well 3 to Well 5, creating a backward burning effect, in which the flame front advanced in a direction opposite to the di-



Relationship between air injected and gas produced from Hanna test. Gas yield is now about double the rate of air injection.

rection of flow. Gas volume and heating value rose.

Currently, gas production is about twice the air injection rate. During the last week in September and the first two weeks of October, for example, air injection varied between 1 and 1.2 million cfpd, while gas production was maintained from 1.7 to 2.4 million cfpd. With the exception of gas produced initially as free gas or from volatilization, the composite heating value of the gas prior to June 1 was relatively low due to air bypassing. After all wells were sealed, the heating value rose significantly. Gas chromatographic analysis indicated that during June and July most of the heating value of the produced gas was derived from methane.

Results to date are encouraging

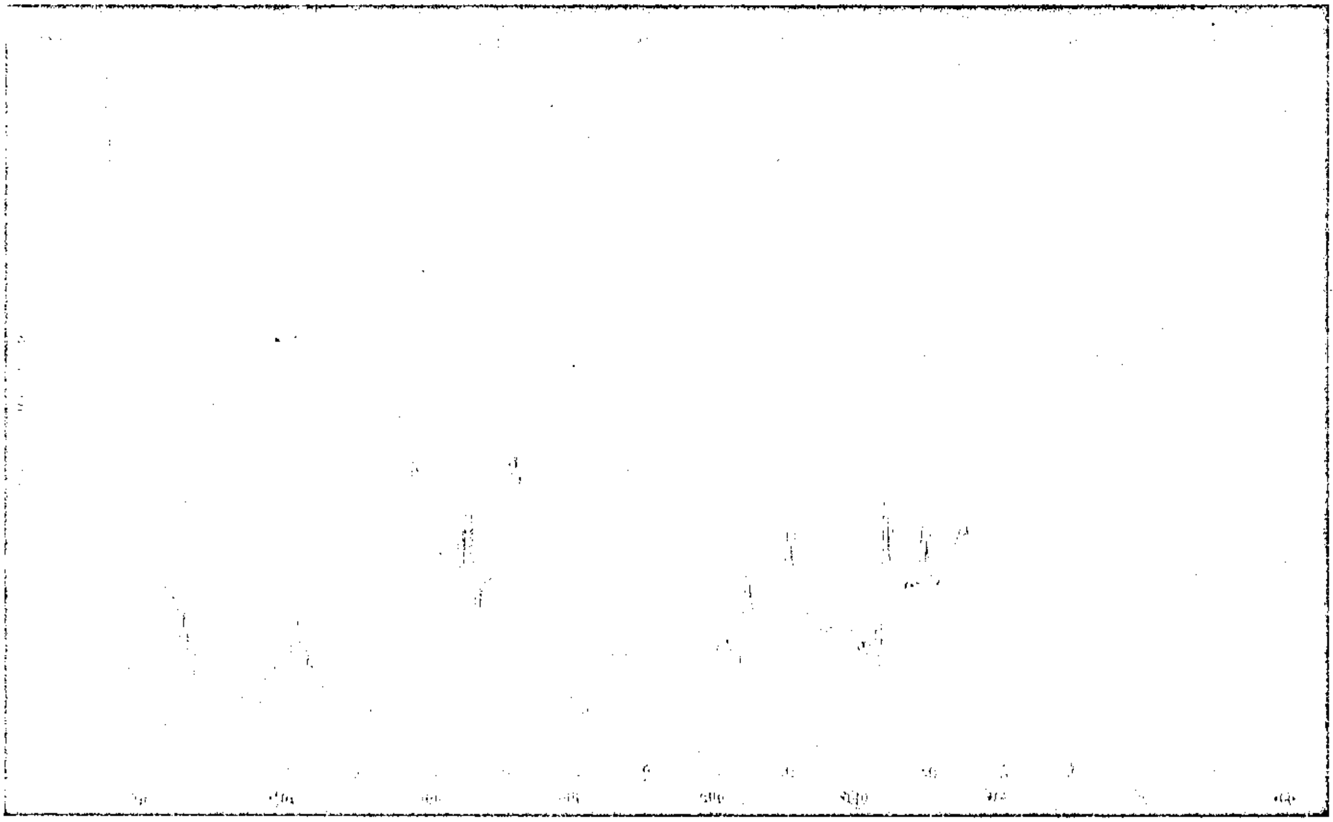
While flow rates exceeding 2 million cfpd of 100 to 200 Btu gas were achieved, it is still too early to completely assess the test results. This is because gas volumes and heating values have fluctuated over a wide range, from 75,000 to over 2 million cfpd, and from 30 to 475 Btu per cu ft.

It has also been shown that switching a well from injection to production can increase flow rates. A good example of this was illustrated recently when Wells 9 and 15 were converted to air intake in the latter part of September. Located along the periphery of the gasification site, these two wells initiated a backward burn which drew the combustion zone outward from the center wells. Heating values and gas volumes have improved considerably since that time. This reversal of gas production and flow conditions needs further investigation to predetermine the life cycle of the wells. Development of suitable mathematical models should allow description of the reaction phenomena occurring, as well as providing a forecast of the well life cycle. The simulation model then may be able to predict when a well should be placed on production and when it should be shut-in. This type of in situ process monitoring and control should result in steady-state gas production, which will be necessary if commercialization is ever to be achieved.

Future experiments

Future flow rates should exceed 5 million cfpd, a flow rate more representative of that required to support a small power station. Future experiments will also include oxygen injection to determine if the combustion reaction can be accelerated or if the gas Btu content can be increased or stabilized. Other Bureau researchers have shown that oxygen-enriched air will increase product gas heating value, but sustained production of a high-quality gas was not maintained. Experiments with oxygen may also promote gasification of char, as has been shown in previous tests. This could increase efficiency by recovering more of the energy associated with the in-place coal.

