EVALUATION OF COAL SAMPLES
FROM
KAISER RESOURCES LIMITED

MARTEN CREEK AREA, LODGEPOLE AREA, FLATHEAD AREA, AND MARTEN RIDGE AREA

CANADA DEPARTMENT OF ENERGY, MINES AND RESOURCES

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METALS REDUCTION AND ENERGY CENTRE
DIVISIONAL REPORT MREC 73/92

- Project No. 03-3-1/16-24

These EMR Coal Quality Tests Pertain to:
- Marten Creek Area
- Marten Ridge Area
- Lodge Pole Area
- Flathead Ridge Area

AN INVESTIGATION OF THE COKING CHARACTERISTICS OF COAL SAMPLES FROM THE 1972 EXPLORATION PROGRAM OF KAISER RESOURCES LIMITED, SPARWOOD, BRITISH COLUMBIA INVESTIGATION NO. 24

by

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

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INTRODUCTION

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

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

This report deals with the 24th Investigation conducted for Kaiser Resources Limited (KRL), Sparwood, British Columbia, and includes an evaluation of the coking potential of 16 cleaned coal samples submitted from KRL's 1972 exploration program. In addition, 16 small samples of raw coal were submitted for Hardgrove Grindability Testing and for Fusibility of ash determinations. The program was initiated by telephone between D.P. Sharma, Supervisor Quality Control, KRL and J.C. Botham on August 29, 1972, and confirmed by letter dated August 29, 1972 from D.P. Sharma which appears in Appendix 1. Some of the data appearing in this report has been transmitted to KRL during the course of the investigation.

COAL PREPARATION

The samples tested are from adit coal samples taken from Marten Creek, Lodgepole, Flathead Ridge, and Marten Ridge. The large samples were cleaned in zinc chloride solution and a bulk flotation cell at KRL's Michel laboratory. The description of each small raw sample received is summarized in Table 1 and a list of the cleaned coal samples is summarized in Table 2. All of the samples were crushed in a hammer mill crusher to approximately 80 per cent minus 1/8 inch in size and processed as outlined in the flowsheet shown in Figure 1.

Laboratory Number	Identification	Data Received	Approx. Sample Weight (lb)
4921-72	Marten Creek Adit No. 1	19/9/72	50
4922-72	Marten Creek Adit No. 3	27/10/72	50
5117-72	Marten Creek Adit No. 4	22/11"72	50
5118-72	Lodge Pole Adit No. 1	4/12/72	50
5119-72	Lodge Pole Adit No. 2	4/12/72	50
2067-73	Marten Creek Adit No. 6	18/1/73	75
2068-73	Flathead Ridge Adit No. 3	20/12/72	75
2220-73	Marten Ridge Adit No. 5 Upper	25/1/73	75
2345-73	Marten Ridge Adit No. 5 Lower	19/2/73	75
2361-73	Marten Ridge Adit No. 7 Upper	16/3/73	70
2390-73	Marten Ridge Adit No. 7 Lower	29/3/73	75
2412-73	Marten Ridge Adit No. 9	3/4/73	70
2510-73	Marten Ridge Adit No. 10	12/4/73	70
2511-73	Marten Ridge Adit No. 11	24/4/73	70
2512-73	Marten Ridge Adit No. 12 Upper	3/5/73	70
2612-73	Marten Ridge Adit No. 12 Lower	10/5/73	60

TABLE 1. List of Small 3/8" x 0 Raw Coal Samples

Laboratory Number	Identification	Data Received	Approx. Sample Weight (lb)
4961-72	Marten Creek Adit No. 1	19/9/72	600
4962-72	Marten Creek Adit No. 3	27/10/72	600
2034-73	Marten Creek Adit No. 4	22/11/72	700
5120-72	Lodge Pole Adit No. 1	4/12/72	750
2016-73	Lodge Pole Adit No. 2	4/12/72	680
2207-73	Marten Creek Adit No. 6	18/1/73	600
2208-73	Flathead Ridge Adit No. 3	20/12/72	600
2228-73	Marten Ridge Adit No. 5 Upper	25/1/73	600
2344-73	Marten Ridge Adit No. 5 Lower	19/2/73	60
2415-73	Marten Ridge Adit No. 7 Upper	16/3/73	600
2414-73	Marten Ridge Adit No. 7 Lower	29/3/73	600
2413-73	Marten Ridge Adit No. 9	3/4/73	600
2562-73	Marten Ridge Adit No. 10	12/4/73	600
2563-73	Marten Ridge Adit No. 11	24/4/73	600
2564-73	Marten Ridge Adit No. 12 Upper	3/5/73	600
2613-73	Marten Ridge Adit No. 12 Lower	10/5/73	600

TABLE 2. List of Cleaned Coal Samples

FIGURE 1

General Project Flowsheet

(Project No. 03-3-1/16-24)

COALS FOR PROJECT

Refer to Table 1 and Table 2.

GENERAL PREPARATION

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

CARBONIZATION

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

COKE EVALUATION

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

LABORATORY WORK

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

Analytical Program

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

A. Chemical and Related Analysis-Conducted by the Fuels Research Centre, Mines Branch (reported in Tables 6, 12 and 18).

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

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

(c) Gross Calorific Value

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

B. Physical Tests (reported in Tables 7, 13 and 19)

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

Representative samples of coke oven coal charges and resultant cokes were taken for proximate analysis and sulphur determination. These values are listed in Tables 11, 17 and 23.

C. Thermal Rheological Properties (reported in Tables 8, 14 and 20)

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

D. Petrography (reported in Tables 9, 15, 21)

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

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

In addition, small 3/8" x 0 raw coal samples were each analysed to determine the Hardgrove Grindability Index and the Fusibility of Ash. Reported in Tables 3, 4 and 5 .

CARBONIZATION

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

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

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

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

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

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

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

The carbonization results are reported in Tables 10, 16 and 22.

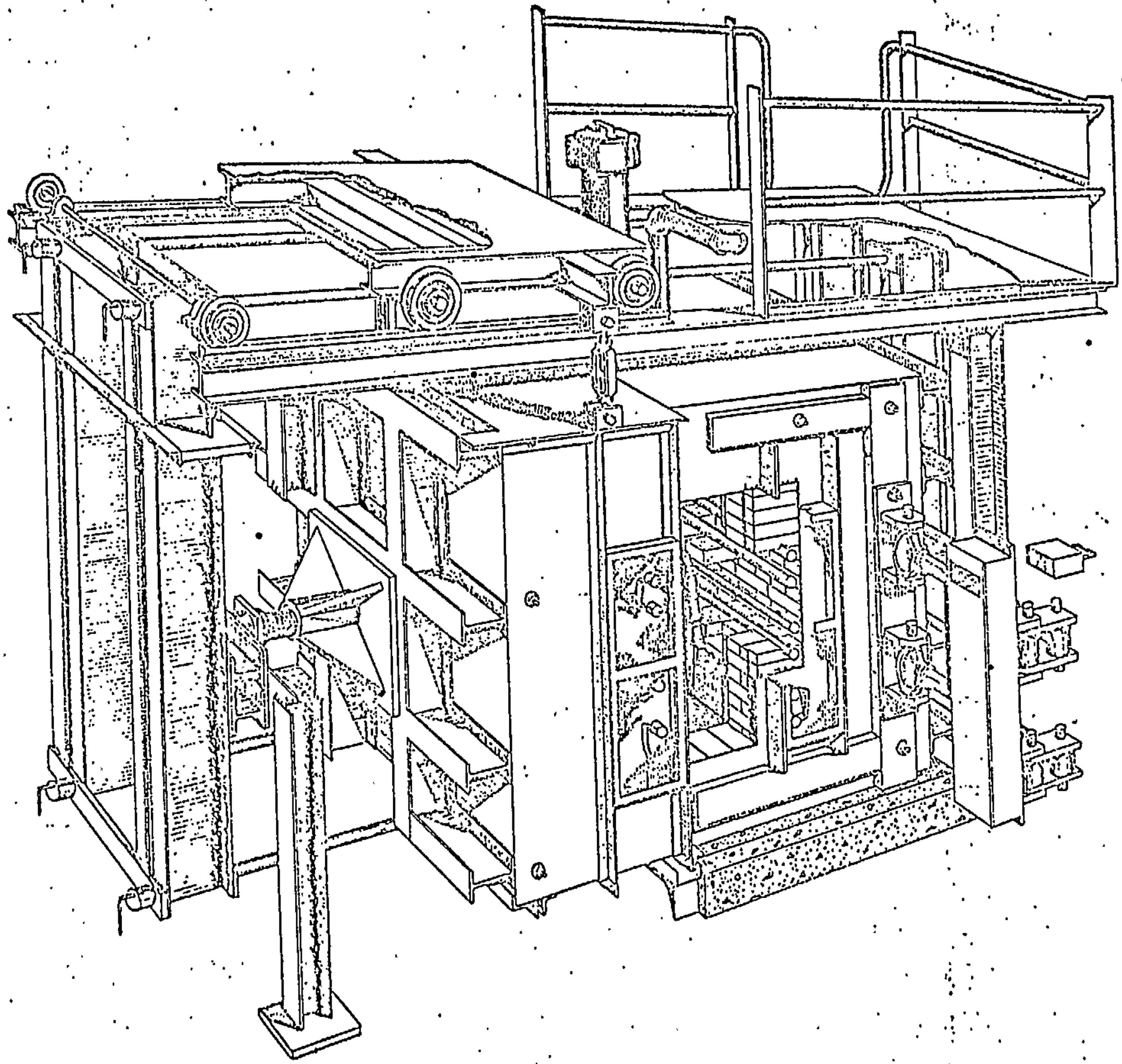


FIGURE 2

Mines Branch Movable-Wall Coke Oven

TABLE 3 Hardgrove Grindability and Fusibility of Ash of 3/8" x 0 Raw Coals

Identification						
Laboratory Number	4921-72	4922-72	5117-72	5118-72	5119-72	2067-73
Description						
Raw Coal from	Marten Creek Adit #1	Marten Creek Adit #3	Marten Creek Adit #4	Lodge Pole Adit #1	Lodge Pole Adit #2	Marten Creek Adit #6
Coal Pulverization						
Sieve Analysis						
Passing / Retained On						
— / 1/4 in. %						
1/4 in. / 1/8 in. %						
1/8 in. / 1/16 in. %						
1/16 in. / 1/32 in. %						
1/32 in. / ....%						
Total Passing 1/8 in. %						
Grindability						
Hardgrove Index	75	109	87	81	110	116
Fusibility of Ash						
Initial Deformation Temp. ... °F	2390	2250	2700+	2410	2200	2700+
Softening Temp. Spherical ... °F	2700+	2680	2700+	2700	2400	2700+
Softening Temp. Hemispherical °F	2700+	2700+	2700+	2700+	2450	2700+
Fluid Temp. .... °F	2700+	2700+	2700+	2700+	2630	2700+

TABLE 4 Hardgrove Grindability and Fusibility of Ash of 3/8" x 0 Raw Coals

Identification						
Laboratory Number	2068-73	2220-73	2345-73	2361-73	2390-73	2412-73
Description — Raw Coal from	Flathead Ridge Adit #3	Marten Ridge Adit #5 Upper	Marten Ridge Adit #5 Lower	Marten Ridge Adit #7 Upper	Marten Ridge Adit #7 Lower	Marten Ridge Adit #9
Coal Pulverization						
Sieve Analysis: Passing / Retained On						
— / 1/4 in. %						
1/4 in. / 1/8 in. %						
1/8 in. / 1/16 in. %						
1/16 in. / 1/32 in. %						
1/32 in. / ....%						
Total Passing 1/8 in. %						
Grindability						
Hardgrove Index	89	73	98	97	56	61
Fusibility of Ash						
Initial Deformation Temp. °F	2300	2160	2700+	2290	2080	2420
Softening Temp. Spherical °F	2700+	2690	2700+	2660	2480	2700
Softening Temp. Hemispherical °F	2700+	2700+	2700+	2700+	2680	2700+
Fluid Temp. °F	2700+	2700+	2700+	2700+	2700	2700+

TABLE 5 Hardgrove Grindability and Fusibility of Ash of 3/8" x 0 Raw Coals

Identification				
Laboratory Number	2510-73	2511-73	2512-73	2612-73
Description				
Raw Coal from	Marten Ridge Adit #10	Marten Ridge Adit #11	Marten Ridge Adit #12 Upper	Marten Ridge Adit #12 Lower
Coal Pulverization				
Sieve Analysis				
Passing / Retained On				
— / 1/4 in. %				
1/4 in. / 1/8 in. %				
1/8 in. / 1/16 in. %				
1/16 in. / 1/32 in. %				
1/32 in. / ....%				
Total Passing 1/8 in. %				
Grindability				
Hardgrove Index	58	69	68	70
Fusibility of Ash				
Initial Deformation Temp. ... °F	2140	2320	2250	2100
Softening Temp. Spherical ... °F	2700+	2700+	2580	2300
Softening Temp. Hemispherical °F	2700+	2700+	2700+	2620
Fluid Temp. .... °F	2700+	2700+	2700+	2640

TABLE 6 Chemical Analyses of Component Coals

Identification						
Laboratory Number	4961-72	4962-72	2034-73	5120-72	2016-73	2208-73
Description						
Clean Coal from	Marten Creek Adit #1	Marten Creek Adit #3	Marten Creek Adit #4	Lodge Pole Adit #1	Lodge Pole Adit #2	Flathead Ridge Adit #3
Classification						
Rank (ASTM)	hvAb	hvAb	hvAb	lvb	lvb	lvb
International System	634	633	533	421	411	421
Specific Volatile Index	172	169	174	195	200	196
Carbon (dmmfb) ....%	86.5	86.2	86.2	89.0	88.6	90.5
Proximate Analysis (db)						
Ash ....%	7.8	7.3	6.9	11.5	10.7	9.1
Volatile Matter ....%	34.3	31.9	29.9	18.3	18.6	20.2
Fixed Carbon ....%	57.9	60.8	63.2	70.2	70.7	70.7
Gross Calorific Value (db)						
Btu per pound	14,150	14,070	13,980	13.700	13,730	14,020
Ultimate Analysis (db)						
Carbon ....%	79.1	79.2	79.5	78.6	78.1	81.3
Hydrogen ....%	5.2	5.0	4.9	4.0	4.3	4.3
Sulphur ....%	0.45	0.60	0.46	0.48	0.51	0.40
Nitrogen ....%	1.4	1.5	1.4	1.2	1.2	1.3
Ash ....%	7.8	7.3	6.9	11.5	10.7	9.1
Oxygen (by difference) .....%	6.1	6.4	6.8	4.2	5.2	3.6
Ash Analysis (db)						
SiO_2 ....%	48.5	50.1	52.6	57.2	52.9	54.4
Al_2O_3 ....%	33.5	32.1	36.4	33.1	35.6	35.3
Fe_2O_3 ....%	5.3	5.2	2.3	1.7	3.3	1.5
TiO_2 ....%	1.5	1.5	1.1	1.5	1.9	1.6
P_2O_5 ....%	4.0	4.2	3.4	1.2	1.0	1.5
CaO ....%	4.6	4.6	3.1	2.5	1.8	2.6
MgO ....%	0.9	1.2	0.4	0.5	0.9	1.2
SO_3 ....%	0.2	0.8	0.1	1.4	0.3	0.8
Na_2O ....%	0.7	0.3	0.2	0.7	0.5	0.3
K_2O ....%	0.9	1.2	1.7	0.9	0.6	1.2

TABLE 7 Physical Tests and Fusibility of Ash of Component Coals

Identification							
Laboratory Number		4961-72	4962-72	2034-73	5120-72	2016-73	2208-73
Description							
Clean Coal from		Marten Creek Adit #1	Marten Creek Adit #3	Marten Creek Adit #4	Lodge Pole Adit #1	Lodge Pole Adit #2	Flathead Ridge Adit #3
Coal Pulverization							
Sieve Analysis							
Passing	Retained On						
	1/4 in. %	1.8	2.4	0.3	0.1	1.2	0.6
1/4 in.	1/8 in. %	10.8	5.5	6.3	5.3	5.8	8.4
1/8 in.	1/16 in. %	22.4	9.0	21.4	15.8	8.8	21.3
1/16 in.	1/32 in. %	19.1	10.7	19.7	17.2	10.5	21.2
1/32 in.	..........%	45.9	72.4	52.3	61.6	73.7	48.5
Total Passing	1/8 in. %	12.6	7.9	6.6	5.4	7.0	9.0
Grindability							
Hardgrove Index		70	121	80	99	142	89
Fusibility of Ash							
Initial Deformation Temp. ...	°F	2250	2210	2700+	2700+	2700+	2490
Softening Temp. Spherical ...	°F	2700+	2700	2700+	2700+	2700+	2700+
Softening Temp. Hemispherical	°F	2700+	2700+	2700+	2700+	2700+	2700+
Fluid Temp.	°F	2700+	2700+	2700+	2700+	2700+	2700+

TABLE 8 Therma, heological Properties of Compc ,it Coals

Identification						
Laboratory Number	4961-72	4962-72	2034-73	5120-72	2016-73	2208-73
Description						
Clean Coal from	Marten Creek Adit #1	Marten Creek Adit #3	Marten Creek Adit #4	Lodge Pole Adit #1	Lodge Pole Adit #2	Flathead Ridge Adit #3
Linear Expansion						
Bd. 52 lb/ft^3 at 2% moisture...%	-7.9	**	*	-9.0	-9.2	-2.0
Gieseler Plasticity						
Start ....°C	407	408	417	470	-	464
Fusion Temp. ....°C	420	424	432	-	-	-
Max. Fluid Temp. ....°C	446	447	448	476	476	468
Final Fluid Temp. ....°C	474	474	466	483	-	474
Solidification Temp. ....°C	482	479	474	502	494	494
Melting Range ....°C	67	66	49	13	-	10
Max. Fluidity ....dd/m	2700	290	36	1.2	0.2	1.2
Torque ....g.in.	40	40	40	40	40	40
Dilatation						
Ti - Softening Temp. ......°C	395	410	410	460	473	467
Tii - Max. Contraction Temp. °C	439	454	451	500	500	505
Tiii - Max. Dilatation Temp. °C	470	479	470	-	-	-
Contraction ....%	27	30	28	19	4	24
Dilatation ....%	81	49	11	NIL (at 500)	NIL (at 500)	NIL (at 500)
Free Swelling Index						
F.S.I.	8	8	5½	3	1	4

*Insufficient Coal
**Electrical Failure, Test Aborted

TABLE . Petrographic Analysis of Component Coals

Identification						
Laboratory Number..............	4961-72	4962-72	2034-73	5120-73	2016-73	2208-73
Description.................... Clean Coal from	Marten Creek Adit #1	Marten Creek Adit #3	Marten Creek Adit #4	Lodge Pole Adit #1	Lodge Pole Adit #2	Flathead Ridge Adit #3
Distribution of Vitrinite Types						
V-6.........................%		0.9	0.6			
V-7.........................%	11.2	0.9	26.1			
V-8.........................%	46.3	27.7	34.2			
V-9.........................%	15.0	40.3	3.7	0.5		
V-10........................%		6.7	0.6	0.9		
V-11........................%		2.5	1.3	0.5		0.6
V-12........................%				9.3	2.1	24.0
V-13........................%				20.5	14.4	31.1
V-14........................%				14.0	13.7	3.6
V-15........................%				0.9	3.9	
V-16........................%					0.3	
V-17........................%						
V-18........................%						
Reactive Components						
Total Vitrinite.............%	72.5	79.0	66.5	46.6	34.4	59.3
Reactive Semi-fusinite (1/3)...%	2.4	2.5	5.3	11.5	12.6	7.5
Exinite.....................%	7.4	2.5	2.7	0.0	0.0	0.0
Total.......................%	82.3	84.0	74.5	58.1	47.0	66.8
Inert Components						
Inert Semi-fusinite (2/3)......%	4.8	5.1	10.7	23.0	25.1	15.1
Micrinite...................%	4.2	3.4	1.1	5.1	6.4	1.1
Fusinite....................%	4.3	3.4	10.7	7.3	15.4	11.9
Mineral Matter..............%	4.4	4.1	3.9	6.5	6.1	5.1
Total.......................%	17.7	16.0	26.4	41.9	53.0	33.2
Petrographic Indices						
Mean Reflectance............%	0.86	0.92	0.82	1.55	1.41	1.31
Balance Index................	0.60	0.48	1.11	6.56	7.07	2.40
Strength Index...............	3.01	3.28	2.93	6.61	5.57	5.37
Stability Index..............	32.0	35.0	32.3	29.0	13.5	52.8

TABLE 10 - Carbonization Data

Test Identification Number	147	148	173	166	167*	179
Data of Test	21/11/72	22/11/72	23/1/73	4/1/73	9/1/73	6/2/73
Laboratory Number	4961-72	4962-72	2034-73	5120-72	2016-73	2208-73
Description						
CARBONIZATION DATA						
Net Weight of Charge (wet) ... lb	534.0	528.0	539.0	543.3		540.5
Moisture in Charge ... %	2.6	3.4	3.2	2.9		2.8
ASTM Bulk Density (wet) ... lb/ft^3	48.5	48.4	48.5	48.5		48.5
Oven Bulk Density (db) ... lb/ft^3	50.0	49.4	50.2	50.7		50.5
CARBONIZATION RESULTS						
Gross Coking Time ... hr:min	8:50	9:05	9:20	9:45		9:30
Maximum Wall Pressure ... lb/in^2	0.31	0.42	0.58	0.42		0.66
Coke Yield Actual ... %	69.1	70.2	71.4	80.5		78.8
Mean Coke size ... in	1.93	1.85	1.79	1.68		2.05
Apparent Specific Gravity	0.87	N.A.	0.88	1.02		0.94
Screen Analysis of Coke (cumulative percentage retained on)						
3 inch sieve	4.1	2.5	2.0	3.4		12.4
2 inch sieve	43.3	35.0	33.5	39.8		50.6
1 1/2 inch sieve	72.3	72.0	65.9	63.4		76.7
1 inch sieve	92.7	93.0	90.4	76.5		89.9
3/4 inch sieve	95.9	95.9	94.7	78.6		91.7
1/2 inch sieve	96.8	96.6	95.7	79.5		92.3
Percentage -1/2 inch (breeze)	3.2	3.4	4.3	20.5		7.7
Tumbler Test (ASTM)						
Stability Factor	42.4	46.8	40.0	33.8		49.3
Hardness Factor	65.9	66.2	69.7	47.1		61.1

Japanese Tumbler Test (JIS) (cumulative percentage retained on)	147 30R	148 30R	173 30R	173 150R	166 30R	166 150R	167*	179 30R	179 150R
50 mm sieve	7.5	9.1	4.2	0.8	11.7	2.5		13.4	4.3
25 mm sieve	81.4	80.8	76.0	51.5	73.9	49.7		82.1	65.6
15 mm sieve	90.9	90.6	91.2	78.9	81.5	61.4		87.8	75.0

*This Coal was charged into the oven but did not carbonize

TABLE 11

Analyses of Coke Oven Charges and Resultant Cokes

Identification						
Test Number.............	147	148	173	166	167	179
Date Charged...........	21/11/72	22/11/72	23/1/73	4/1/73	9/1/73	6/2/73
Description.............						
Clean Coal from	Marten Creek Adit #1	Marten Creek Adit #3	Marten Creek Adit #4	Lodge Pole Adit #1	Lodge Pole Adit #2	Flathead Ridge Adit #3
Coke Oven Charge						
Laboratory Number.........	4961-72	4962-72	2034-73	5120-72	2016-73	2208-73
Proximate Analysis (db)						
Ash...................%	7.8	7.3	6.9	11.5	10.7	9.1
Volatile Matter.......%	34.3	31.9	29.9	18.3	18.6	20.2
Fixed Carbon ....%	57.9	60.8	63.2	70.2	70.7	70.7
Sulphur (db)............%	0.45	0.60	0.46	0.48	0.51	0.40
Resultant Coke						
Laboratory Number.........	5087-72	5088-72	2206-73	2197-73	No Coke Sample	2255-73
Proximate Analysis (db)						
Ash...................%	10.8	10.2	9.8	12.8	-	11.2
Volatile Matter.......%	1.0	0.6	1.0	0.5	-	0.5
Fixed Carbon..........%	88.2	89.2	89.2	86.7	-	98.3
Sulphur (db)............%	0.41	0.39	0.39	0.55	-	0.41

TABLE 12 Chemical Analyses of Component Coals

Identification						
Laboratory Number	2207-73	2228-73	2344-73	2413-73	2414-73	2415-73
Description Clean Coal from	Marten Creek Adit #6	Marten Ridge Adit #5 Upper	Marten Ridge Adit #5 Lower	Marten Ridge Adit #9	Marten Ridge Adit #7 Lower	Marten Ridge Adit #7 Upper
Classification						
Rank (ASTM)	hvAb	hvAb	hvAb	hvAb	hvAb	hvAb
International System	612	511	511	623	621	622
Specific Volatile Index	164	159	166	161	160	160
Carbon (dmmfb) %	86.3	86.2	86.9	85.4	85.9	85.4
Proximate Analysis (db)						
Ash %	9.1	8.5	9.7	4.8	7.9	7.2
Volatile Matter %	30.6	29.8	29.1	35.0	31.2	32.1
Fixed Carbon %	60.3	61.7	61.3	60.2	60.9	60.7
Gross Calorific Value (db)						
Btu per pound	13,620	13,550	13,550	14,300	13.700	13.830
Ultimate Analysis (db)						
Carbon %	77.6	78.2	77.6	80.9	78.4	78.7
Hydrogen %	4.8	4.5	4.5	5.1	4.7	4.9
Sulphur %	0.47	0.44	0.35	0.36	0.36	0.47
Nitrogen %	1.3	1.2	0.0	1.5	1.5	1.5
Ash %	9.1	8.5	9.7	4.8	7.9	7.2
Oxygen (by difference) %	6.7	7.2	7.9	7.3	7.1	7.2
Ash Analysis (db)						
SiO_2 %	56.2	36.2	56.7	48.8	54.4	48.7
Al_2O_3 %	33.2	28.5	35.7	33.5	33.2	26.9
Fe_2O_3 %	2.6	18.6	1.6	12.2	2.5	2.0
TiO_2 %	1.3	0.8	1.7	1.2	1.5	1.4
P_2O_5 %	2.5	4.1	1.9	0.4	3.3	6.5
CaO %	2.5	7.1	2.0	1.5	3.1	7.8
MgO %	0.5	2.5	0.3	0.7	0.9	2.2
SO_3 %	0.0	1.1	0.1	0.1	0.0	0.1
Na_2O %	0.2	0.3	0.3	0.1	0.1	0.2
K_2O %	1.7	0.9	0.4	1.8	0.4	0.6

TABLE 13 Physical Tests and Fusibility of Ash of Component Coals

Identification							
Laboratory Number		2207-73	2228-73	2344-73	2413-73	2414-73	2415-73
Description .... Clean Coal from		Marten Creek Adit #6	Marten Ridge Adit #5 Upper	Marten Ridge Adit #5 Lower	Marten Ridge Adit #9	Marten Ridge Adit #7 Lower	Marten Ridge Adit #7 Upper
Coal Pulverization							
Sieve Analysis							
Passing	Retained On						
	1/4 in. %	0.4	0.0	6.8	2.2	1.6	0.5
1/4 in.	1/8 in. %	5.0	3.5	15.8	14.4	15.8	7.7
1/8 in.	1/16 in. %	16.6	21.6	15.9	22.1	26.2	18.3
1/16 in.	1/32 in. %	16.0	22.3	16.9	20.1	19.0	16.4
1/32 in.	..........%	62.0	52.6	44.6	41.2	37.4	57.1
Total Passing	1/8 in. %	5.4	3.5	22.6	83.4	82.6	91.8
Grindability							
Hardgrove Index		126	67	95	57	53	103
Fusibility of Ash							
Initial Deformation Temp. ... °F		2500	2180	2700+	2670	2700+	2150
Softening Temp. Spherical ... °F		2700+	2320	2700+	2700+	2700+	2630
Softening Temp. Hemispherical °F		2700+	2450	2700+	2700+	2700+	2700+
Fluid Temp. .... °F		2700+	2700+	2700+	2700+	2700+	2700+

TABLE 14 Thermal Rheological Properties of Component Coals

Identification						
Laboratory Number	2207-73	2228-73	2344-73	2413-73	2414-73	2415-73
Description Clean Coal from	Marten Creek Adit #6	Marten Ridge Adit #5 Upper	Marten Ridge Adit #5 Lower	Marten Ridge Aidt #9	Marten Ridge Aidt #7 Lower	Marten Ridge Adit #7 Upper
Linear Expansion						
Bd. 52 lb/ft^3 at 2% moisture...%	-7.0	*	*	-3.8	-8.3	-6.9
Gieseler Plasticity						
Start ....°C	425	427	426	416	424	421
Fusion Temp. ....°C	-	-	-	433	-	-
Max. Fluid Temp. ....°C	445	438	443	446	443	441
Final Fluid Temp. ....°C	459	455	459	464	455	454
Solidification Temp. ....°C	462	464	465	468	468	459
Melting Range ....°C	34	28	33	48	31	32
Max. Fluidity ....dd/m	4	2.1	3	21	3	4.8
Torque ....g.in.	40	40	40	40	40	40
Dilatation						
Ti - Softening Temp. ....°C	416	440	416	407	428	418
Tii - Max. Contraction Temp. °C	458	500	500	451	473	467
Tiii - Max. Dilatation Temp. °C	470	-	-	464	-	485
Contraction ....%	28	20	28	27	23	31
Dilatation ....%	-26	NIL (at 500°C)	NIL (at 500°C)	4	NIL (at 500°C)	-18
Free Swelling Index						
F.S.I.	2	2	2	3	2½	2½

*Not requested

TABLE etrographic An ysis of Compor t Coals

Identification						
Laboratory Number	2207-73	2228-73	2344-73	2413-73	2414-73	2415-73
Description / Clean Coal from	Marten Creek Adit #6	Marten Ridge Adit #5 Upper	Marten Ridge Adit #5 Lower	Marten Ridge Adit #9	Marten Ridge Adit #7 Lower	Marten Ridge Adit #7 Upper
Distribution of Vitrinite Types						
V-6 %	1.1		1.1	1.4		
V-7 %	4.3	6.6	17.7	27.8	0.5	7.4
V-8 %	23.5	27.1	26.7	27.0	13.9	34.9
V-9 %	20.3	14.4	6.7	10.8	22.5	20.1
V-10 %	1.1			0.7	17.2	1.5
V-11 %	1.0				1.4	
V-12 %					1.0	
V-13 %						
V-14 %						
V-15 %						
V-16 %						
V-17 %						
V-18 %						
Reactive Components						
Total Vitrinite %	51.3	48.1	52.2	67.7	56.5	63.9
Reactive Semi-fusinite (1/3) %	6.7	7.2	8.0	4.3	7.9	5.2
Exinite %	3.2	1.3	1.1	5.1	3.7	3.9
Total %	61.2	56.6	61.3	77.1	68.1	73.0
Inert Components						
Inert Semi-fusinite (2/3) %	13.3	14.5	16.1	8.5	15.8	10.3
Micrinite %	5.9	1.9	1.4	3.0	3.2	3.1
Fusinite %	14.5	22.2	15.8	8.7	8.5	9.6
Mineral Matter %	5.1	4.8	5.4	2.7	4.4	4.0
Total %	38.8	43.4	38.7	22.9	31.9	27.0
Petrographic Indices						
Mean Reflectance %	0.89	0.87	0.82	0.88	0.96	0.87
Balance Index	1.69	2.09	1.90	0.91	1.21	1.00
Strength Index	2.84	2.39	2.43	3.00	3.52	3.16
Stability Index	20.0	0.0	0.0	34.2	45.0	38.0

TABLE 16 - Carbonization Data

Test Identification Number................	180	*	**	224	222	223
Data of Test..............................				18/6/73	14/6/73	13/6/73
Laboratory Number.........................	2207-73	2228-73	2344-73	2413-73	2414-73	2415-73
Description...............................						
CARBONIZATION DATA						
Net Weight of Charge (wet)...........lb	541.5			547.8	547.8	546.2
Moisture in Charge...................%	3.5			2.8	3.2	3.5
ASTM Bulk Density (wet)..........lb/ft^3	48.5			48.5	48.5	48.3
Oven Bulk Density (db)...........lb/ft^3	50.2			51.2	51.0	50.7
CARBONIZATION RESULTS						
Gross Coking Time................hr:min	9:30			9:15	9:55	9:50
Maximum Wall Pressure............lb/in^2	0.35			0.42	0.31	0.34
Coke Yield Actual....................%	69.9			65.3	67.1	69.0
Mean Coke size......................in	2.17			1.66	1.62	1.64
Apparent Specific Gravity.............	0.91			0.84	0.91	0.91
Screen Analysis of Coke (cumulative percentage retained on)						
3 inch sieve..........................	16.0			1.2	7.6	2.8
2 inch sieve..........................	57.4			21.9	41.7	37.7
1 1/2 inch sieve......................	80.3			60.0	61.3	61.0
1 inch sieve..........................	91.3			91.7	72.0	75.1
3/4 inch sieve........................	92.8			92.7	73.9	78.3
1/2 inch sieve........................	93.4			94.3	75.2	79.6
Percentage -1/2 inch (breeze).........	6.6			5.7	24.8	20.4
Tumbler Test (ASTM)						
Stability Factor......................	36.4			23.1	23.7	28.4
Hardness Factor.......................	51.4			69.2	40.5	48.8
Japanese Tumbler Test (JIS) (cumulative percentage retained on)	30R	150R		***	30R	30R
50 mm sieve...........................	13.0	0.9		Insufficient Coke in proper size range	0.5	1.6
25 mm sieve...........................	74.5	49.0			60.5	64.4
15 mm sieve...........................	83.1	63.1			71.3	76.0

*** Insufficient coke in proper size range

* Not Carbonized on advice of KRL

** Not Carbonized due to insufficient sample

TABLE 17

Analyses of Coke Oven Charges and Resultant Cokes

Identification						
Test Number............	180	*	*	224	222	223
Date Charged...........	7/2/73			18/6/73	14/6/73	13/6/73
Description............						
100% Clean Coal from	Marten Creek Adit #6	Marten Ridge Adit #5 Upper	Marten Ridge Adit #5 Lower	Marten Ridge Adit #9	Marten Ridge Adit #7 Lower	Marten Ridge Adit #7 Upper
Coke Oven Charge						
Laboratory Number.........	2207-73	2228-73	2344-73	3121-73	3119-73	3120-73
Proximate Analysis (db)						
Ash...................%	9.1	8.5	9.7	4.6	8.1	7.2
Volatile Matter........%	30.6	29.8	29.1	33.6	30.8	31.3
Fixed Carbon ....%	60.3	61.7	61.3	61.7	61.0	61.5
Sulphur (db)............%	0.47	0.44	0.35	0.38	0.39	0.44
Resultant Coke						
Laboratory Number.........	2256-73	*	*	3484-73	3482-73	3483-73
Proximate Analysis (db)						
Ash...................%	12.6			7.0	11.1	10.0
Volatile Matter........%	1.3			1.2	1.3	1.3
Fixed Carbon..........%	86.1			91.8	87.6	88.8
Sulphur (db)............%	0.54			0.45	0.3	0.45

* Not Carbonized

TABLE 10 Chemical Analyses of Component Coals

Identification				
Laboratory Number	2562-73	2563-73	2564-73	2613-73
Description	Marten Ridge Adit #10	Marten Ridge Adit #11	Marten Ridge Adit #12 Upper	Marten Ridge Adit #12 Lower
Classification				
Rank (ASTM)	hvAb	hvAb	hvAb	hvAb
International System	622	622	622	622
Specific Volatile Index	160	159	160	162
Carbon (dmmfb) %	84.8	85.3	84.8	84.6
Proximate Analysis (db)				
Ash %	6.1	5.4	7.5	6.6
Volatile Matter %	36.2	32.9	34.7	33.3
Fixed Carbon %	57.7	61.7	57.9	60.1
Gross Calorific Value (db)				
Btu per pound	14,050	14,090	13,810	13,990
Ultimate Analysis (db)				
Carbon %	79.1	80.1	77.8	78.5
Hydrogen %	5.3	5.1	5.1	5.1
Sulphur %	0.35	0.35	0.47	0.37
Nitrogen %	1.5	1.5	1.3	1.4
Ash %	6.1	5.4	7.5	6.6
Oxygen (by difference) %	7.6	7.5	7.8	8.0
Ash Analysis (db)				
SiO_2 %	46.3	45.6	56.1	47.1
Al_2O_3 %	33.1	33.7	27.6	29.3
Fe_2O_3 %	8.5	6.3	6.7	10.0
TiO_2 %	1.3	1.4	1.2	1.2
P_2O_5 %	4.5	4.0	2.0	4.9
CaO %	3.1	4.6	3.2	4.3
MgO %	0.7	1.9	1.2	1.2
SO_3 %	0.1	0.3	0.7	0.1
Na_2O %	0.4	0.2	0.2	0.3
K_2O %	0.7	0.6	1.6	0.9

TABLE 19 Physical Tests and Fusibility of Ash of Component Coals

Identification					
Laboratory Number		2562-73	2563-73	2564-73	2613-73
Description		Marten Ridge Adit #10	Marten Ridge Adit #11	Marten Ridge Adit #12 Upper	Marten Ridge Adit #12 Lower
Coal Pulverization					
Sieve Analysis					
Passing	Retained On				
	1/4 in. %	1.7	0.7	1.0	0.9
1/4 in.	1/8 in. %	12.3	8.7	9.1	9.2
1/8 in.	1/16 in. %	24.0	18.5	20.3	24.0
1/16 in.	1/32 in. %	20.1	17.3	19.4	19.3
1/32 in.	..........%	41.9	54.8	50.2	46.6
Total Passing	1/8 in. %	86.0	90.6	89.9	89.9
Grindability					
Hardgrove Index		52	68	63	60
Fusibility of Ash					
Initial Deformation Temp.	°F	2130	2500	2320	2130
Softening Temp. Spherical	°F	2700+	2700	2600	2370
Softening Temp. Hemispherical	°F	2700+	2700+	2700+	2580
Fluid Temp.	°F	2700+	2700+	2700+	2650

TABLE 20 Thermal Rheological Properties of Component Coals

Identification				
Laboratory Number	2562-73	2563-73	2564-73	2613-73
Description	Marten Ridge Adit #10	Marten Ridge Adit #11	Marten Ridge Adit #12 Upper	Marten Ridge Adit #12 Lower
Linear Expansion				
Bd. 52 lb/ft^3 at 2% moisture...%	-5.9	-3.6	-6.6	-7.5
Gieseler Plasticity				
Start ....°C	408	413	412	408
Fusion Temp. ....°C	424	429	428	425
Max. Fluid Temp. ....°C	442	438	440	436
Final Fluid Temp. ....°C	462	457	458	452
Solidification Temp. ....°C	467	463	463	462
Melting Range ....°C	54	44	46	44
Max. Fluidity ....dd/m	39.8	13.7	19.6	20.5
Torque ....g.in.	40	40	40	40
Dilatation				
Ti - Softening Temp. ......°C	398	400	413	409
Tii - Max. Contraction Temp. °C	450	445	458	461
Tiii - Max. Dilatation Temp. °C	470	464	477	480
Contraction ....%	29	29	29	26
Dilatation ....%	-4	-13	-14	-12
Free Swelling Index				
F.S.I.	3	3½	3	3

TABLE 2 etrographic An...ysis of Compo' 't Coals

Identification				
Laboratory Number..............	2562-73	2563-73	2564-73	2613-73
Description....................	Marten Ridge Adit #10	Marten Ridge Adit #11	Marten Ridge Adit #12 Upper	Marten Ridge Adit #12 Lower
Distribution of Vitrinite Types				
V-6..........................%	3.1		1.4	8.5
V-7..........................%	17.2	18.9	19.1	30.3
V-8..........................%	33.5	39.4	47.5	28.7
V-9..........................%	7.0	9.1	4.2	0.8
V-10.........................%		0.8	0.7	
V-11.........................%				
V-12.........................%				
V-13.........................%				
V-14.........................%				
V-15.........................%				
V-16.........................%				
V-17.........................%				
V-18.........................%				
Reactive Components				
Total Vitrinite..............%	60.8	68.2	72.9	68.3
Reactive Semi-fusinite (1/3)...%	6.7	4.1	2.2	2.8
Exinite......................%	4.1	2.6	4.4	6.5
Total........................%	71.6	74.9	79.5	77.6
Inert Components				
Inert Semi-fusinite (2/3)......%	13.3	8.3	4.4	5.5
Micrinite....................%	5.4	2.8	2.9	3.3
Fusinite.....................%	6.3	10.9	8.8	9.8
Mineral Matter...............%	3.4	3.1	4.4	3.8
Total........................%	28.4	25.1	20.5	22.4
Petrographic Indices				
Mean Reflectance.............%	0.82	0.84	0.83	0.78
Balance Index.................	1.20	0.98	0.77	0.98
Strength Index................	2.88	3.01	2.95	2.86
Stability Index...............	30.2	34.6	32.3	31.3