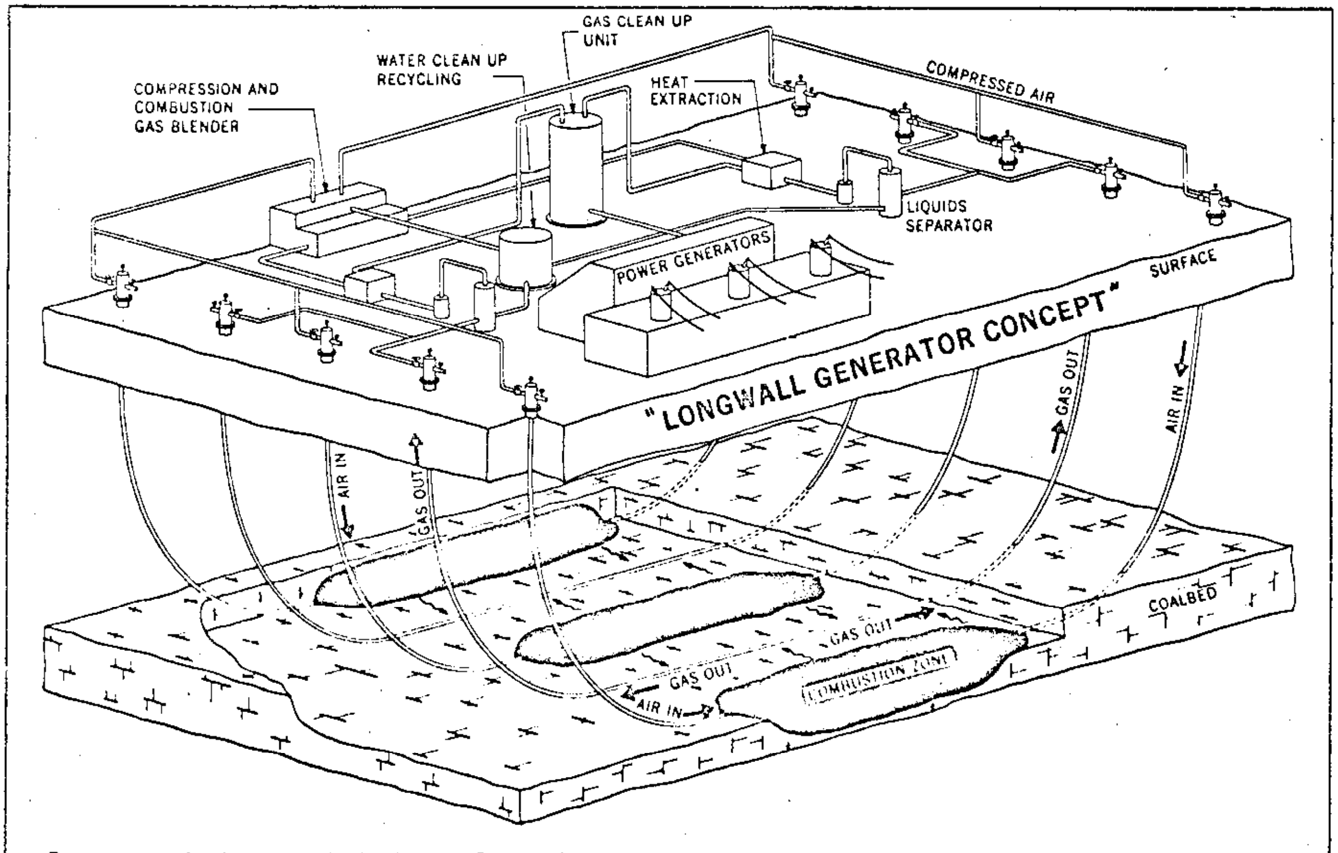
To stimulate better gas flow, directional horizontal holes will be drilled through the coal bed. These horizontal holes increase coal utilization in direct proportion to their length. The coal will be burned between parallel horizontal holes drilled in the butt cleat direction. This preferred direction would enable the injected air and product gasses to move along the face cleats for maximum permeability, perhaps eliminating the need to fracture the coal prior to injection. By using this technique, pressured cells could be directionally drilled and spaced in predetermined directions to the face and butt cleats to help control combustion zone movement. This



Wide fluctuations were recorded in the heating value analysis. Peak following May 30 occurred after the switch to "backward burning."

form of directional drilling is termed a "longwall generator."

Both the use of oxygen and directional drilling is programmed for initiation before the end of Fiscal Year 1974. Results of these experiments will help determine whether underground gasification offers better economic and environmental advantages than conventional technology for obtaining energy from coal. ■



Power generation is one use for in situ gas. Combustion zones are created by drilling holes in the direction of optimal gas flow.

Appendix E - Strip Logs

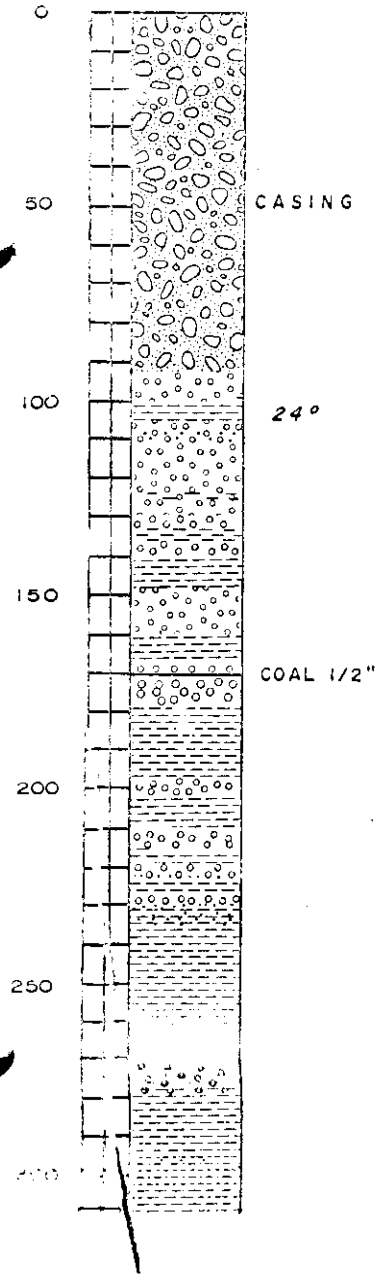
E-1	D. D. H. 71-1	Sheets 1, 2
E-2	D. D. H. 71-2	Sheets 1, 2
E-3	D. D. H. 71-3	Sheets 1, 2, 3
E-4	D. D. H. 71-4	Sheets 1, 2
E-5	D. D. H. 71-5	Sheet 1