TABLE 22 - Carbonization Data

Test Identification Number	234	232		233		230	
Data of Test	10/7/73	5/7/73		9/7/73		28/6/73	
Laboratory Number	2562-73	2563-73		2564-73		2613-73	
Description							
CARBONIZATION DATA							
Net Weight of Charge (wet) ... lb	547.8	547.0		546.0		540.2	
Moisture in Charge ... %	2.5	3.2		3.2		3.3	
ASTM Bulk Density (wet) ... lb/ft^3	48.5	48.4		48.5		48.4	
Oven Bulk Density (db) ... lb/ft^3	51.2	50.9		50.8		50.2	
CARBONIZATION RESULTS							
Gross Coking Time ... hr:min	9:25	9:50		9:25		9:25	
Maximum Wall Pressure ... lb/in^2	0.31	0.62		0.50		0.37	
Coke Yield Actual ... %	67.2	68.0		68.5		67.0	
Mean Coke size ... in	1.50	1.72		1.81		1.87	
Apparent Specific Gravity	0.81	0.84		0.86		0.84	
Screen Analysis of Coke (cumulative percentage retained on)							
3 inch sieve	1.6	2.2		3.0		5.3	
2 inch sieve	15.5	28.3		35.8		40.1	
1 1/2 inch sieve	46.6	62.8		68.2		69.4	
1 inch sieve	80.8	88.7		88.8		88.5	
3/4 inch sieve	91.5	93.1		93.4		92.7	
1/2 inch sieve	94.9	94.4		94.8		94.1	
Percentage -1/2 inch (breeze)	5.1	5.6		5.2		5.9	
Tumbler Test (ASTM)							
Stability Factor	15.5	37.8		26.8		28.7	
Hardness Factor	69.9	69.5		69.9		66.6	
Japanese Tumbler Test (JIS) (cumulative percentage retained on)	*	30R	150R	30R	150R	30R	150R
50 mm sieve		6.6	0.0	4.3	0.0	3.4	0.0
25 mm sieve		69.9	4.5	65.3	33.3	67.0	37.2
15 mm sieve		88.0	71.6	85.5	66.8	86.9	69.4

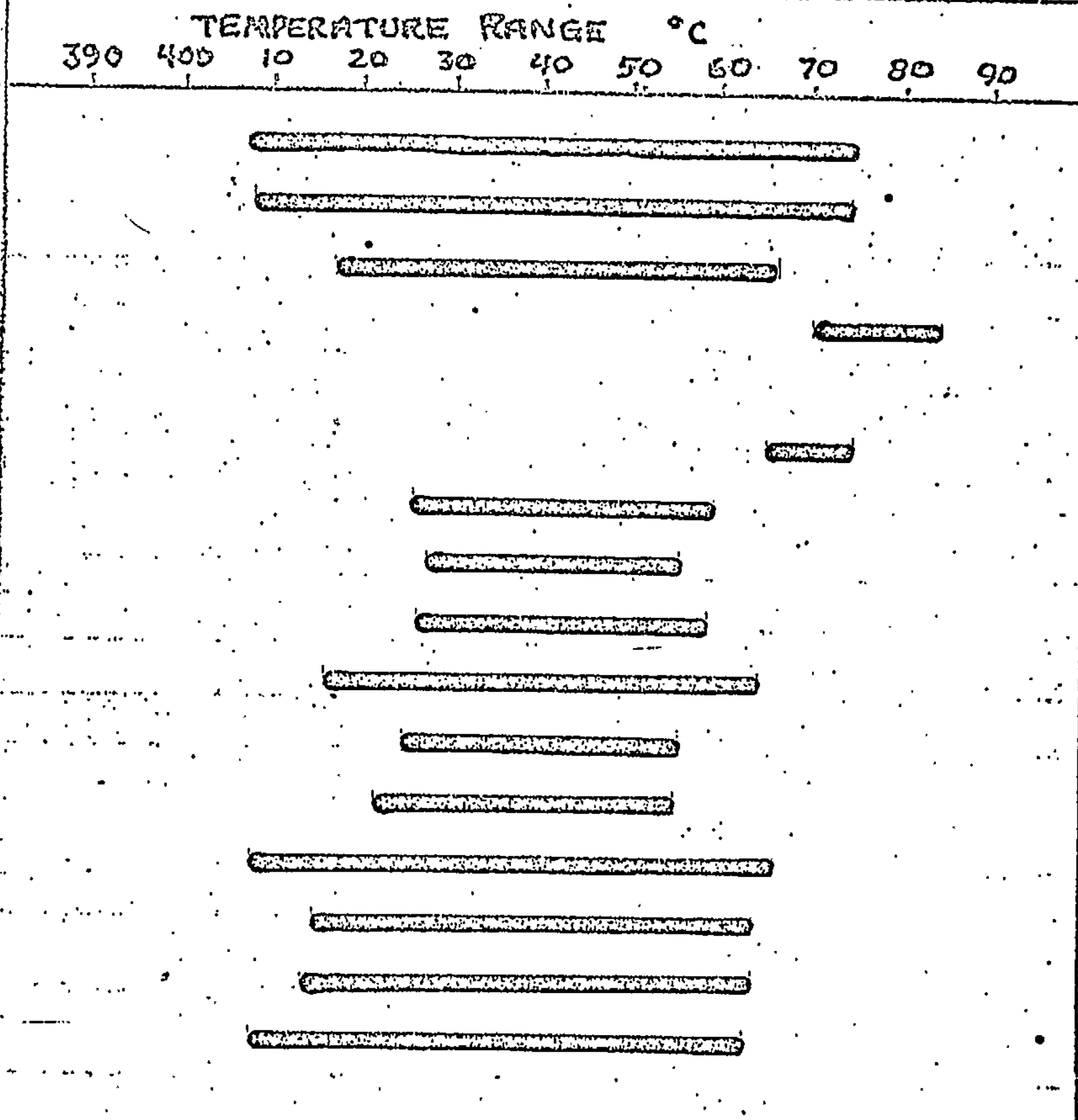
* Insufficient Coke in proper size range

TABLE 23

Analyses of Coke Oven Charges and Resultant Cokes

Identification				
Test Number............	234	232	233	230
Date Charged...........	10/7/73	5/7/73	9/7/73	28/6/73
Description............	Marten Ridge Adit #10	Marten Ridge Adit #11	Marten Ridge Adit #12 Upper	Marten Ridge Adit #12 Lower
Coke Oven Charge				
Laboratory Number.........	2562-73	2563-73	2564-73	2613-73
Proximate Analysis (db)				
Ash...................%	6.1	5.4	7.5	6.6
Volatile Matter........%	36.2	32.9	34.7	33.3
Fixed Carbon ....%	57.7	61.7	57.8	60.1
Sulphur (db)............%	0.35	0.35	0.47	0.37
Resultant Coke				
Laboratory Number.........	3518-73	3516-73	3517-73	3514-73
Proximate Analysis (db)				
Ash...................%	9.2	7.6	11.4	9.9
Volatile Matter........%	1.4	1.7	1.3	1.8
Fixed Carbon...........%	89.4	90.7	87.3	88.3
Sulphur (db)............%	0.39	0.40	0.44	0.47

FIGURE 3 Summary of Coal Plasticity Data for Component Coals



COAL	MAX. DIV./MIN.	V.M (db) %
4961-72	2700	34·3
4962-72	290	31·9
2034-73	36	29·9
5120-72	1·2	18·3
2016-73	0·2	18·6
2208-73	1·2	20·2
2207-73	4	30·6
2228-73	2·1	29·8
2344-73	3	29·1
2413-73	21	35·0
2414-73	3	31·2
2415-73	4·8	32·1
2562-73	39·8	36·2
2563-73	13·7	32·9
2564-73	19·6	34·7
2613-73	20·5	33·3

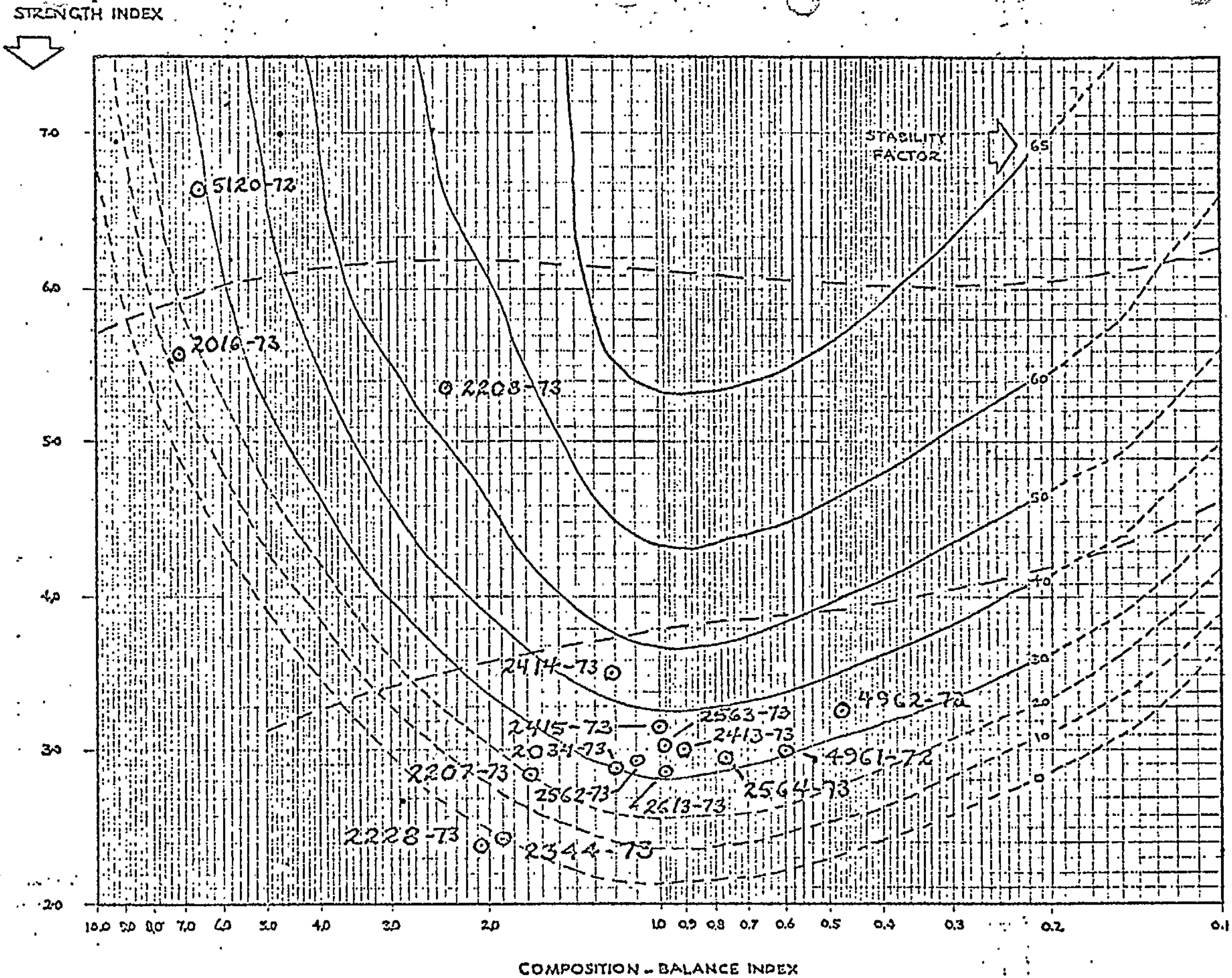


FIGURE 4. Potential Stability Factors for Component Coals

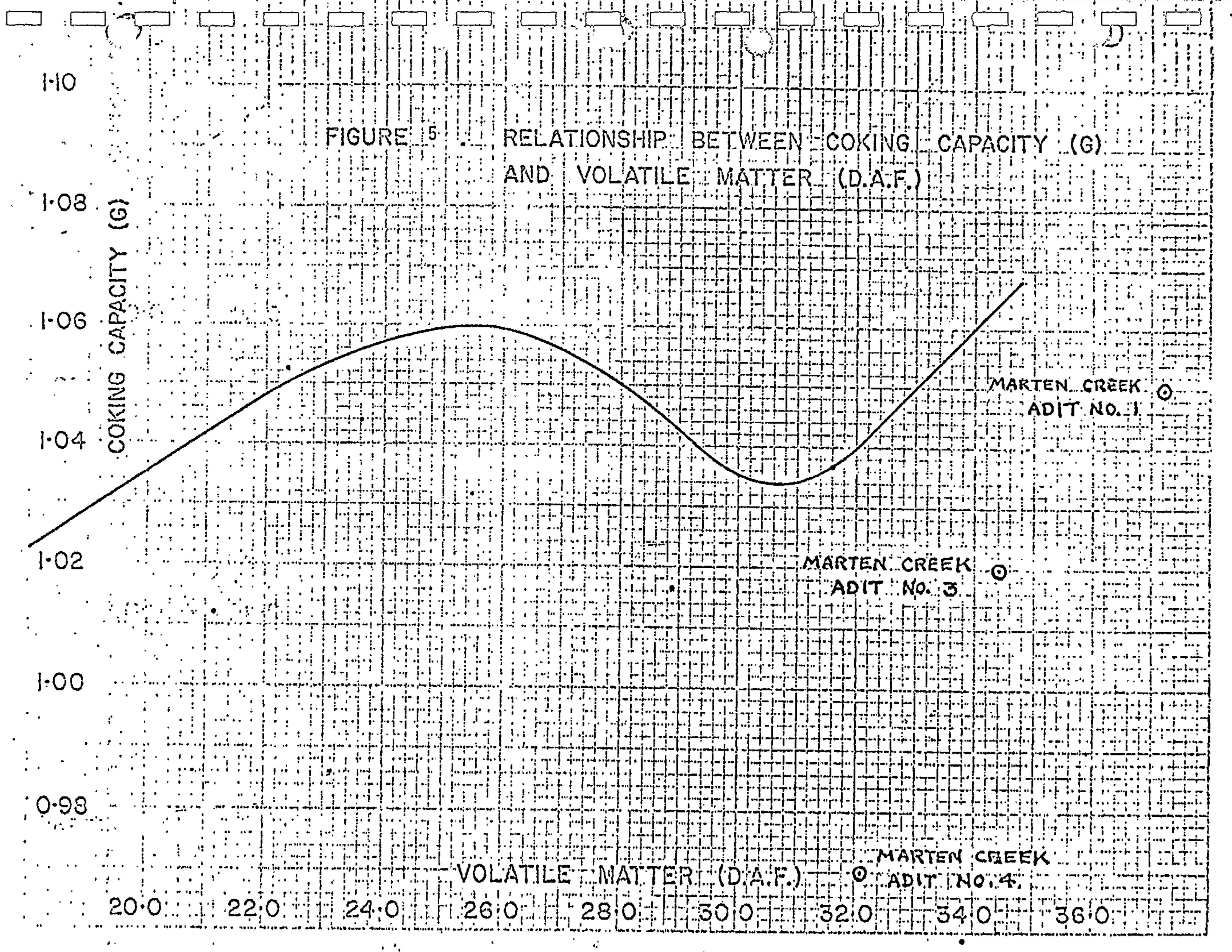
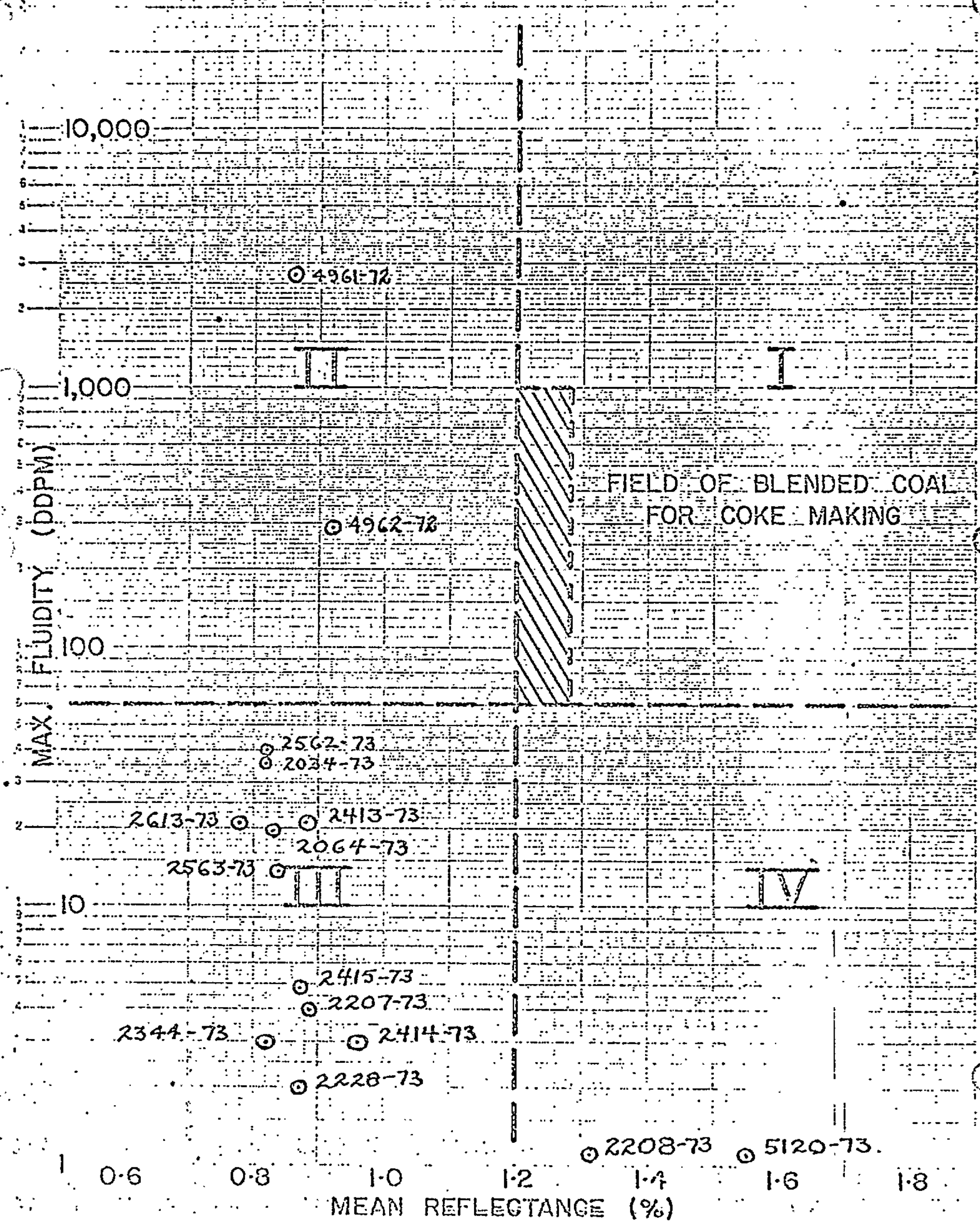


FIGURE 5 . RELATIONSHIP BETWEEN COKING CAPACITY (G) AND VOLATILE MATTER (D.A.F.)
COKING CAPACITY (G)
1·10
1·08
1·06
1·04
1·02
1·00
0·98
MARTEN CREEK ADIT NO. 1
MARTEN CREEK ADIT NO. 3
MARTEN CREEK ADIT NO. 4
VOLATILE MATTER (D.A.F.)
20·0
22·0
24·0
26·0
28·0
30·0
32·0
34·0
36·0

Figure 6 RELATIONSHIP BETWEEN MAX. FLUIDITY AND MEAN REFLECTANCE.



ACKNOWLEDGEMENT

The authors are grateful to the Fuels Research Centre for the chemical analyses of the coal and coke samples.

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MARTEN CREEK ADITS
1, 2 & 3

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MINES BRANCH

OTTAWA

Fuels Research Centre
Divisional Report FRC 73/75 RCCC

EVALUATION OF COAL SAMPLES FROM KAISER RESOURCES LTD. 1972 EXPLORATION PROGRAMME PART II MARTEN CREEK - LOCATIONS OF ADITS 1 AND 3 MARTEN CREEK COAL AREA

by

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November 1973

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by

B. N. Nandi* and D. S. Montgomery**

This Part II of the present report is in continuation of our previous Report No. FRC 73/70 RCCC, November 1973 and gives an interpretation of some of the data in MREC Report No. 73/92. (1)

SAMPLES

Marten Creek Adits 1 and 3 were obtained from MREC in one pound bags.

PART II - STUDIES ON THE MARTEN CREEK COALS

DISCUSSION

MARTEN CREEK COAL ADIT 1

The proximate analysis and reflectance measurement in oil indicate that this coal is classified as high volatile bituminous A (ASTM Standard). The dilatation of 81, Free Swelling Index of 8 and Plasticity of 2700 dd/m from Giesler Plastometer indicate that this is a high fluid coal. The plasticity of 0.61 from dilatometer test is well above the minimum acceptance level of 0.15.

The petrographic analysis shows that the sample contains 72.5% vitrinite and 7.4% exinite and very low inertinite (fusinite and semi-fusinite) content of 20%. Exinite generally produces high fluidity on carbonization. Assessing these factors the indications are that this is a high volatile and highly fluid coal that will produce porous coke of low ASTM Stability Index because the pores or cavities in the coke will be large and numerous and the cell walls in the coke will tend to be thin. It should however be an excellent

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coal for blending with low volatile coal.

Microscopic Examination of Semi-Coke

Microscopic examination of semi-coke shows good bonding between fused vitrinite and oxidized vitrinite, fusinite and partially oxidized vitrinite (see Figures 1 and 2). High volatile coal produces grain structure and in the case of partially oxidized vitrinite very little grain formation can be observed (see Figure 1). The large pores or cavities are generally obtained in the coke from highly fluid coal (see Figure 2). The structure of semi-coke indicates that this is a good coke but may have poor stability index because of the presence of large proportion of large pores.

Microscopic Examination of High Temperature Coke

The high temperature coke from Marten Creek Coal Adit 1 was produced in the 500-lb movable wall coke oven at 1000°C. The structure shown in Figure 3 indicates the formation of well developed grains with good bonding and fusion. In Figure 4, the structure of the high temperature coke possesses good fusion between fusinite and semi-fusinite in normal reflected light. With crossed nicols and gypsum compensator, the same left hand maceral (SF), which was considered as semi-fusinite in Figure 4, appears to be fused vitrinite with grain structure (see Figure 5). The grain structure of coke is also formed in the semi-fusinite (SF) shown in Figure 5. Some of the oxidized vitrinites in this coal are not completely inert because this so-called inert oxidized vitrinite softens and forms cavities or pores (see Figure 6, (O.V.) owing to the evolution of gases at about 400°C. Fully oxidized vitrinite can be classified as inerts because it neither softens nor melts even at 1000°C. This high temperature coke from cauliflower end (see Figure 6) shows very good fusion and bonding between the reactives and inert macerals. Because of larger pore size in this coke which (originated in part from the presence of exinite) it is assumed that the strength and the stability index of this coke would be lower than that of good metallurgical coke produced from blended coals. The stability factor of the Marten Creek Adit 1 coke from the 500-lb movable wall oven was 42.7 which is low, probably for the reasons indicated by the microscopic examination.

MARTEN CREEK ADIT 3

This coal possesses similar proximate analysis and dilatometric properties as Marten Creek Adit 1. Petrographic analysis shows that the vitrinite content is 6.5% higher and exinite content is 5% lower than Marten Creek Adit 1. But the total proportion of reactive macerals remains the same. Maximum fluidity (290 dd/m) and dilatation 49% are much lower than those of Marten Creek Adit 1. The slightly low fluidity in this high volatile A rank coal indicates that this coal will produce a slightly better coke than Marten Creek Adit 1.

Microscopic Analysis of Coal

About 5% of the vitrinite shows fissures and cracks of the same type previously reported in Lodge Pole Adit 2 in Report FRC 73/72 (2), Part I (see Figure 8). The exinites are mostly associated with fusinite and micrinite (see Figure 9) and on heating to about 350-400°C, the fluidity of exinite helps to wet the inert macerals and some of the oxidized vitrinite. In Lodge Pole Adit 1 the exinite was totally absent because of its high rank.

Microscopic Examination of Semi-Coke

The presence of pyrites in the nonfused mass of vitrinite (Figure 10) indicates that possibly the pyrites were deposited in the cracked vitrinite which was oxidized in situ after the formation of coal. (2). Microscopic examination of semi-coke shows the presence of partially oxidized vitrinite in the semi-coke structure (see Figure 10). The bonding between oxidized (OV), partially oxidized (POV) and fused vitrinites is very strong (see Figures 10 and 11) and does not show any cracks or fissures in the semi-coke. It also appears from those micrographs (Figures 10 and 11) that these partially oxidized vitrinites are not inerts like those in the Lodge Pole Adit 2 (2) because of the formation of pores and grainy structure in the coke. In Figure 11, the good bonding and fusion between semi-fusinite, fusinite, oxidized vitrinite and fused vitrinite indicate that this sample will produce good coke.

Microscopic Examination of High Temperature Coke

The high temperature coke was produced in the 500-lb movable wall coke oven and the ASTM Stability Index of this coke was 46.8. The oxidized vitrinite (OV) in Figure 12 cannot be rated as inert because pores and small cavities suggest the softening of this maceral and the evolution of gases from the surface on heating. A good bonding between the oxidized vitrinite (OV), partially oxidized vitrinite (POV), semi-fusinite (SF), fusinite (F) and fused vitrinite (FV) is shown in Figures 12 and 13. Well developed grain formation which is generally produced in the coke from good high volatile coals also indicates that this coal will produce better metallurgical coke than Marten Creek Adit 1. It seems from the structure of coke that most of the so-called oxidized vitrinite in the semi-coke or coke are mildly oxidized. This mild oxidation probably raised the stability of this coal to 46.8 as compared with the stability factor of Marten Creek Adit 1 of 42.7.

CONCLUSION

<u>Marten Creek Adit 1</u>

Marten Ridge Adit 1 is a high volatile bituminous A coal and has a vitrinite and exinite content of 72.5% and 7.4% respectively and the total reactive content of the coal is about 82%. Because of its high exinite content, the fluidity of this coal will be high and the determined value of the fluidity by Gieseler Plastometer is 2700 dd/m. The vitrinites in this coal are partially or mildly oxidized. Both semi-coke and high temperature coke possess good bonding and fusion between reactive and inert macerals. The content of inerts especially semi-fusinite is very low in comparison with other coals from the Crowsnest area. High volatile bituminous coal generally produce medium stability index and porous coke when carbonized alone. This coal if blended with Lodge Pole Adit 1 or Adit 3 coal should produce metallurgical coal of good stability index. This Marten Creek Adit 1 coal may be sold as premium coal to the Japanese market because Japanese coke makers have been seeking a high volatile, low ash and high fluid coal from Western Canada for a long time for blending.

<u>Marten Creek Adit 3</u>

The properties of this coal sample are very similar to those of Marten Creek Adit 1 except that the exinite content is 5% lower. Fissured or cracked vitrinites are present in this coal in a low proportion and this sample also contains more oxidized vitrinite and partially or mildly oxidized vitrinite than Marten Creek Adit 1. Because of its low exinite content and the presence of a high proportion of mildly oxidized vitrinite the fluidity of this coal is much lower (290 dd/m) in comparison with Marten Creek Adit 1. The stability index is highest in the high temperature coke possibly due to the low fluidity. It seems that some of the vitrinites are behaving as inerts due to oxidation. This is a good coal for the blending with low volatile coal in certain proportions.

Of these two samples from the Marten Creek area, Marten Creek Adit 1 is considered to be a premium coal which is being sought after by Japanese coke makers for its high volatile matter, high fluidity and low ash content.

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TABLE 1

PROXIMATE ANALYSIS

	Marten Creek Adit #1	Marten Creek Adit #3
Ash	7.8	7.3
Volatile matter	34.3 HVA	31.9 HVA
Fixed carbon	57.9	60.8
	100.0	100.0
Sulphur (db)	0.45	0.60
F.S.I.	8	8

TABLE 2

DILATOMETRIC TEST

Softening temperature θ_s °C	395	410
Contraction C	27	30
Max. temperature contraction θ_c °C	439	454
Dilatation	81	49
Max. temperature of dilatation	470	479
Plasticity index $\frac{C}{\theta_s - \theta_c}$	0.61	0.68

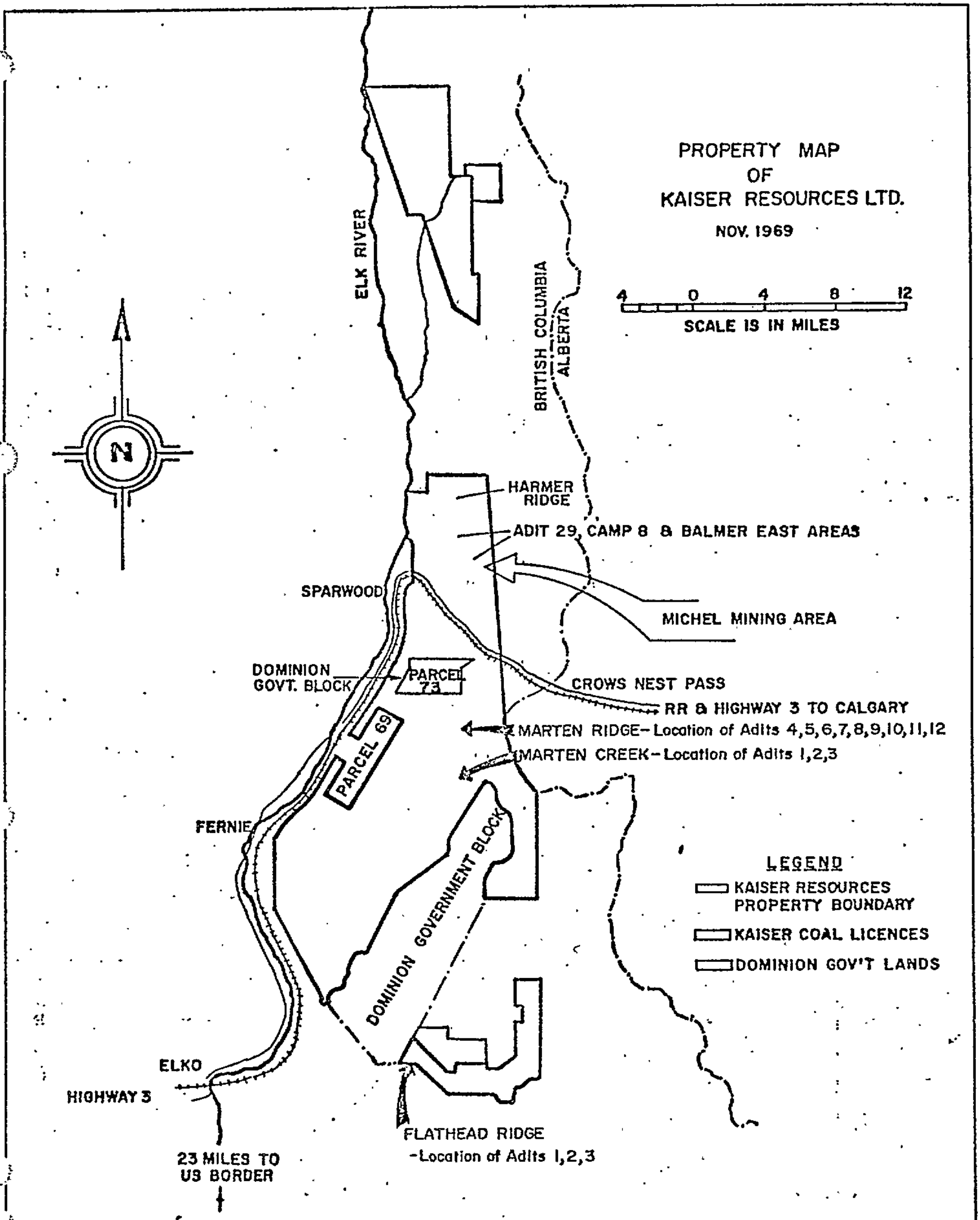
TABLE 3

PETROGRAPHIC ANALYSIS	%	%
Vitrinite	72.5	79.0
Exinite	7.4	2.5
Micrinite	4.2	3.4
Semi-fusinite	7.2	7.6
Fusinite	4.3	3.4
Mineral matter	4.4	4.1
	100.0	100.0
Mean max. reflectance in oil	0.86	0.92
Predicted stability index (ASTM)	32.0	35.0
Experimental stability index	42.4	46.8

TABLE 4

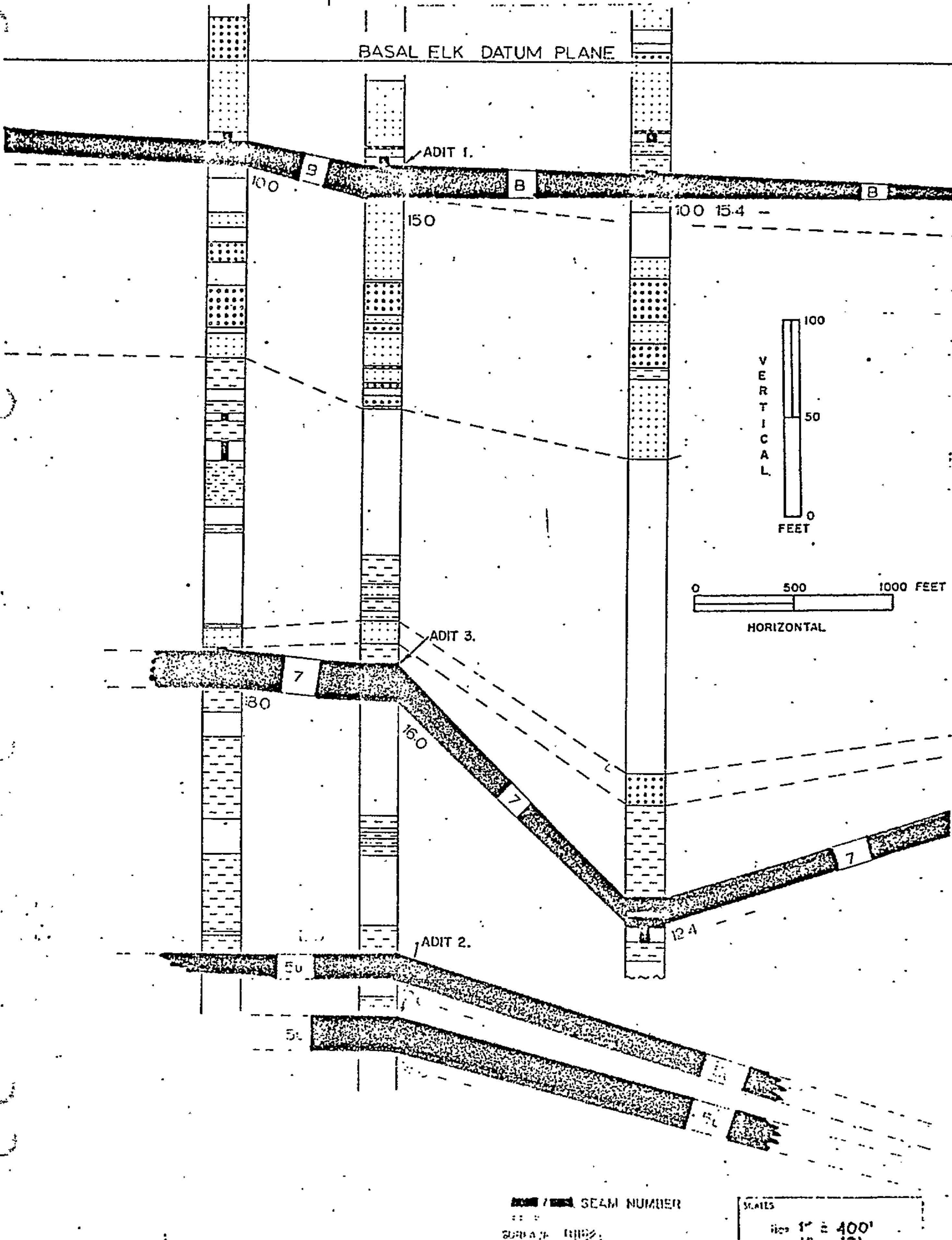
GIESELER PLASTICITY

		Marten Creek Adit #1	Marten Creek Adit #3
Start	°C	407	408
Fusion temperature	°C	420	424
Max. fluid temp.	°C	446	447
Final Fluid temp.	°C	474	474
Solidification temp.	°C	482	479
Melting range	°C	67	66
Max. fluidity dd/m		2700	290
Torque		40	40


PROPERTY MAP
OF
KAISER RESOURCES LTD.
NOV. 1969
4 0 4 8 12
SCALE IS IN MILES
ELK RIVER
BRITISH COLUMBIA
ALBERTA
N
HARMER RIDGE
ADIT 29, CAMP 8 & BALMER EAST AREAS
SPARWOOD
MICHEL MINING AREA
DOMINION GOVT. BLOCK
PARCEL 73
CROWS NEST PASS
RR & HIGHWAY 3 TO CALGARY
MARTEN RIDGE-Location of Adits 4,5,6,7,8,9,10,11,12
MARTEN CREEK-Location of Adits 1,2,3
PARCEL 69
FERNIE
DOMINION GOVERNMENT BLOCK
LEGEND
KAISER RESOURCES PROPERTY BOUNDARY
KAISER COAL LICENCES
DOMINION GOV'T LANDS
ELKO
HIGHWAY 3
FLATHEAD RIDGE
-Location of Adits 1,2,3
23 MILES TO US BORDER

MARTEN CREEK COAL AREA

CORRELATION CHART



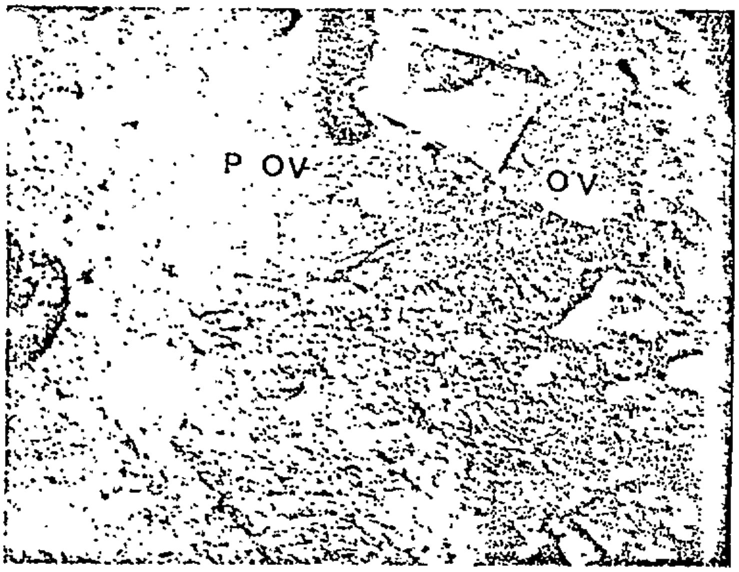


Figure 1. Semi-coke from Marten Creek Adit 1, POV - partially oxidized vitrinite, O.V. - oxidized vitrinite. X600

Figure 2. Semi-coke from Marten Creek Adit 1 F - Fusinite, O.V. Oxidized vitrinite.