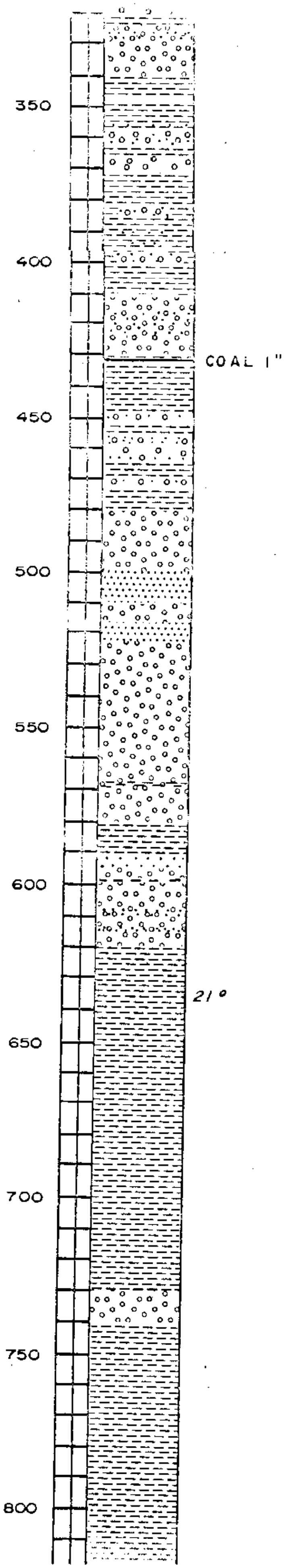
Appendix E-1
Sheet 1

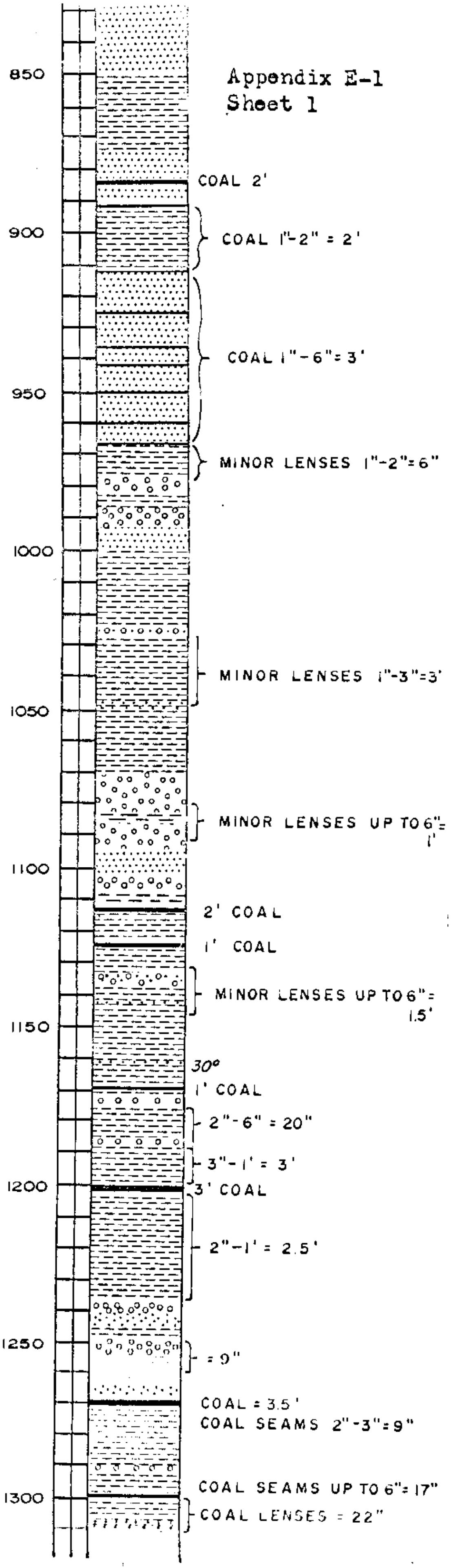
COAL LOG

PROPERTY .... BOWRON RIVER
HOLE NO. .... DDH 71-1
CO-ORDINATES ..... 11683 N
..... 15489 E
ELEVATION 2404.0
DIP .... 90°
BEARING ....
TOTAL LENGTH .... 1546'
DRILL TYPE ....
REMARKS ....

DESCRIPTION







BETHLEHEM COPPER CORPORATION LTD

COAL LOG

PROPERTY ………… BOWRON RIVER

HOLE NO. ………… DDH 71-1

CO-ORDINATES …… 11685 N

…… 15489 E

ELEVATION ………… 2404.0

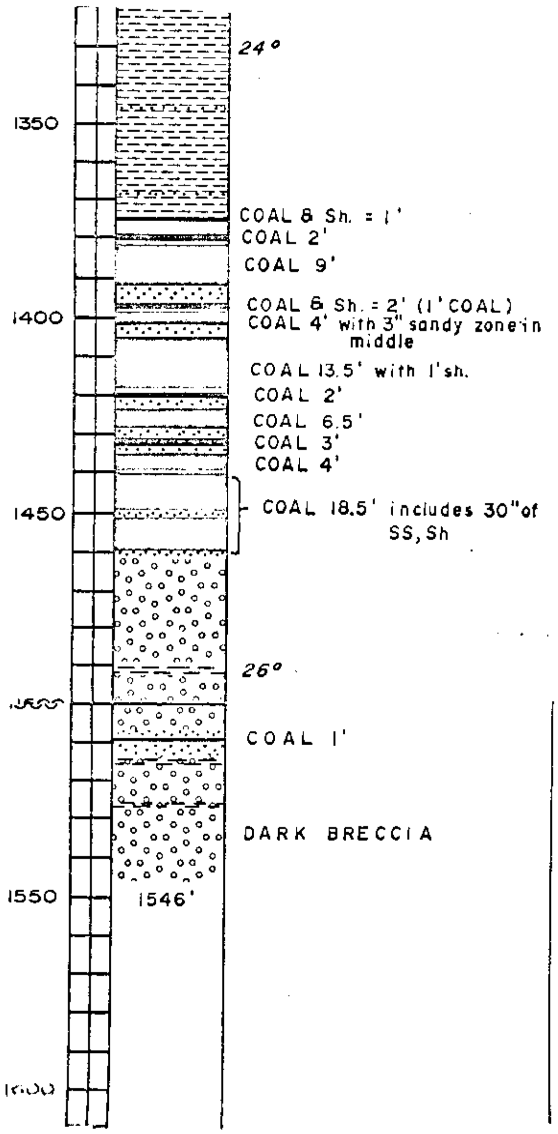
DIP ………………………… 90°

BEARING …………

TOTAL LENGTH …… 1546'