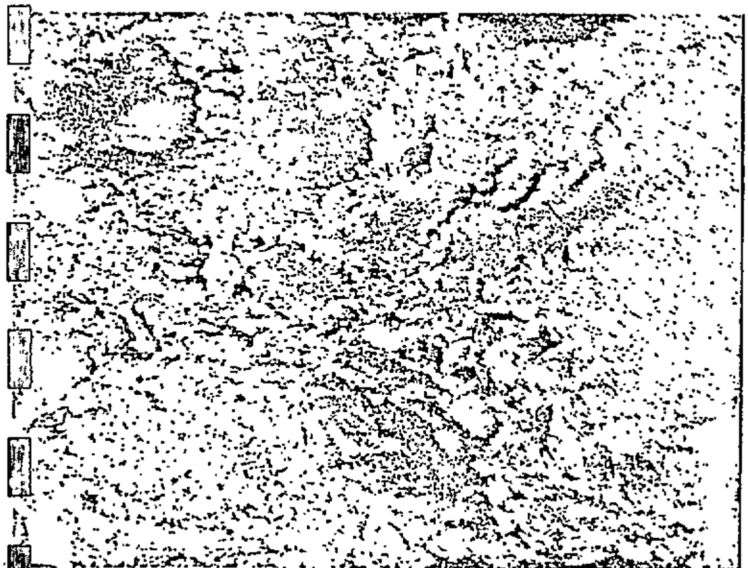


Figure 3. High temperature coke from Marten Creek Adit 1. X600

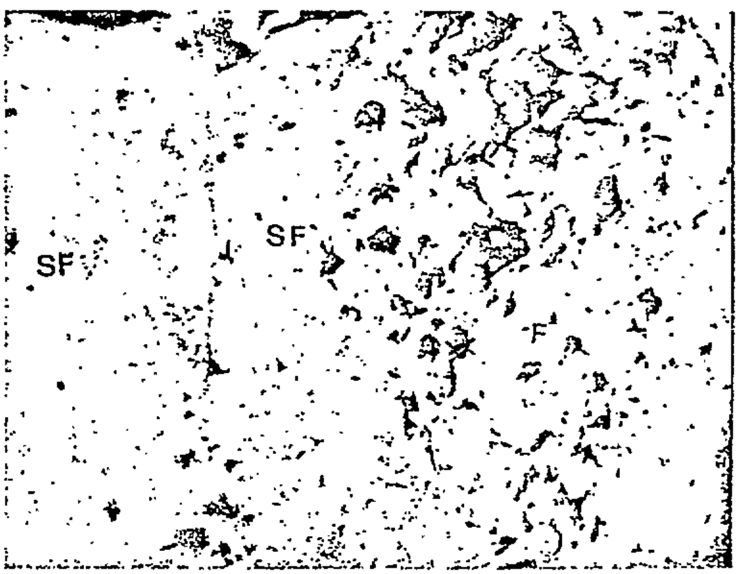


Figure 4. High temperature coke from Marten Creek Adit 1. S.F. Semi-fusinite, F - Fusinite. X600

Figure 5. Same as in Figure 4, F.V. - Fused vitrinite, S.F. - Semi-fusinite. X600 Crossed Nicols

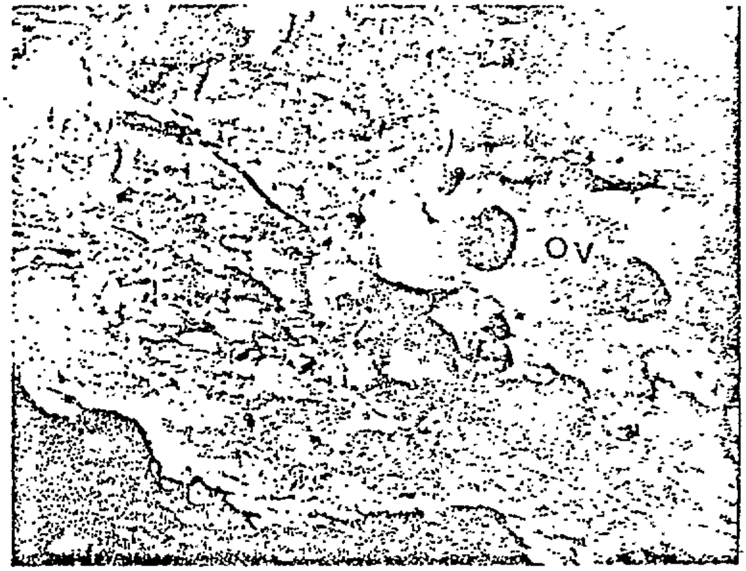


Figure 6. High temperature coke from Marten Creek Adit 1. O.V. Oxidized Vitrinite. X600 Crossed Nicol

Figure 7. High temperature coke from Marten Creek Adit 1. S.F. - Semi-fusinite. X250

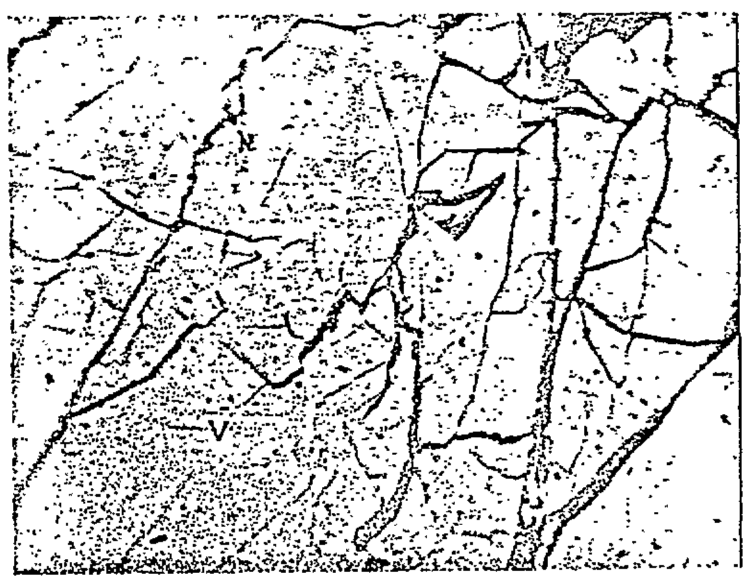


Figure 8. Marten Creek Adit 3 coal, cracked vitrinite. V-vitrinite.

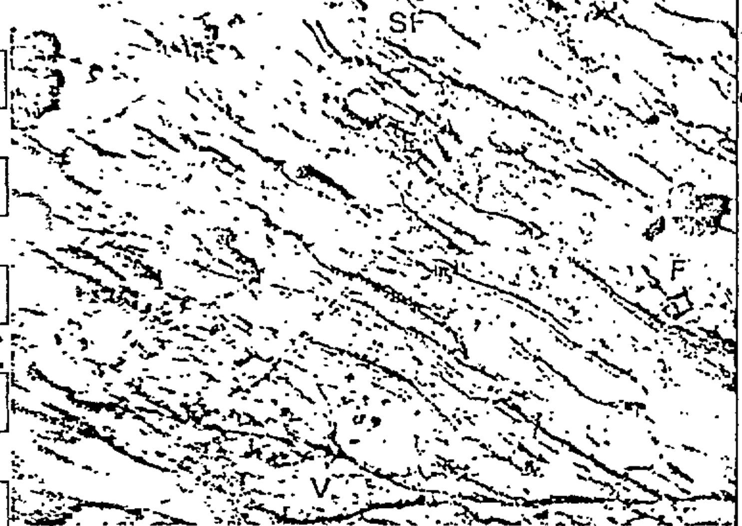


Figure 9. Marten Creek Adit 3 coal. Structure of exinite, and other macerals. E - exinite, V-vitrinite, F - fusinite, S.F. - Semi-fusinite.

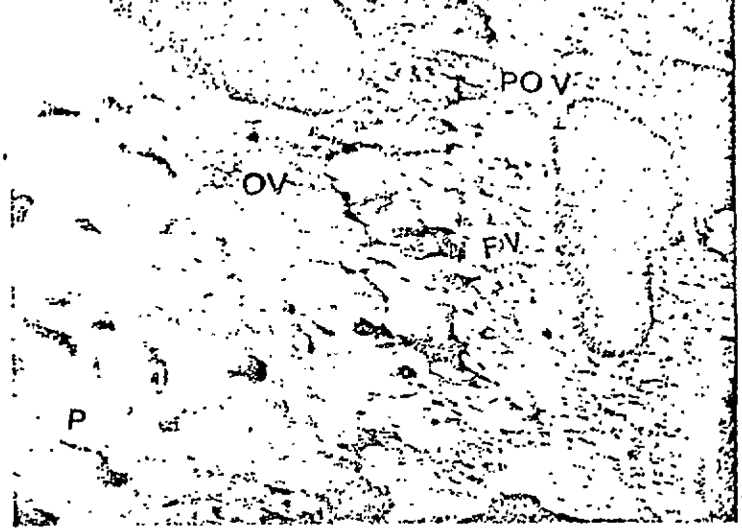


Figure 10. Semi-coke from Marten Creek Adit 3 O.V.-oxidized vitrinite, P.O.V. - partially oxidized vitrinite, F.V.-fused vitrinite, P-pyrites

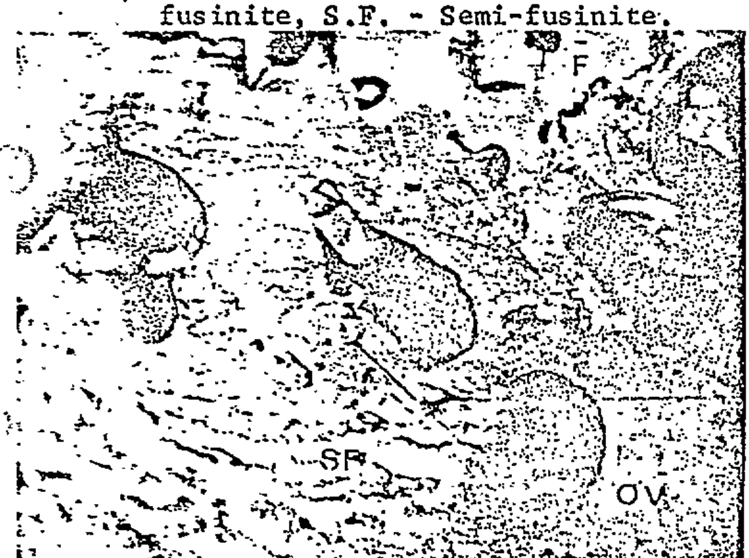


Figure 11. Semi-coke from Marten Creek Adit 3. S.F.-semi-fusinite, F.-fusinite O.V. oxidized vitrinite. X600

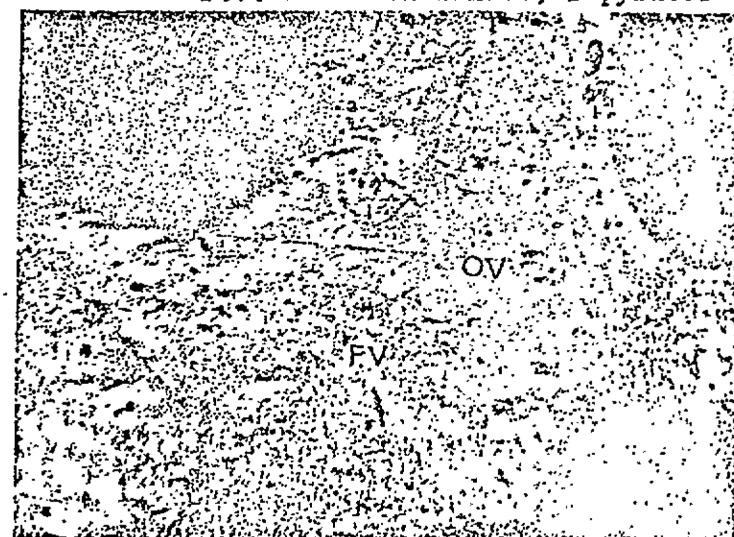


Figure 12. High temperature coke from Marten Creek Adit 3. O.V. oxidized vitri ite, F.V. - fused vitrinite. X600

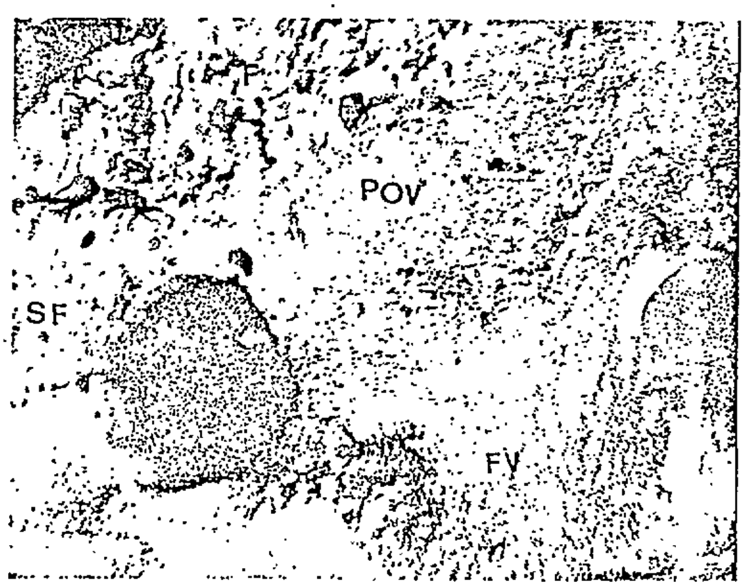


Figure 13. High temperature coke from Marten Creek coal Adit 3. F.-fusinite, S.F. semi-fusinite, P.O.V.-partially oxidized vitrinite, F.V.-fused vitrinite. X600

TABLE I

ANALYSIS OF B SEAM

MARTEN CREEK ADIT #1

X-CUT @ 125'; SEAM THICKNESS 14.4'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	19.0	7.9
Volatile Matter	%	33.7	38.6
Fixed Carbon	%	47.3	53.5
Free Swelling Index		6.5	7.0
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.66	0.71
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	386.0	381.0
Fusion Temp.	°C	406.0	408.0
Maximum Fluid Temp.	°C	448.0	447.0
Final Fluid Temp.	°C	447.0	476.0
Solidification Temp.	°C	481.0	483.0
Melting Range	°C		
Maximum Fluidity	ddm	2830.0	2350.0

TABLE II

SCREEN ANALYSIS

B SEAM ADIT #1 MARTEN CREEK

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	33.3	22.3	33.3	22.3
-3/8" + 28M	43.4	18.1	76.7	19.9
-28M + 100M	15.5	11.8	92.2	18.6
-100M + 0	7.8	17.3	100.0	18.5

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	11.8	28.2	11.8	28.2
-3/8" + 28M	50.2	18.3	62.0	20.2
-28M + 100M	21.1	15.4	83.1	19.0
-100M + 0	16.9	14.8	100.0	18.3

TABLE III

WASHABILITY STUDY OF B SEAM

MARTEN CREEK ADIT #1

X-CUT @ 125'; SEAM THICKNESS 14.4

SIZE & WT. %	SPECIFIC GRAVITY	% WT.	% ASH	% V.M.	% SUL.	CUMULATIVE FLOAT (%) WT.	CUMULATIVE FLOAT (%) ASH	CUMULATIVE FLOAT (%) V.M.	CUMULATIVE FLOAT (%) SUL.	±0.1 SP. GR.	Z
-28M + 100M (15.5%)	FLOAT 1.30	69.7	2.4	36.3	0.68	69.7	2.4				34.9
	1.30 -1.35	5.9	7.0	33.9	0.65	75.6	2.8				72.7
	1.35 -1.40	3.8	10.8	31.2	0.65	79.4	3.1			16.2	77.5
	1.40 -1.45	3.3	14.7	31.0	0.65	82.7	3.6				81.0
	1.45 -1.50	1.6	19.2	30.4	0.66	84.3	3.9			8.4	83.5
	1.50 -1.55	1.6	24.9	29.8	0.61	85.9	4.3				85.1
	1.55 -1.60	1.1	30.8	29.6	0.65	87.0	4.6			4.7	86.5
	1.60 -1.70	1.5	38.2	27.0	0.61	88.5	5.2			3.4	87.8
	1.70 -1.80	1.6	45.3	24.9	0.60	90.1	5.9				89.3
	SINK 1.80	9.9	66.0	18.8	0.21	100.0	11.8				95.1
Composite -4" + 28M (76.7%)	FLOAT 1.30	57.4	4.4			57.4	4.4				28.7
	1.30 -1.35	8.5	9.3			65.9	5.0				61.7
	1.35 -1.40	5.1	13.2			71.0	5.6			28.0	68.5
	1.40 -1.45	4.7	19.6			75.5	6.5				73.4
	1.45 -1.50	2.5	25.2			78.2	7.1			12.8	76.9
	1.50 -1.55	1.2	29.1			79.4	7.4				78.8
	1.55 -1.60	1.1	33.3			80.5	7.8			5.2	80.0
	1.60 -1.70	1.6	41.9			82.1	8.4			4.2	81.3
	1.70 -1.80	1.5	48.4			83.6	9.2				82.9
	SINK 1.80	16.4	74.4			100.0	19.9				91.8
-4" + 3/8" (33.3%)	FLOAT 1.30	51.1	5.7	38.5	0.64	51.1	5.7				25.6
	1.30 -1.35	8.3	9.9			59.4	6.3				55.3
	1.35 -1.40	6.2	13.2			65.6	6.9			30.0	62.5
	1.40 -1.45	6.5	19.6			72.1	8.1				68.9
	1.45 -1.50	3.8	25.2			75.9	8.9			15.8	74.0
	1.50 -1.55	1.4	30.2			77.3	9.3				76.6
	1.55 -1.60	1.4	34.2			78.7	9.8			5.9	78.0
	1.60 -1.70	2.1	41.6			80.8	10.6			4.8	79.8
	1.70 -1.80	1.9	51.9			82.7	11.5				81.8
	SINK 1.80	17.3	73.8			100.0	22.3				91.4

TABLE III (cont'd)

WASHABILITY STUDY OF B SEAM

MARTEN CREEK ADIT #1

X-CUT @ 125'; SEAM THICKNESS 14.4

SIZE & WT. %	SPECIFIC GRAVITY	% WT.	% ASH	% V.M.	% SUL.	CUMULATIVE FLOAT (%) WT.	CUMULATIVE FLOAT (%) ASH	CUMULATIVE FLOAT (%) V.M.	CUMULATIVE FLOAT (%) SUL.	±0.1 SP. GR.	Z
-3/8" + 28M (43.4%)	FLOAT 1.30	62.2	3.6	33.3	0.79	62.2	3.6				31.1
	1.30 -1.35	8.7	8.8	31.5	0.76	70.9	4.4				66.6
	1.35 -1.40	4.3	13.2	29.2	0.74	75.2	4.9			21.1	73.1
	1.40 -1.45	3.4	19.7	27.8	0.78	78.6	5.5				76.9
	1.45 -1.50	1.4	25.3	27.5	0.80	80.0	5.9			7.9	79.3
	1.50 -1.55	1.0	27.8	26.4	0.68	81.0	6.1				80.5
	1.55 -1.60	0.9	32.2			81.9	6.4			3.8	81.5
	1.60 -1.70	1.3	42.3			83.2	6.9			2.8	82.6
	1.70 -1.80	1.1	43.8			84.3	7.5				83.8
	SINK 1.80	15.7	74.9			100.0	18.1				92.2
Composite -4" + 100M (92.2%)	FLOAT 1.30	59.4	4.0			59.4	4.0				29.7
	1.30 -1.35	8.1	9.0			67.5	4.6				63.4
	1.35 -1.40	4.9	12.9			72.4	5.2			23.4	70.0
	1.40 -1.45	4.5	19.0			76.9	6.0				74.7
	1.45 -1.50	2.3	24.5			79.2	6.5			10.9	78.0
	1.50 -1.55	1.3	28.2			80.5	6.9				79.9
	1.55 -1.60	1.1	32.9			81.6	7.2			4.7	81.0
	1.60 -1.70	1.6	41.3			83.2	7.9			3.9	82.4
	1.70 -1.80	1.5	47.8			84.7	8.6				84.0
	SINK 1.80	15.3	73.5			100.0	18.5				92.4
	FLOAT 1.30										
	1.30 -1.35										
	1.35 -1.40										
	1.40 -1.45										
	1.45 -1.50										
	1.50 -1.55										
	1.55 -1.60										
	1.60 -1.70										
	1.70 -1.80										
	SINK 1.80										

TABLE IV

B SEAM MARTEN CREEK ADIT #1

LABORATORY FROTH FLOTATION TEST

SIZE & WT. %	TIME SEC.	FROTH WT. %	FROTH ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-28M + 100M (15.5%)	0 - 30	82.7	6.5	82.7	6.5
	30 - 60	4.6	9.0	87.3	6.6
	60 - 90	1.0	11.3	88.3	6.7
	90 - 120				
	120 - 150				
	TAILINGS	11.7	47.9	100.0	11.5
-100M + 0 (7.8%)	0 - 30	50.5	6.8	50.5	6.8
	30 - 60	19.0	10.0	69.5	7.7
	60 - 90	7.5	14.1	77.0	8.3
	90 - 120	4.2	17.6	81.2	8.8
	120 - 150	3.3	25.2	84.5	9.4
	TAILINGS	15.5	60.1	100.0	17.3

Test Condition

Two hundred gms. of coal floated in 3,000 c.c. WEMCO laboratory cell at 6.6% pulp density. Three drops of kerosene used as a conditioner and one drop of MIBC as a frother.