DRILL TYPE ………

REMARKS …………



Appendix E-1
Sheet 2

THLEHEM COPPER CORPORATION L

COAL LOG

PROPERTY ………… BOWRON RIVER

HOLE NO. ………… DDH-71-2

CO-ORDINATES … 10455 N

…… 16390 E

ELEVATION ……… 2401.0'

DIP ……………… 90°

BEARING …………

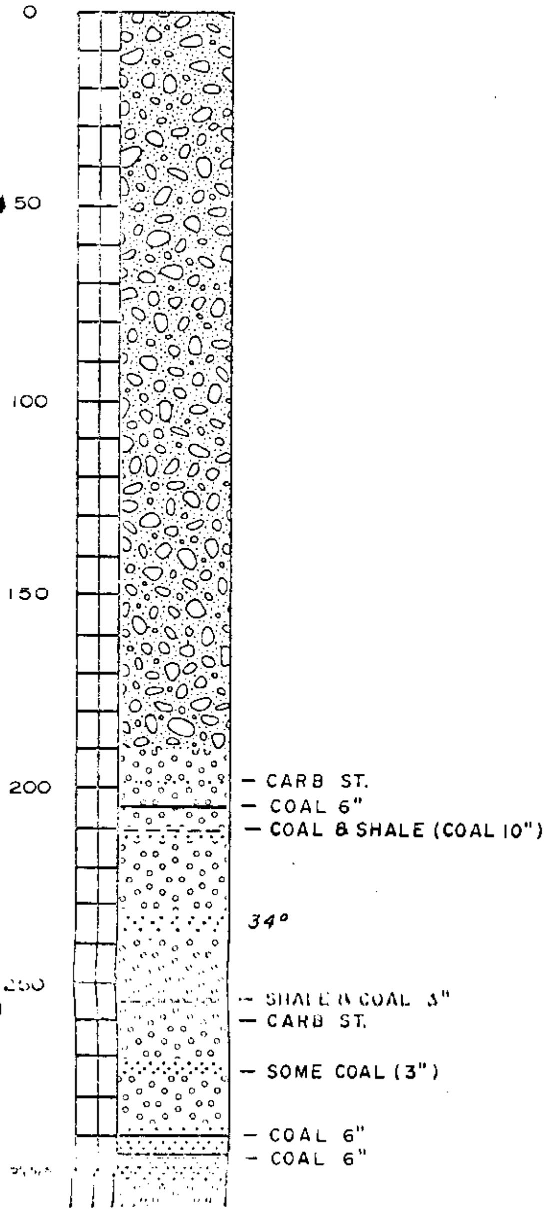
TOTAL LENGTH … 1317'

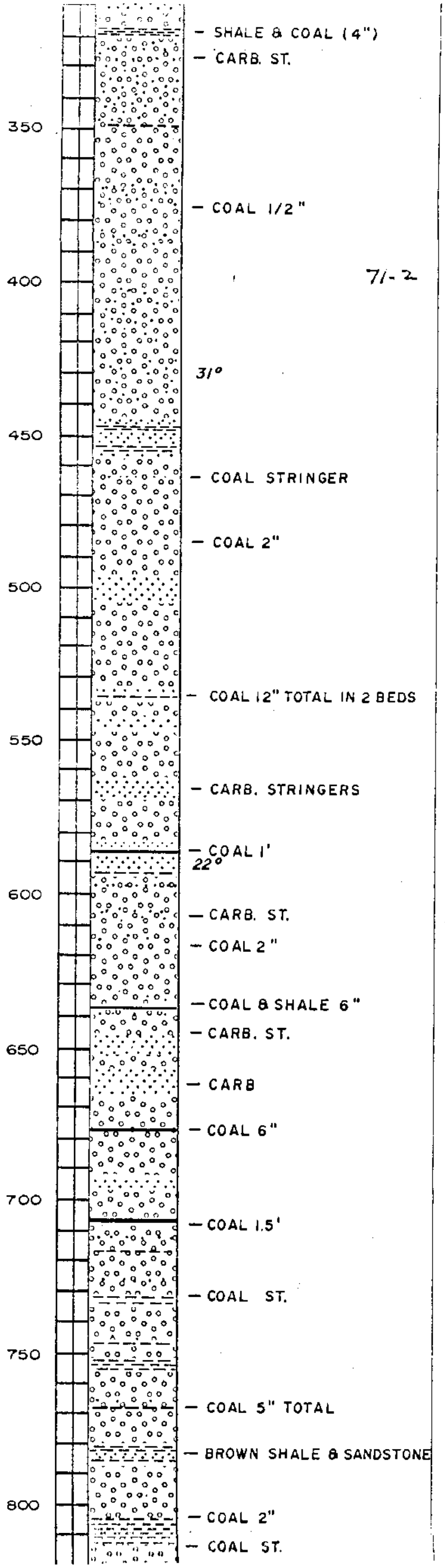
DRILL TYPE ………

REMARKS …………

Appendix E-2
Sheet 1

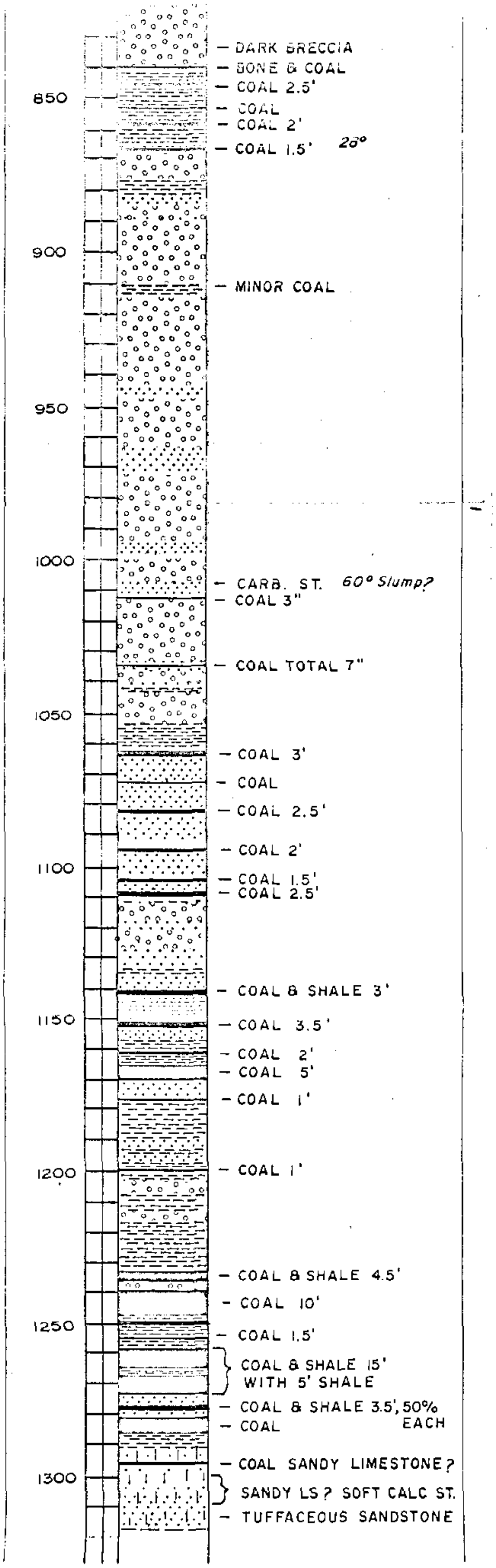
DESCRIPTION





71-2

D.D.H. 71-2



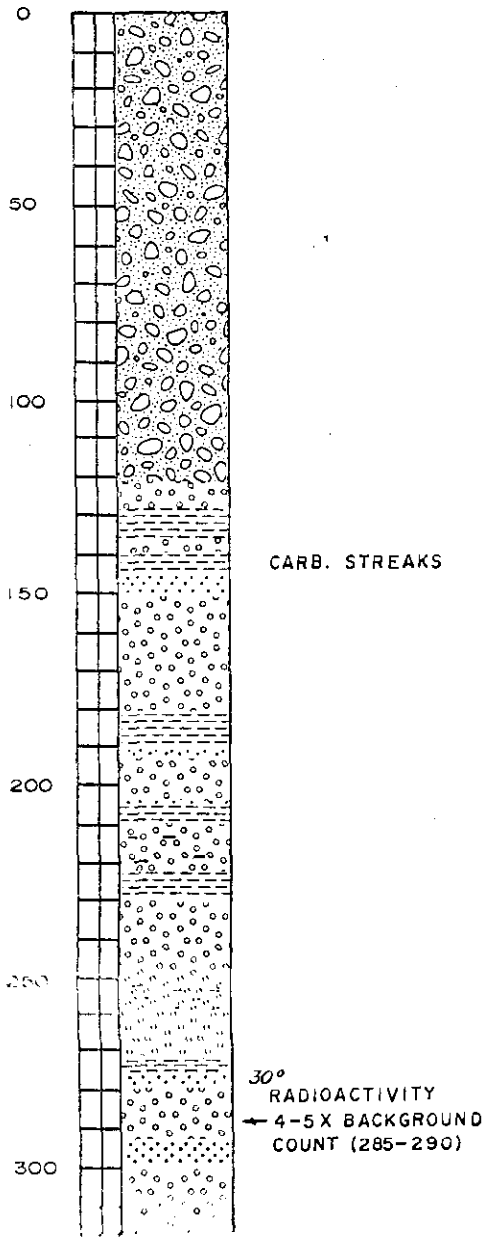
Appendix E-2
Sheet 2

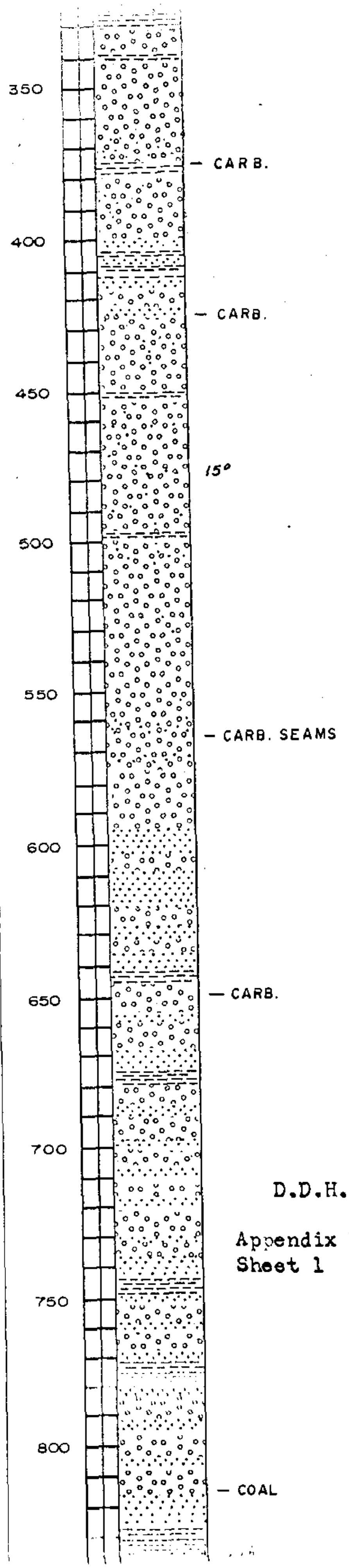
BETHLEHEM COPPER CORPORATION L

COAL LOG

PROPERTY	BOWRON RIVER	
HOLE NO.	DDH-71-3	
CO-ORDINATES	9361	N
	14177	E
ELEVATION	2379.6	
DIP	90°	
BEARING		
TOTAL LENGTH	2412'	
DRILL TYPE		
REMARKS		