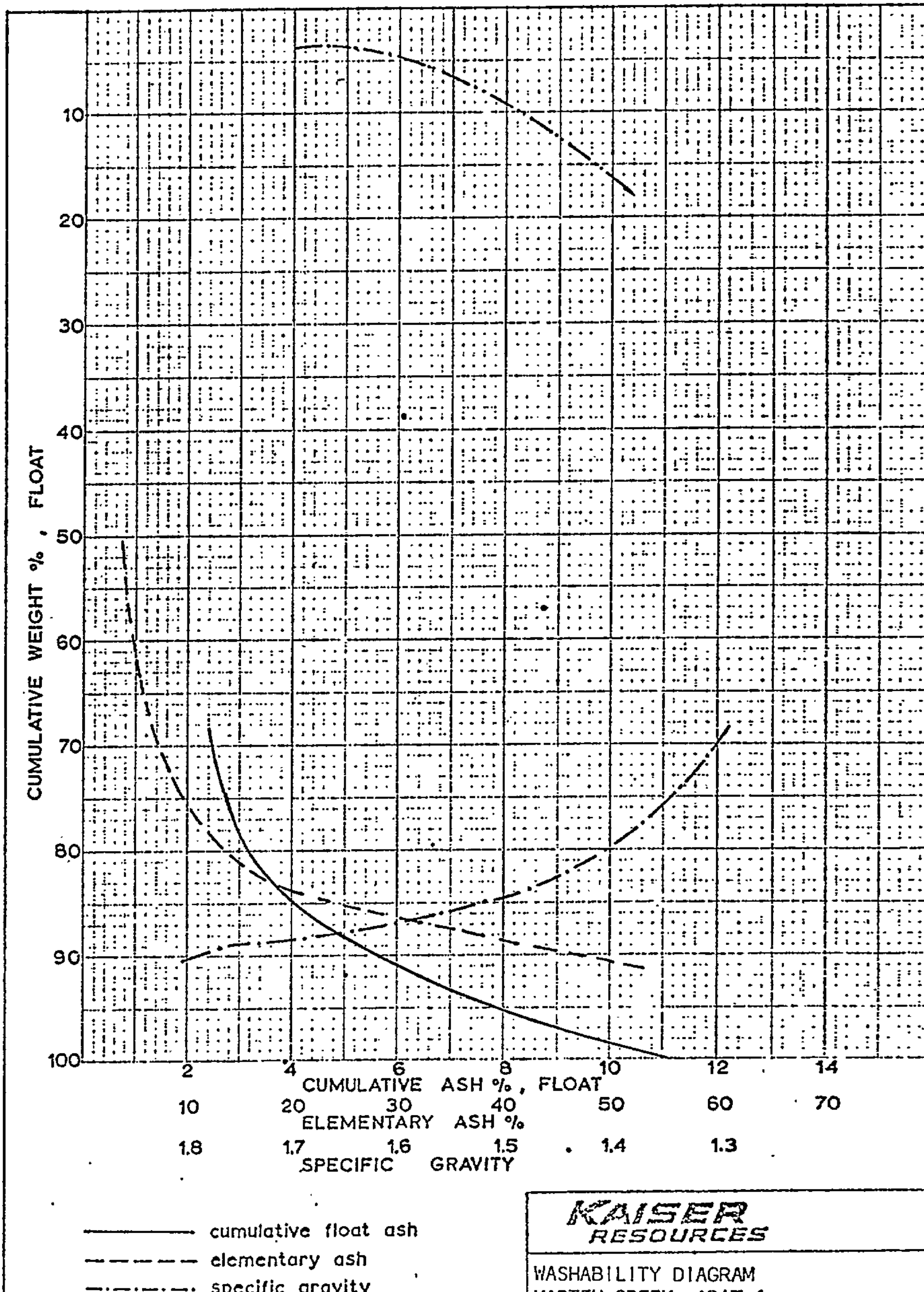
TABLE V

B SEAM, MARTEN CREEK, ADIT #1

YIELD VS. ASH

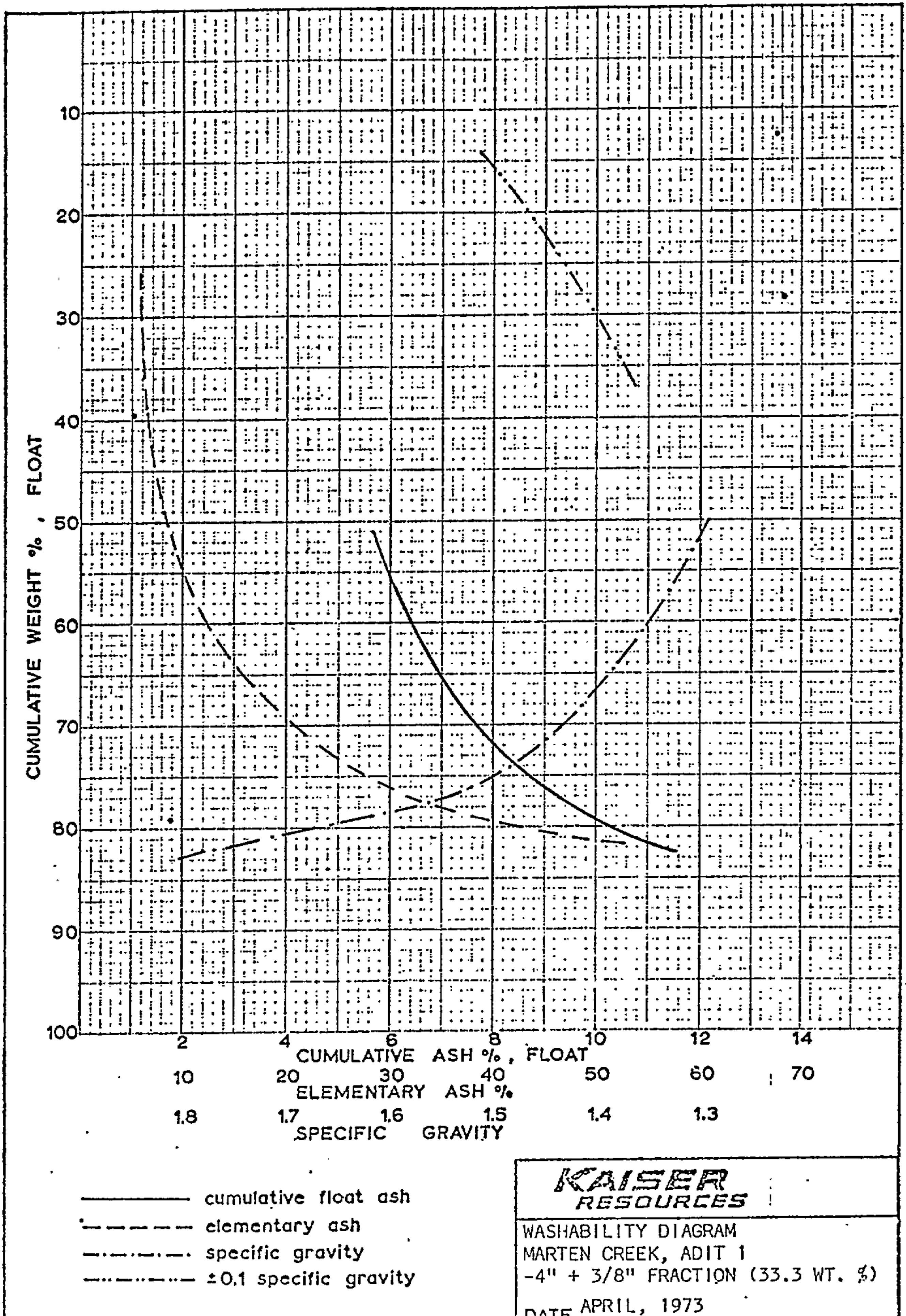
BASIS: Gravity separation of -4" + 100M fraction and froth flotation of -100M x 0 fraction.

-4" + 100M (92.2%)				100M x 0 (7.8%) 84.5% YIELD @ 9.4 ASH		COMPOSITE	
S.G.	CUM. WT. %	YIELD WT. % X .922	ASH %	YIELD 7.8 x 84.5	ASH %	YIELD	ASH %
		a	•	b		a + b	
1.30	59.4	54.8	4.0	6.6	9.4	61.4	4.6
1.35	67.4	62.1	4.6	6.6	9.4	68.7	5.1
1.40	72.4	66.8	5.2	6.6	9.4	73.4	5.6
1.45	76.9	70.9	6.0	6.6	9.4	77.5	6.3
1.50	79.2	73.0	6.5	6.6	9.4	79.6	6.7
1.55	80.5	74.2	6.9	6.6	9.4	80.8	7.1
1.60	81.6	75.2	7.2	6.6	9.4	81.8	7.4
1.70	83.2	76.7	7.9	6.6	9.4	83.3	8.0
1.80	84.7	78.1	8.6	6.6	9.4	84.7	8.7
TOTAL	100.0	92.2	18.5	7.8	17.3	100.0	18.4



KAISER RESOURCES

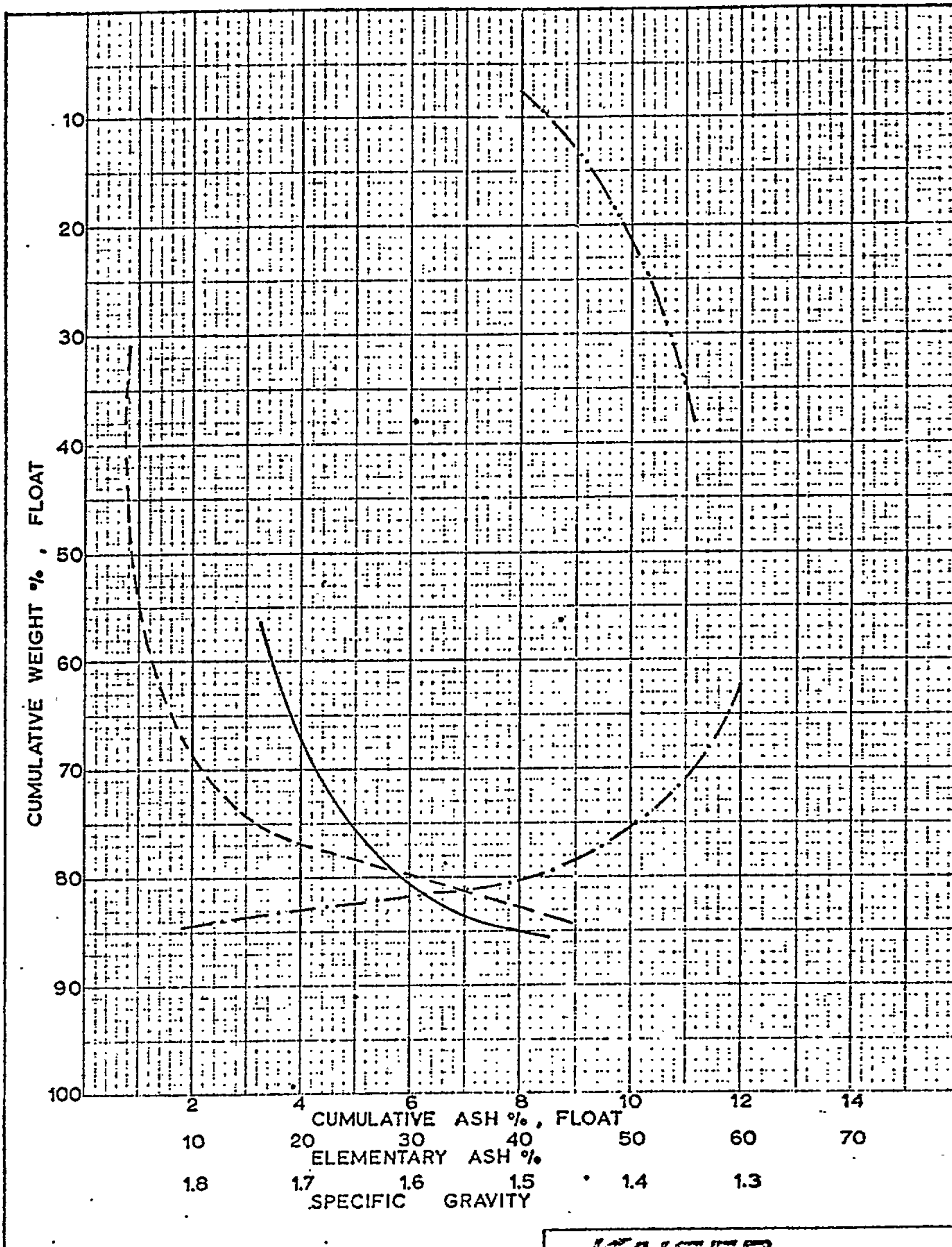
WASHABILITY DIAGRAM
MARTEN CREEK, ADIT 1
-28M + 100M FRACTION (15.5 WT. %)
DATE APRIL, 1973



KAISER RESOURCES

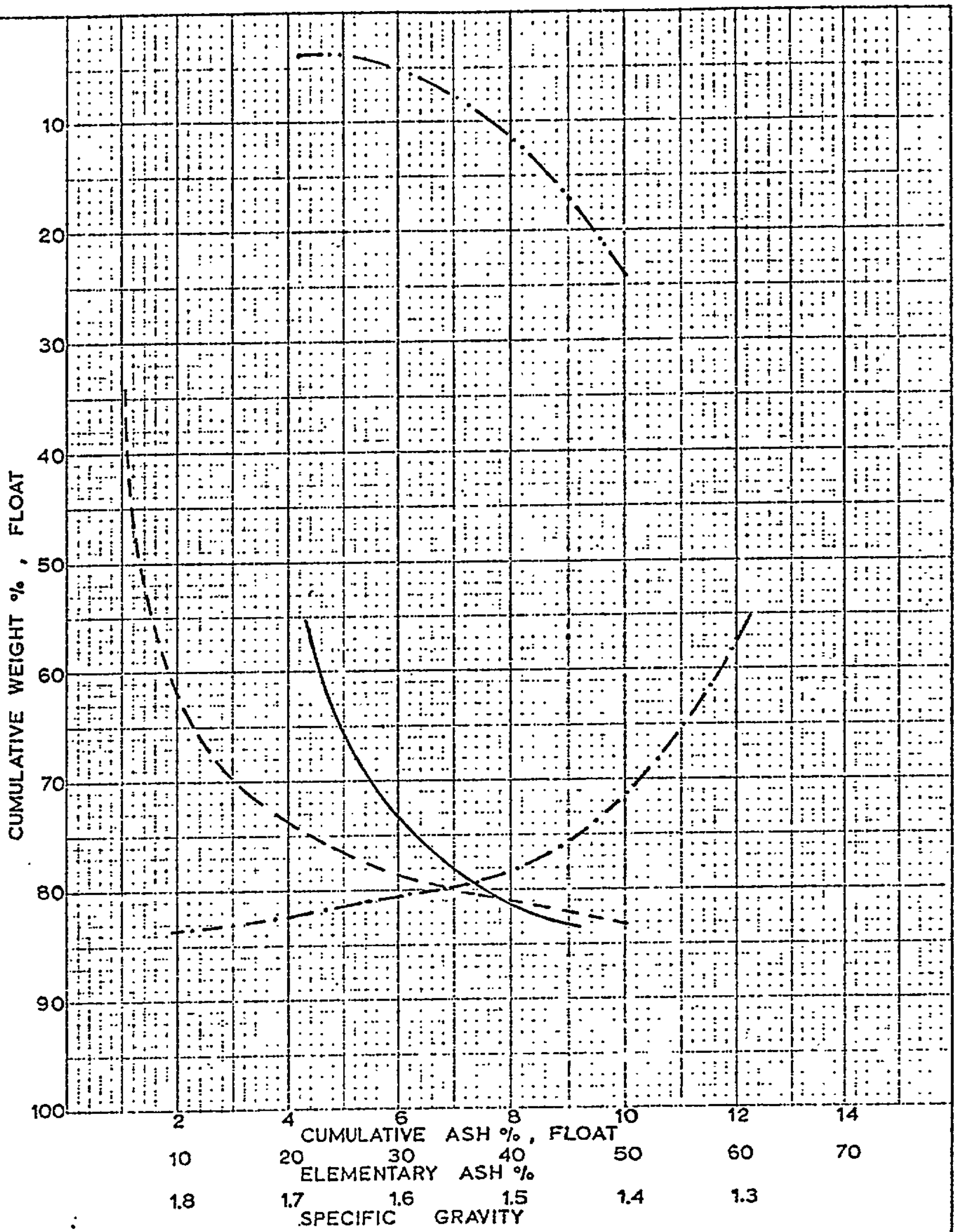
WASHABILITY DIAGRAM
MARTEN CREEK, ADIT 1
-4" + 3/8" FRACTION (33.3 WT. %)

DATE APRIL, 1973



KAISER RESOURCES

WASHABILITY DIAGRAM
MARTEN CREEK, ADIT 1
-3/8" + 28M FRACTION (43.4 WT. %)
DATE APRIL, 1973

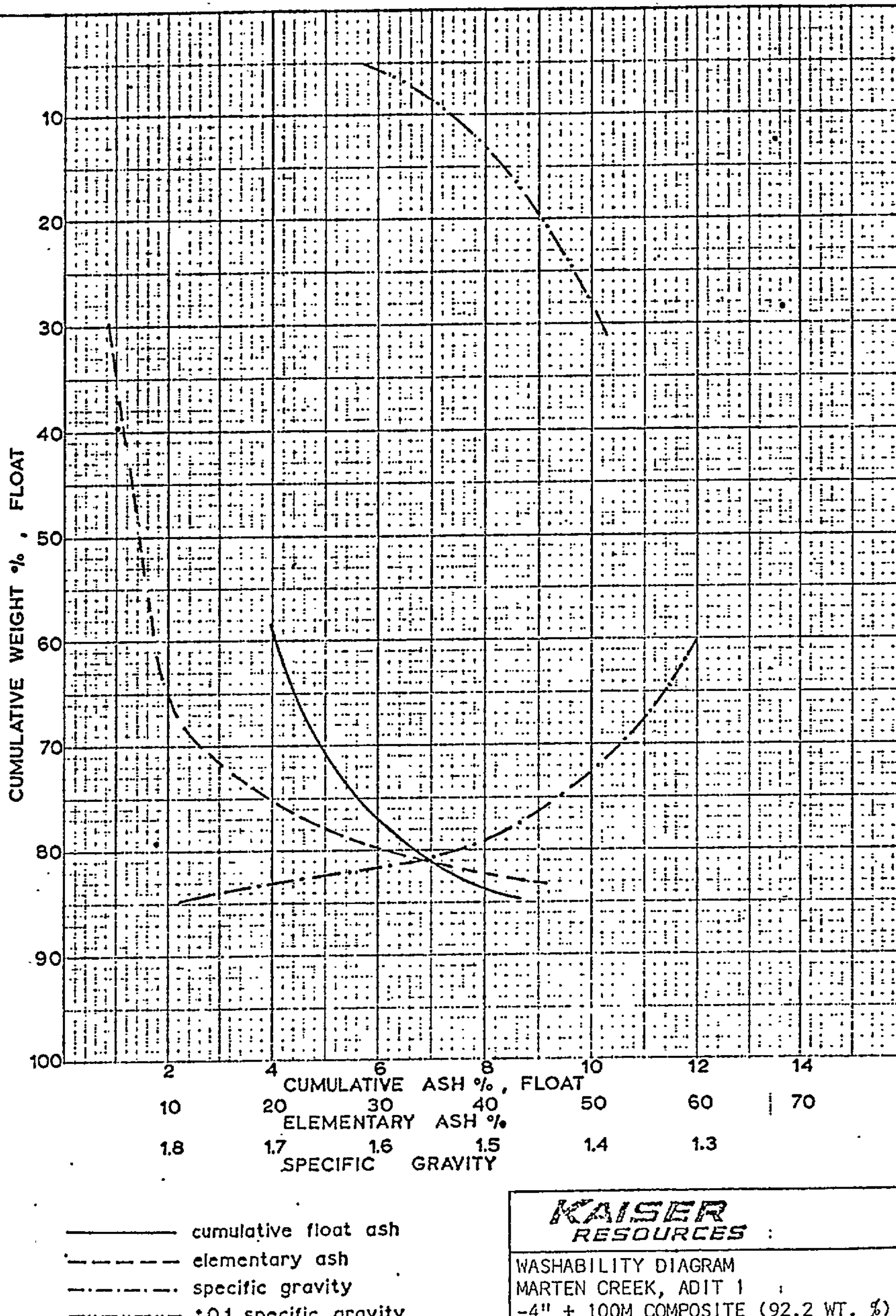


cumulative float ash
elementary ash
specific gravity
±0.1 specific gravity

KAISER RESOURCES

WASHABILITY DIAGRAM
MARTEN CREEK, ADIT 1
-4" + 28M COMPOSITE (76.7 WT. %)

DATE APRIL, 1973



KAISER RESOURCES

WASHABILITY DIAGRAM
MARTEN CREEK, ADIT 1
-4" + 100M COMPOSITE (92.2 WT. %)

DATE APRIL, 1973

TABLE I

ANALYSIS OF #5 SEAM
MARTEN CREEK ADIT #2
X-CUT @ 140 FT. SEAM THICKNESS 18.1 FT.