DESCRIPTION





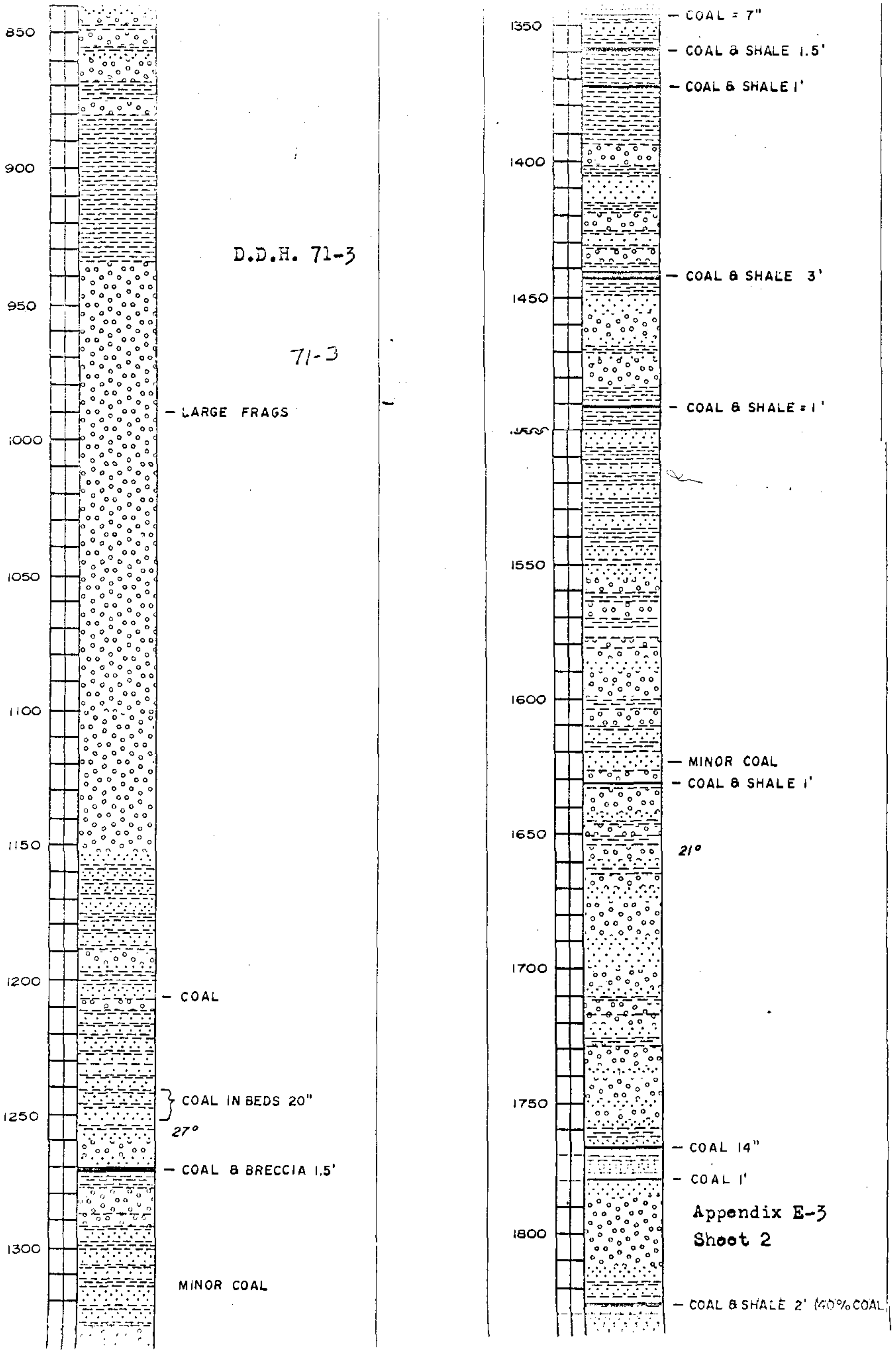
71-3

D.D.H. 71-3

Appendix E-3
Sheet 1

D.D.H. 71-3

71-3



Appendix E-3
Sheet 2

BETHLEHEM COPPER CORPORATION LTD

COAL LOG

PROPERTY .... BOWRON RIVER

HOLE NO. DDH-71-3

CO-ORDINATES	9361	N
......	14177	E

ELEVATION 2379.6

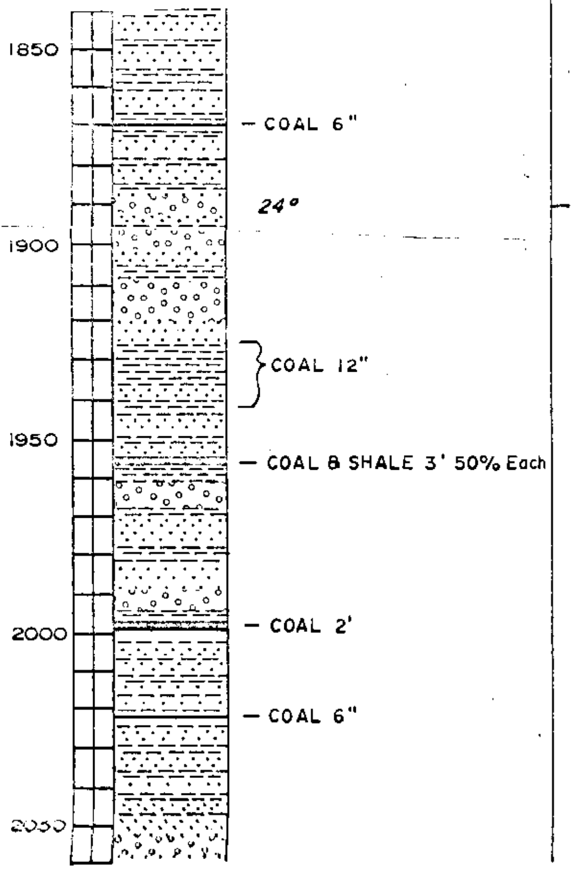
DIP .... 90°

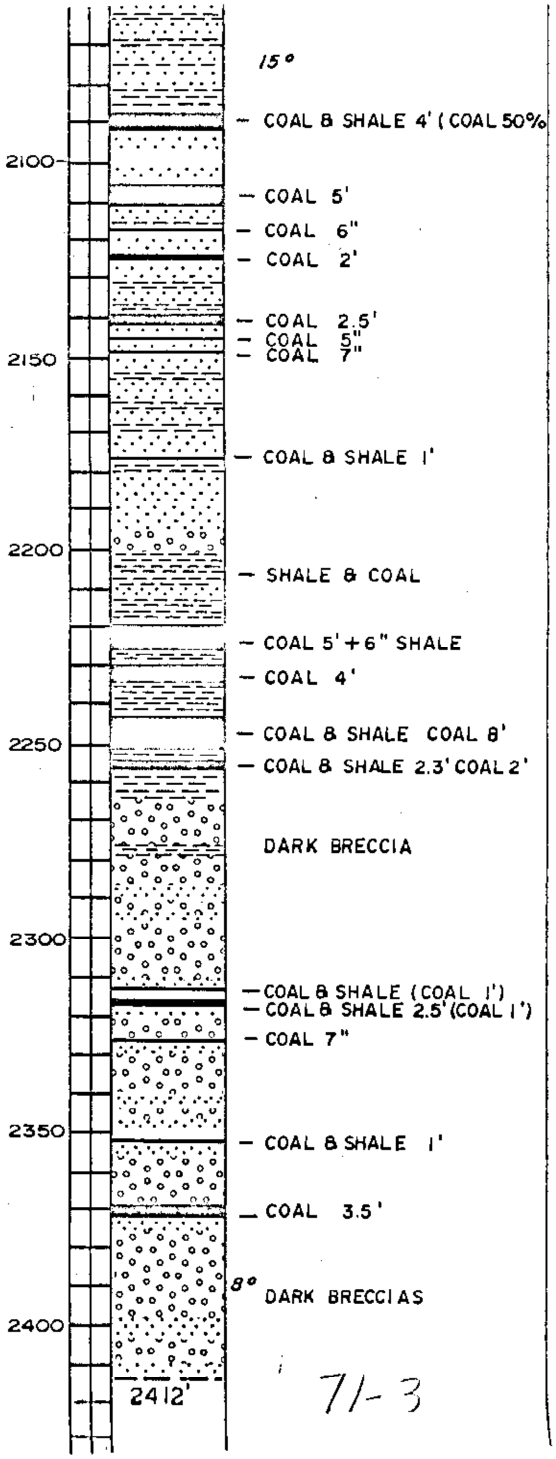
BEARING ....

TOTAL LENGTH .... 2412'