			RAW COAL	CLEAN COAL
Proximate Analysis (db)				
Ash	%		40.2	14.4
Volatile Matter	%		22.3	33.0
Fixed Carbon	%		37.5	52.6
Free Swelling Index			1.0	5.0
Gross Calorific Value (dmmfb)				
Btu Per Pound				
Ultimate Analysis (db)				
Carbon	%			
Hydrogen	%			
Sulphur	%		0.37	0.78
Nitrogen	%			
Ash	%			
Oxygen (by difference)	%			
Ash Fusion				
Initial Deformation Temp.	IT			
Softening Temp.	ST			
Fluid Temp.	FT			
Grindability				
Hardgrove Index				
Giesler Plasticity				
a Start	°C	(1ddm)	413.0	422.0
b Fusion Temp.	°C	(5ddm)	430.0	437.0
c Maximum Fluid Temp.	°C		449.0	450.0
d Final Fluid Temp.	°C	(1ddm)	470.0	467.0
e Solidification Temp.	°C		476.0	471.0
f Melting Range	°C	(d-a)	57.0	49.0
g Maximum Fluidity	ddm		74.0	11.5

TABLE II

SCREEN ANALYSIS

#5 SEAM ADIT #2 MARTEN CREEK

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	15.5	39.8	15.5	39.8
-3/8" + 28M	39.5	40.7	55.0	40.4
-28M + 100M	30.5	39.3	85.5	40.0
-100M + 0	14.5	30.4	100.0	38.6

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	2.4	40.8	44.3	40.8
-3/8" + 28M	41.9			
-28M + 100M	35.0	37.9	79.3	39.5
-100M + 0	20.7	32.4	100.0	38.0

Note: Coal being extremely friable, it was impossible to run washabilities on raw coal. Therefore, the coal was put through attrition tests and washabilities run on +28M, 28M + 100M and -100 + 0 as shown in Table III.

TABLE I

ANALYSIS OF #7 SEAM
MARTEN CREEK ADIT #3
X-CUT @ 80'; SEAM THICKNESS 28.1'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	22.7	7.2
Volatile Matter	%	28.5	32.2
Fixed Carbon	%	48.8	60.6
Free Swelling Index		6.5	7.5
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.54	0.62
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	392	393°
Fusion Temp.	°C	415	422
Maximum Fluid Temp.	°C	454	454
Final Fluid Temp.	°C	477	477
Solidification Temp.	°C	481	482
Melting Range	°C	62°	55°
Maximum Fluidity	ddm	295	175

TABLE II

SCREEN ANALYSIS

7 SEAM ADIT #3 MARTEN CREEK

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	5.3	50.7	5.3	50.7
-3/8" + 28M	45.2	29.3	50.5	31.5
-28M + 100M	32.6	14.2	83.1	24.7
-100M + 0	16.9	13.6	100.0	22.9

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	2.3	53.4	2.3	53.4
-3/8" + 28M	42.1	32.5	44.4	33.6
-28M + 100M	34.3	16.9	78.7	26.3
-100M + 0	21.3	10.7	100.0	22.9

LODGE POLE –
FLATHEAD AREA

D-CAN-5.15

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MINES BRANCH

OTTAWA

FUELS RESEARCH CENTRE

DIVISIONAL REPORT FRC 73/70 RCCC

EVALUATION OF COAL SAMPLES FROM KAISER RESOURCES LTD. 1972 EXPLORATION PROGRAMME

PART I - FLATHEAD RIDGE - LOCATIONS OF ADITS 1, 2 and 3. WEST LODGE POLE AREA

by

B. N. Nandi and D. S. Montgomery

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INTRODUCTION

In July, 1973, Mr. J. B. Murphy, Chief Geologist, Kaiser Resources Ltd. requested an assessment of the coke-making potential resulting from their 1972 exploration programme. These samples were first sent to Metals Reduction and Energy Centre of Mines Branch for the 500-lb coke oven test and chemical, physical and petrographic analysis. MREC Report[1] No. 73/92 by J. Botham, W. Gardiner, J.G. Jorgenson and T. A. Lloyd dated October, 1973, describing the coke oven test was subsequently forwarded to Kaiser Resources Ltd. A request was then made by Mr. Murphy for an assessment of the coal quality based upon the petrographic analysis and a study of the coking behaviour of the different macerals as deduced from the microscopic examination of semi-coke prepared at 550°C obtained from the Ruhr dilatometer test and other physical and chemical analyses. It was agreed that the format of presentation was to conform with that previously reported on coal samples submitted in 1971-72 and reported in FRC Reports (2, 3, 4 and 5).

SAMPLES

The following samples of coal were received from MREC, in one pound plastic bags. The description of the samples, and sampling station locations were sent by Mr. Murphy in a separate letter. For convenience these data are tabulated below:

1. Flathead Ridge described as Lodge Pole area Adits 1, 2 and 3.
2. Marten Creek Adits 1 and 3.
3. Marten Ridge Adits 4, 5, 6, 7, 9, 10, 11 and 12.

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These samples were taken from three locations within the Crowsnest coal field. These three locations - which are shown on the property map (Figure 1) and (1) Flathead Ridge, (2) Martin Creek and (3) Martin Ridge. The positions and thickness of the seams are shown in the correlation charts (Figures 2a, 2b and 2c). The top of the Moose Mountain member as shown in the correlation charts represents the base or the bottom of the coal measures. The basal Elk member represents the upper portion but not the top of the Kootenay formation.

This report will be written in 3 parts and will be submitted separately:

Part 1. Studies on the Flat Ridge Coals.

Part 2. Studies on the Martin Creek Coals.

Part 3. Studies on Martin Ridge Coals.

Part I - Studies on the Flathead Ridge Coals

Lodge Pole Adit 1

Lodge Pole Adit 2

Lodge Pole Adit 3 (marked as Flathead Ridge Adit 3).

Evaluation Procedure and Results

a) Proximate analysis, calorific value, microscopic examination

Maceral analysis and reflectance measurements were carried out by MREC of Mines Branch according to ASTM specifications. The Ruhr dilatometric test was done according to German specifications DIN 51739. The results are given in Tables 1, 2 and 3.

b) Microscopic examination of semi-coke

In order to understand the coking character, the structure of the coke and the state of oxidation in vitrinite, the semi-coke produced in the Ruhr dilatometer at 550°C was polished and examined microscopically with a reflected light microscope at 600 magnification in oil. This examination will show the nature of bonding of the vitrinite, that is to say, the extent to which this maceral itself has fused and how well it is bonded to and fused with the inert macerals such as the fusinite, semi-fusinite and mineral matter. This examination will reveal the reactive nature and formation of coke in the semi-fusinite and also the non-reactive nature of oxidized vitrinite.

Lodge Pole Adit 1

The proximate analysis and the reflectance of the vitrinite in oil indicate that the coal is a low volatile bituminous coal. This coal does not show any dilatation but it possesses a good contraction and plasticity index of 0.47. The plasticity index value is very well above the minimum acceptable limit of 0.15. Maceral analysis shows that this coal has 46.6% vitrinite and 34.5% semi-fusinite and the reactives to inerts ratio (according to Shapiro and Gray method) is 58:42. The indications from these results are that this coal will produce coke.

Detailed microscopic examination of the macerals in Lodge Pole 1 coal shows that the vitrinite in this coal is well developed and free from cracks or fissures. In some cases it is difficult to differentiate vitrinite from semi-fusinite. This is well illustrated in Figure 3 which shows that this maceral actually contains both vitrinite (V) and semi-fusinite (S.F.). This is observed by using crossed nicols prisms and a gypsum compensator. The vitrinite part remains unchanged in appearance but the laminar structure of the semi-fusinite stands out as shown in Figure 4. Further, the high reflectance areas of fusinite can be seen on the left side and semi-fusinite on the right side. In Figure 5, the reflectances of both vitrinite (left) and semi-fusinite are practically the same. The cellular structure of semi-fusinite (S.F.) in this Figure is not well developed. When observed with crossed nicols and gypsum compensator it is easier to differentiate vitrinite and semi-fusinite. According to some North American coal petrographers the right hand side maceral in Figure 5 is considered to be pseudo-vitrinite, in reality this so-called pseudo-vitrinite is nothing but semi-fusinite as observed in the Figure 6 (right hand side).

In this coal there are low and high reflectance semi-fusinites as shown in Figure 7. The structure of the low reflectance semi-fusinite (left hand side and right side marked S.F.) appeared to be high reflectance vitrinite. On examining with crossed nicols and gypsum compensator, the structure of high reflectance semi-fusinite looks like fusinite whereas the vitrinitic-like structure appears to be semi-fusinite.

This is a very difficult coal from the point of view of maceral identification as these can only be identified under crossed nicols. Identification of the macerals for point counting is therefore very time consuming to obtain the accurate analytical data. It is meaningless to apply the BCR-U.S.

Steel ASTM stability factor method directly to this coal in order to obtain accurate ASTM stability index factor data due to the high semi-fusinite content and its laminated structure. In this particular type of coal past experience indicates that the assumption of 1/3 semi-fusinite as reactive is not applicable for ASTM stability factor calculation.

The Microscopic Examination of Semi-Coke

The Figure 9 shows good anisotropic coke structure and good bonding between the reactive and inert macerals. The structures are flaky (flow type) (6) which are characteristic of coke from low volatile coal. There is oxidized vitrinite (O.V.) in the semi-coke, which is also well bonded (see Figures 9 and 10).

Two types of semi-fusinite can be observed in the semi-coke: (1) low reflectance flat surface with very little cellular structure (Figure 11), (2) high reflectance semi-fusinite with wavy and cellular structure (Figure 13). It appeared from the micrograph in the Figure 11 that the low reflectance semi-fusinite was not altered after heating at 550°C but from Figure 12 the formation of grain structure of coke in the same semi-fusinite is observed with crossed nicols and gypsum compensator. In the case of high reflectance cellular-type semi-fusinite (Figure 13), this maceral did not form any grain structure at 550°C (see Figure 14). It also appeared that the bondings between the low reflectance semi-fusinite and reactive vitrinite was stronger and fused (see right hand side of the Figure 12) than those of the high reflectance semi-fusinie and reactive vitrinite (see right side of Figure 14).

Microscopic Examination of High Temperature Coke

This coke from Lodge Pole Adit 1 was prepared in the 500-lb movable wall coke oven at about 1000°C and the stability index of this coke is 33.8. The microscopic examination of this coke shows formation of flaky ("flow type") anisotropic structure, good fusion, good bonding between the reactive and inert macerals (see Figure 15). The high reflectance fine granular structure on the right hand side of the Figure 15 shows the formation of coke in the semi-fusinite. Vitrinite of high rank coal (around 18% VM) generally produces flaky or "flow type" structure. It also appears from the Figure 16 and 17 that the proportion of inert macerals is higher than the reactive macerals. This is a poor sign and this may be one of the reasons for the low stability index of this coke.

Lodge Pole Adit 2

From the proximate analysis and reflectance in oil, the rank of this coal appeared to be the same as Lodge Pole Adit 1. The dilatometric properties are quite different from Lodge Pole Adit 1. The plasticity index from the dilatometric test is 0.11 which is below the minimum acceptable level of 0.15. The low plasticity index and contraction indicates that this coal will not produce coke.

The petrographic analysis shows that the vitrinite content of 34% is lower than Lodge Pole Adit 1 and the fusinite and semi-fusinite content of 53% is higher than Lodge Pole Adit 1.

The microscopic examination shows that most of the vitrinite in Lodge Pole Adit 2 are partially fractured and cracked as shown in Figure 18. This suggests that the vitrinite has lost the property of cold flow due to oxidation. The presence of pyrites inside the fractures or cracks (see Figure 19) suggests that these fractures were developed in situ after the formation of coal probably due to tectonic pressure. Probably air and water have seeped down into these fractures and eventually these fractured vitrinites have become gradually oxidized by this process. Some of the vitrinite, where the cracks are filled with either pyrites or some mineral matter, has a higher reflectance (see Figure 20).

When a high reflectance maceral with cellular structure (left, centre and right of Figure 21) is observed in normal reflected light, this maceral is considered to be semi-fusinite and the low reflectance macerals with flat surface (a and b in the Figure 21) are considered as vitrinite. But by using crossed nicols and gypsum compensator this low reflectance macerals appeared to be semi-fusinite with cellular structure. (See Figure 22).

Microscopic Examination of Semi-Coke

The same type of structure of low reflectance and high reflectance semi-fusinite which was shown in the Figure 21 can be observed in the semi-coke (Figure 23). The low reflectance vitrinite part was neither fused nor melted when heated up to 550°C (see Figure 24) but the formation of granular structure of coke was observed in the semi-fusinite part, (with crossed nicols and gypsum compensator).

Most of the vitrinite in the semi-coke behaved as an inert maceral probably due to oxidation in situ and the bonding or fusion between inert and reactive macerals are not observed (see Figure 25). The semi-coke shows very little anisotropy. With crossed nicols and gypsum compensator the formation of the grain structure and fused mass is observed in the semi-fusinite (Figure 26). The grainy structure of coke or formation of a fused mass which can not be seen in the semi-fusinite in the normal reflected light (see Figure 27) can be observed with crossed nicols and gypsum compensator (see Figure 28).

It appears from the microscopic examination of semi-coke from Lodge Pole Adit 2 that the vitrinite maceral in this coal is mostly inert and does not melt on heating whereas the semi-fusinite part partially melts. It is assumed that for this reason this Lodge Pole Adit 2 when charged in the 500-lb movable wall coke oven failed to produce coke or even agglomeration of coal mass.

Lodge Pole Adit 3 (Flathead Ridge)

The proximate analysis and the reflectance of the vitrinite in oil indicates that Flathead Ridge Adit 3 coal is a low volatile bituminous coal. The volatile matter of this coal is about 2% higher than that of Lodge Pole Adit 1 and Adit 2. This coal does not show any dilatation but possesses good contraction and plasticity index of 0.63 which is well above the minimum acceptance level of 0.15. Maceral analysis shows that this sample has 59.3% vitrinite, 34.5% fusinite and semi-fusinite. The reactives to inert ratio (according to Shapiro and Grey) is 67:33. From the evaluation of these results the indications are that Flathead Ridge No. 3 coal will produce good coke.

Microscopic Examination of Coal

Microscopic examination shows that the vitrinite macerals are well developed and free from fissures and cracks although some very high reflectance vitrinites (around 10%) are observed. It is assumed that this high reflectance vitrinite (about 1.8) may not melt during heating and it is difficult to ascertain whether this high reflectance vitrinite is oxidized. In Lodge Pole 2, the low reflectance maceral which was considered as vitrinite in normal reflected light appeared to be semi-fusinie by using cross nicols and gypsum compensator (see Figures 21 and 22). But in this coal the low reflectance maceral (marked V in the Figure 29) does not change in strucutre when seen by using the crossed nicols and gypsum compensator, (see Figure 30). Microscopic examination of this coal maceral indicates that this is a better coal than Lodge Pole Adit 1 and Adit 2.

Examination of Semi-Coke

Figure 31 shows the good bonding and fusion of inerts and reactives. The partially oxidized vitrinite (POV) has also melted in some places and formed grainy coke. The bonding here is very good in comparison with oxidized vitrinite in the Figure 32. The bonding or fusion on the left hand side of the oxidized vitrinite here is poor. It appears from these photo micrographs that the high reflectance vitrinite is behaving for the most part like oxidized vitrinite on carbonization.

The structure of semi-fusinite in the semi-coke (see Figure 33) does not show any formation of coke in normal reflected light but using cross nicols and gypsum compensator the formation of flaky and grainy structure of coke in the semi-fusinite can be observed. The bonding and fusion of the semi-fusinite in this coal is better than that in Lodge Pole Adit 1 and Adit 2. The structure of the semi-coke in relation to fusion and bonding of fusinite and micrinite is shown in Figure 35. A strong bonding between the fusinite and reactive vitrinite can be observed in this Figure (35).

Microscopic Examination of High Temperature Coke

This coke was prepared in the 500-lb movable wall coke oven at about 1000°C and the stability index of this coke is 49.3. The micrograph in Figure 36 shows the formation of coke from semi-fusinite (SF) and fused vitrinite (FV). Apparently formation of coke is not observed in the semi-fusinite in normal reflected light. With crossed nicols and gypsum compensator the grain structure of coke formation is observed in the semi-fusinite. (See Figures 37 and 38). The bonding between the fusinite and vitrinite is very poor at the far end of the coke (see Figure 39), but a good flow type or flaky structure (see Figure 40) was observed in the cauliflower side of the coke. This high temperature coke, on the average, shows strong and fused structure with small pores.

CONCLUSION

Lodge Pole Adit 1

This sample has vitrinite content of 47% , semi-fusinite 34.5% and has good plasticity index. This is a high rank coal which generally produces good coke. Low reflectance semi-fusinites are reactives and high reflectance semi-fusinites are inerts. The coke obtained from 500-lb coke oven has a stability index of 34 which indicates that this produces a weak coke. Microscopic examination suggests that the high semi-fusinite content is one of the causes for the low stability factor. If the semi-fusinite content were reduced to a lower level by washing at 1.55 S.G. this coal could probably be sold as premium coking coal. After washing it is expected that this coal will produce a good metallurgical coke when blended with high fluid coal such as Marten Creek Adit 1 coal.

Lodge Pole Adit 2

The vitrinite of this sample is mostly fractured. Maceral analysis shows that vitrinite content is 34%, and 55% semi-fusinite and fusinite. Plasticity index of 0.11 which is lower than the minimum acceptable level of 0.15 indicates that this coal will not produce coke at all. Oxygen content of this coal is 5% which is 1% higher than Lodge Pole 1 coal sample. Low plasticity index, high oxygen content in coal, non-agglomerating nature semi-coke, poor bonding and fusion in the semi-coke indicate that this coal is not suitable for coking. However, possibly deeper penetration into the seam into areas that have not been oxidized might yield a coal somewhat more similar to that found in Adit 1. It would presumably pay to look into the geological reasons for this oxidized state.

Lodge Pole Adit 3 (Flathead Ridge)

Of all the three samples from this area, Lodge Pole Adit 3 coal possesses highest vitrinite and lowest semi-fusinite macerals. Plasticity index is the highest (0.63) though the maximum fluidity from Gieseler plastometer remains the same as Lodge Pole 1 (1.2). The coke structure shows good bonding and good fusion and this is attributed to the stability index of about 50. Considering the results of petrographic analysis dilatation tests and microscopic examination of semi-coke and high temperature coke, the indications are that this coal will produce the strongest and best coke out of these 3 samples sent from Flathead Ridge area.

ACKNOWLEDGEMENT

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2. Nandi, B. N. and Montgomery, D. S., "Evaluating Coal from Sparwood Ridge Area, Crowsnest Coal field, B.C." Divisional Report FRC 70/39 Prep. June 1970.

3. Nandi, B. N. and Montgomery, D. S., "Evaluation of Coal Samples from the Sparwood Ridge Area, Crowsnest Coalfield, B.C. (Kaiser No. 7 Seam - Adit 75), Divisional Report FRC 71/9 Prep. January 71.

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6. Patrick, J.W., Reynolds, M.J., and Shaw, F.H., "Development of Optical Anisotropy in Vitrains during Carbonization", P 198-204, Vol 52, July, Fuels 1973, London.