DRILL TYPE ....

REMARKS ....





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Appendix E-3

Sheet 3

COAL LOG

PROPERTY .... BOWRON RIVER

HOLE NO. DDH-71-4

CO-ORDINATES .... 4470 Est. N
.... 16760 E

ELEVATION .... 2420 Est.

DIP .... 90°

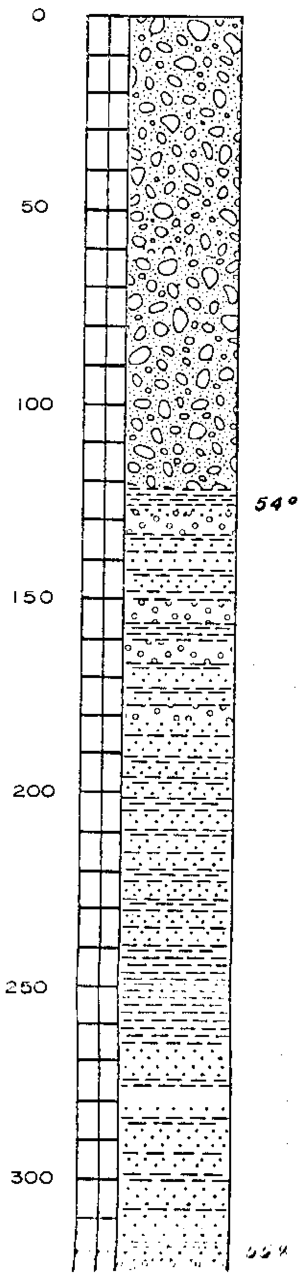
BEARING ....

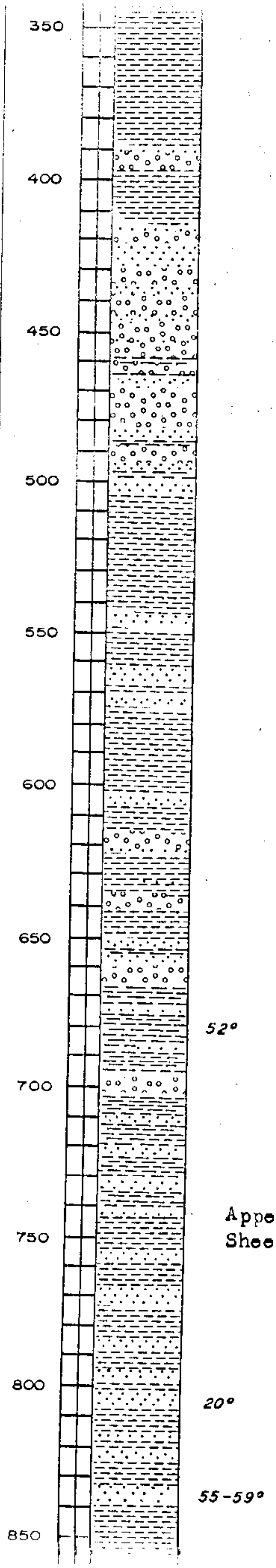
TOTAL LENGTH ....

DRILL TYPE ....

REMARKS ....

DESCRIPTION



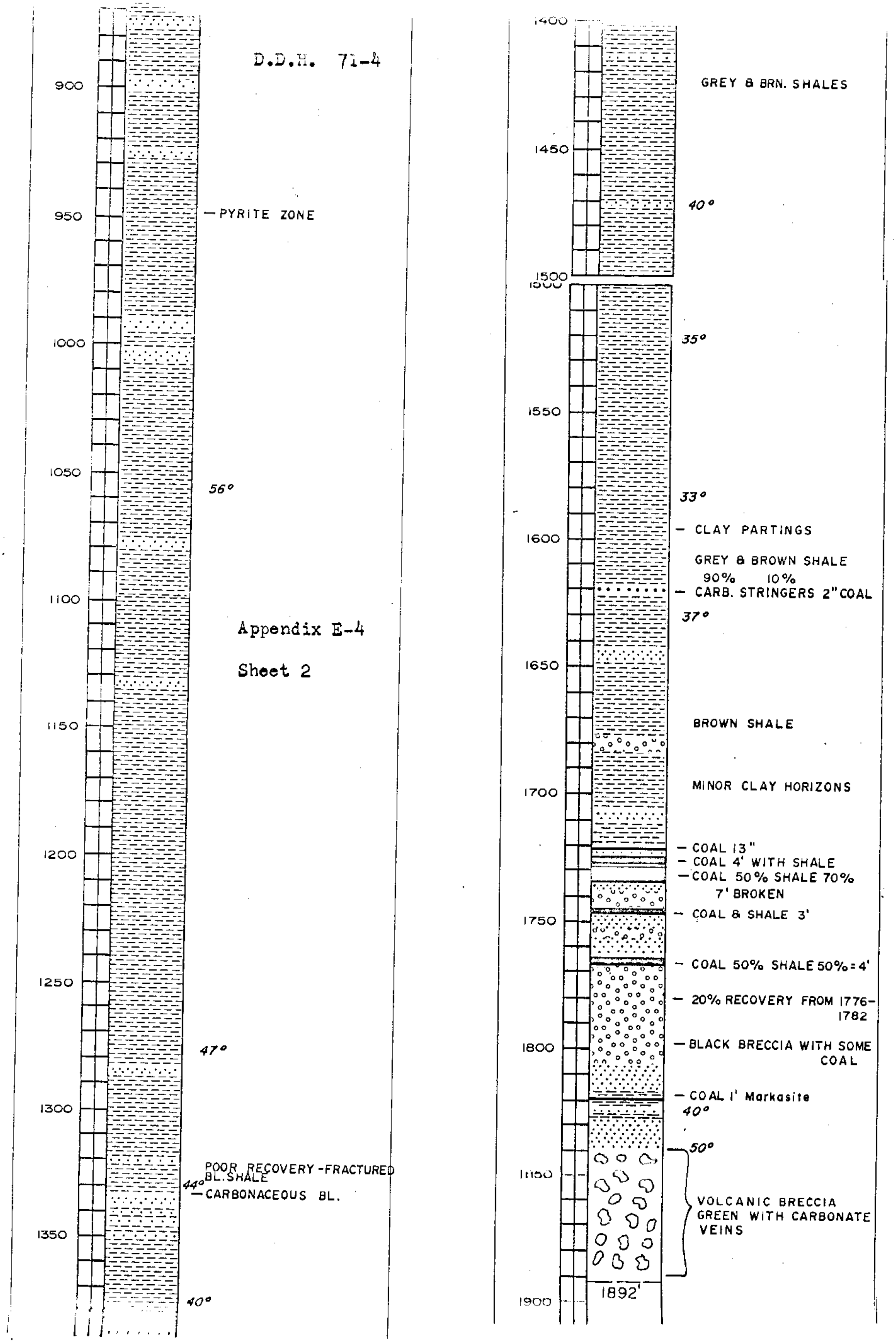


Appendix E-4
Sheet 1

D.D.H. 71-4

Appendix E-4

Sheet 2



PROPERTY ………… BOWRON RIVER

HOLE NO. ………… DDH-71-5

CO-ORDINATES … 12931 N

…… 14693 E

ELEVATION ………… 2399.6

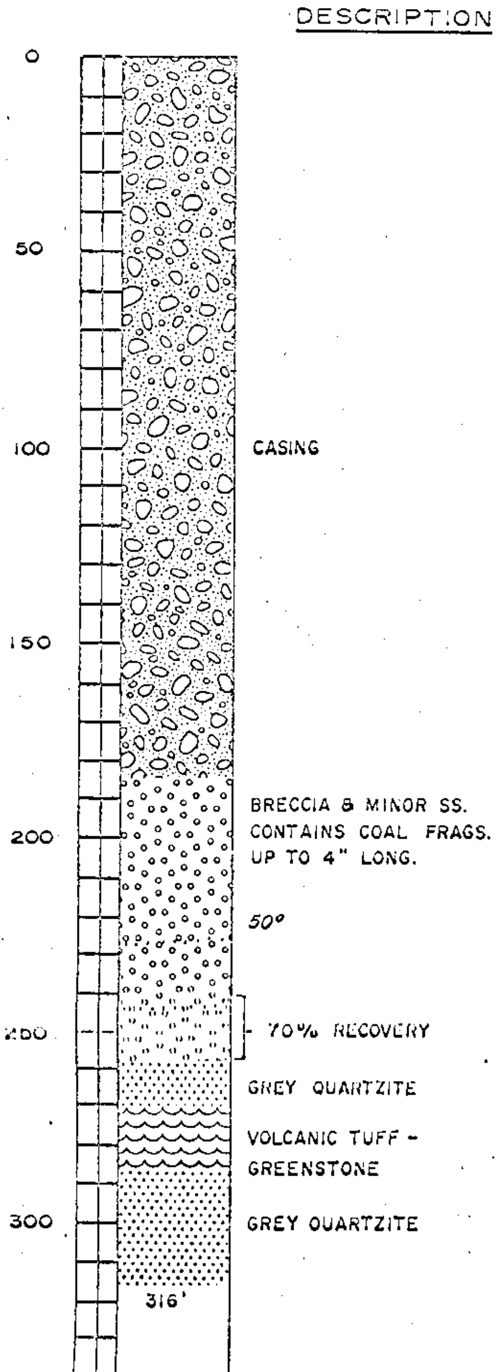
DIP ………………………… 90°

BEARING …………

TOTAL LENGTH … 316'

DRILL TYPE ………

REMARKS ……………



Appendix E-5