TABLE 1

Proximate Analysis (dry basis)

	Lodge Pole Adit 1	Flathead Ridge Lodge Pole Adit 3	Lodge Pole Adit 2
Ash	11.5	9.1	10.7
Volatile Matter	18.3	20.2	18.6
Fixed Carbon	70.2	70.7	70.7
	100.0	100.0	100.0
Sulphur (d b)	0.48	0.40	0.51
Oxygen (d b)	4.05		5.00
Gross Calorific Value BTU/per pound	13699		13726
Free Swelling Index (F.S.I.)	3	4	1

TABLE 2

Dilatometric Test

Softening Temperature θ_s °C	460	467	486
Contraction °C	19	24	4
Maximum Temperature of Contraction θ_c °C	500	505	522
Dilatation	-	-	-
Maximum Temperature of Dilatation °C	-	-	-
Plasticity Index $\frac{C}{\theta_c - \theta_s}$	0.47	0.63	0.11

TABLE 3

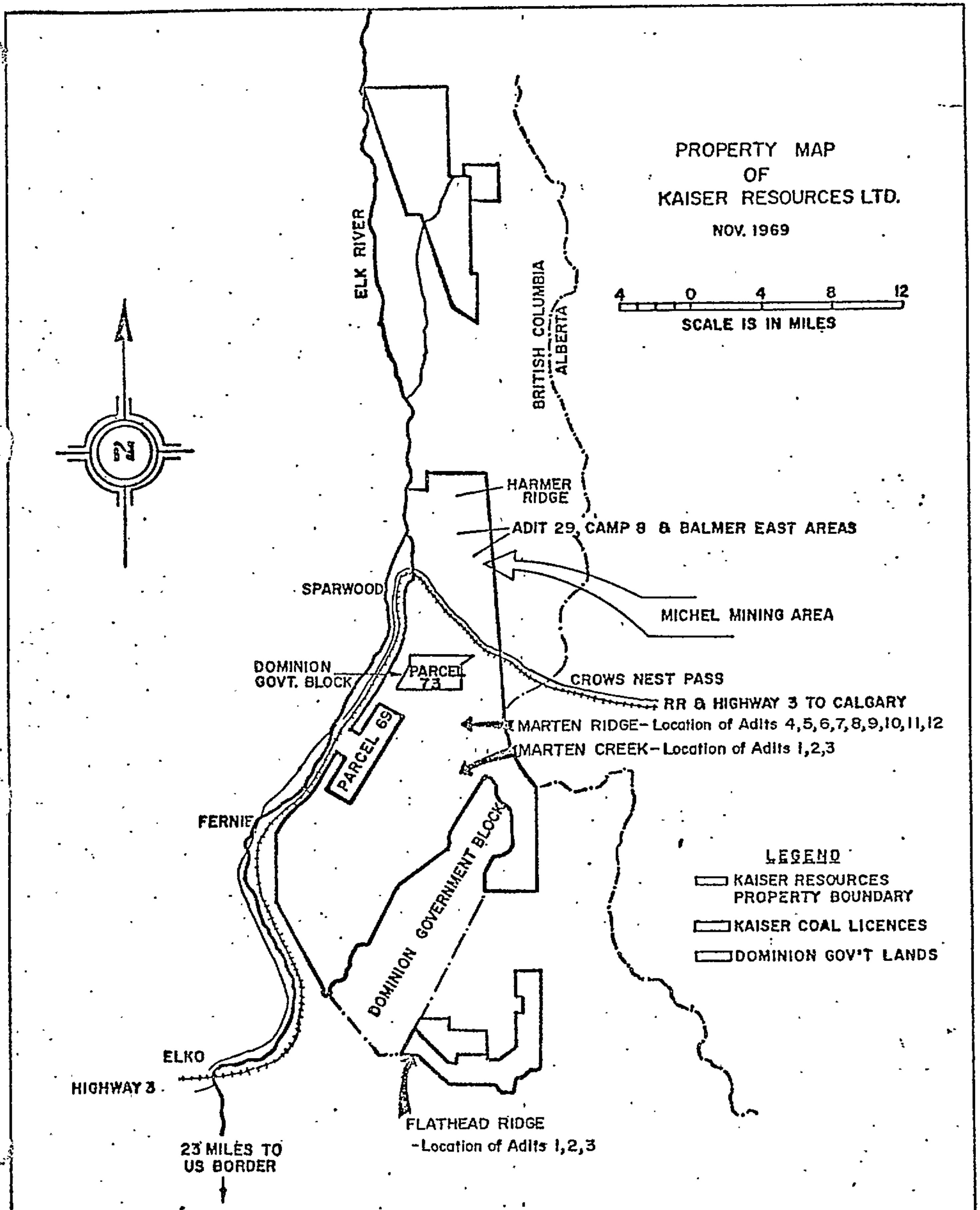
Petrographic Analysis

	Lodge Pole Adit 1 %	Flathead Ridge Lodge Pole Adit 3 %	Lodge Pole Adit 2 %
Vitrinite	46.6	59.3	34.4
Exinite	0.0	0.0	0.0
Micrinite	5.1	1.1	6.4
Semi-fusinite	34.5	22.6	37.7
Fusinite	7.3	11.9	15.4
Mineral Matter	6.5	5.1	6.1
	100.0	100.0	100.0
Maximum Reflectance in oil	1.55	1.31	1.41
Predicted Stability Index	29.0	52.8	13.5
Experimental Stability Index	33.8	49.3	Nil (does not coke at all)

TABLE 4

Gieselar Plasticity

Start	°C	470	464	-
Fusion Temperature	°C	-	-	-
Maximum Fluid Temp.	°C	476	468	476
Final Fluid Temp.	°C	483	474	-
Solidification Temp.	°C	502	494	494
Melting Range	°C	13	.0	-
Maximum Fluidity dd/m		1.2	1.2	0.2
Torque		40	40	40



PROPERTY MAP
OF
KAISER RESOURCES LTD.
NOV. 1969
4 0 4 8 12
SCALE IS IN MILES
ELK RIVER
BRITISH COLUMBIA
ALBERTA
HARMER RIDGE
ADIT 29, CAMP 8 & BALMER EAST AREAS
SPARWOOD
MICHEL MINING AREA
DOMINION GOVT. BLOCK
PARCEL 73
CROWS NEST PASS
RR & HIGHWAY 3 TO CALGARY
MARTEN RIDGE-Location of Adits 4,5,6,7,8,9,10,11,12
MARTEN CREEK-Location of Adits 1,2,3
PARCEL 6S
PARCEL 6S
FERNIE
DOMINION GOVERNMENT BLOCK
LEGEND
KAISER RESOURCES PROPERTY BOUNDARY
KAISER COAL LICENCES
DOMINION GOV'T LANDS
ELKO
HIGHWAY 3
23 MILES TO US BORDER
FLATHEAD RIDGE -Location of Adits 1,2,3

Figure 1

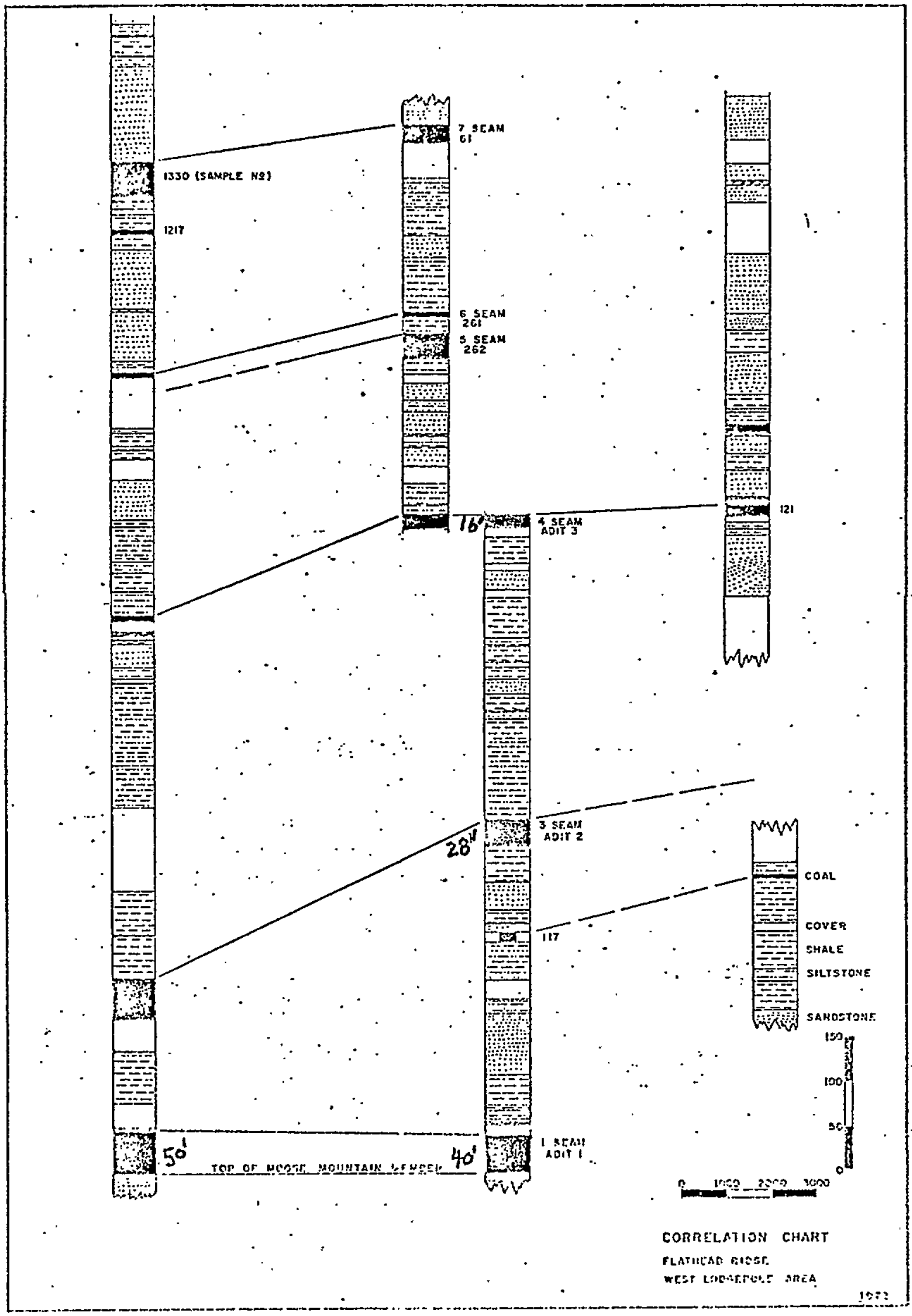

7 SEAM
61
1330 (SAMPLE NO)
1217
6 SEAM
261
5 SEAM
262
16'
4 SEAM
ADIT 3
121
3 SEAM
ADIT 2
28'
117
COAL
COVER
SHALE
SILTSTONE
SANDSTONE
150
100
50
0
50'
40'
1 SEAM
ADIT 1
0 1000 2000 3000
CORRELATION CHART

Figure 2A

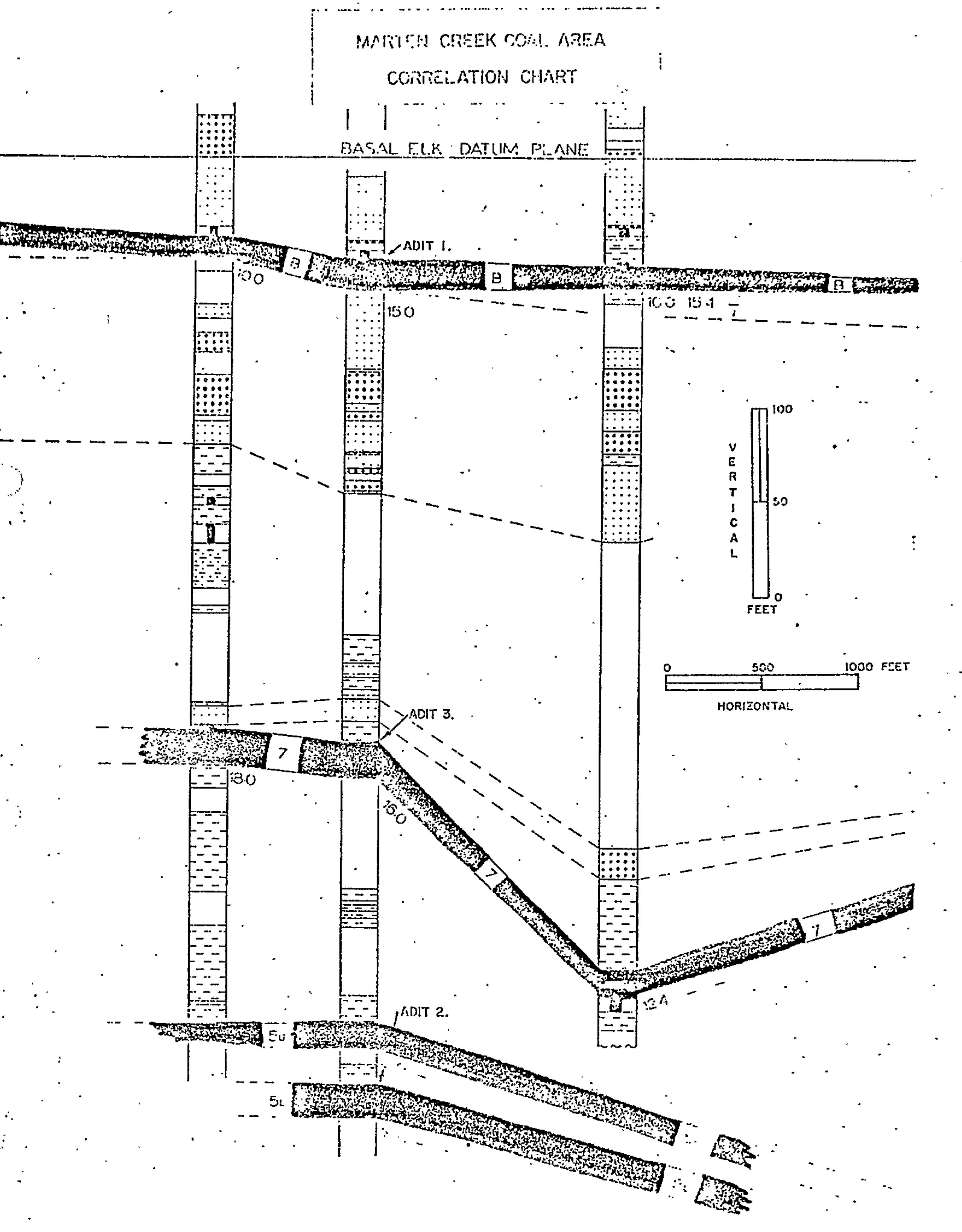

MARTEN CREEK COAL AREA
CORRELATION CHART
BASAL ELK DATUM PLANE
ADIT 1.
ADIT 3.
ADIT 2.
VERTICAL
100
50
0
FEET
0
500
1000 FEET
HORIZONTAL
8
7
5u
5L

Figure 2B

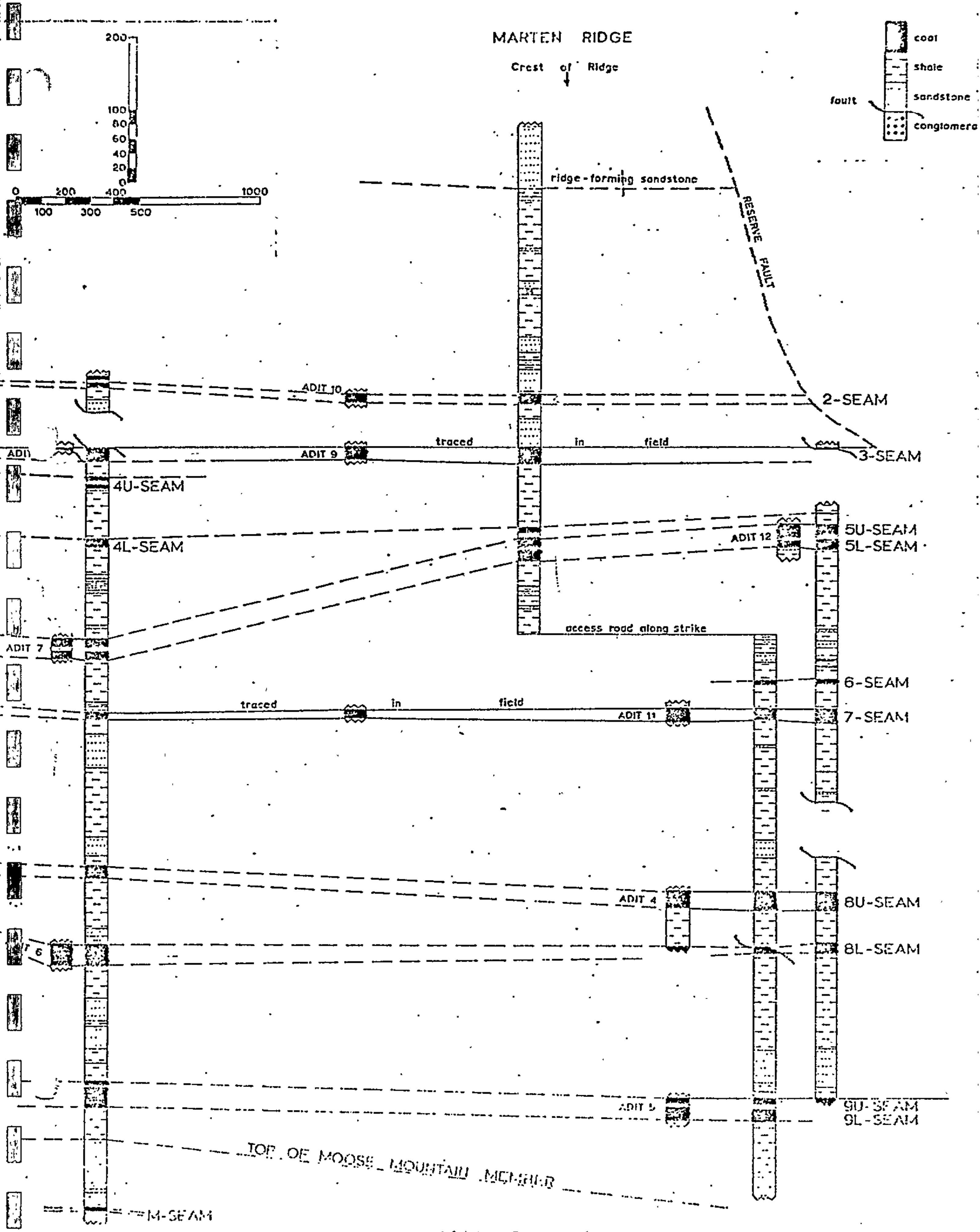

MARTEN RIDGE
Crest of Ridge
coal
shale
sandstone
fault
conglomerate
200
100
80
60
40
20
0
0
200
400
1000
100
300
500
ridge-forming sandstone
RESERVE FAULT
ADIT 10
2-SEAM
traced in field
ADIT 9
3-SEAM
4U-SEAM
4L-SEAM
ADIT 12
5U-SEAM
5L-SEAM
access road along strike
ADIT 7
6-SEAM
traced in field
ADIT 11
7-SEAM
ADIT 4
8U-SEAM
8L-SEAM
9U-SEAM
9L-SEAM
TOP OF MOOSE MOUNTAIN MEMBER
M-SEAM

Figure 2C

igure 3. Lodge Pole Adit 1. Vitrinite (V) and semi-fusinite (S.F.) in coal. X600

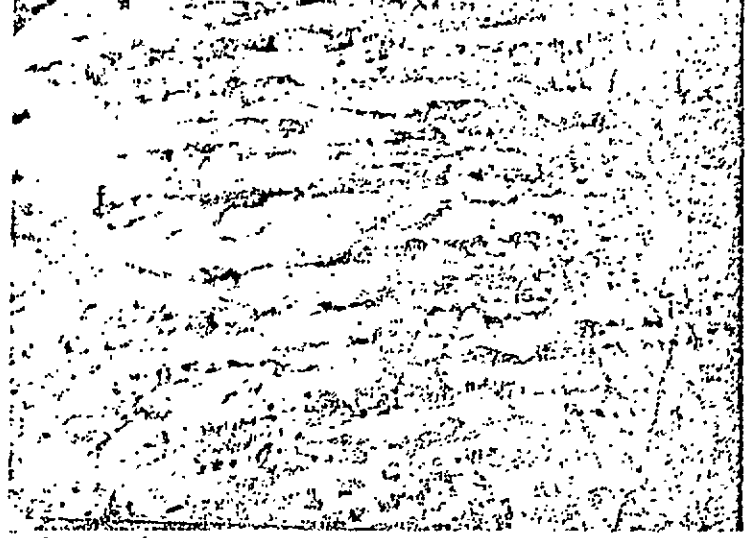
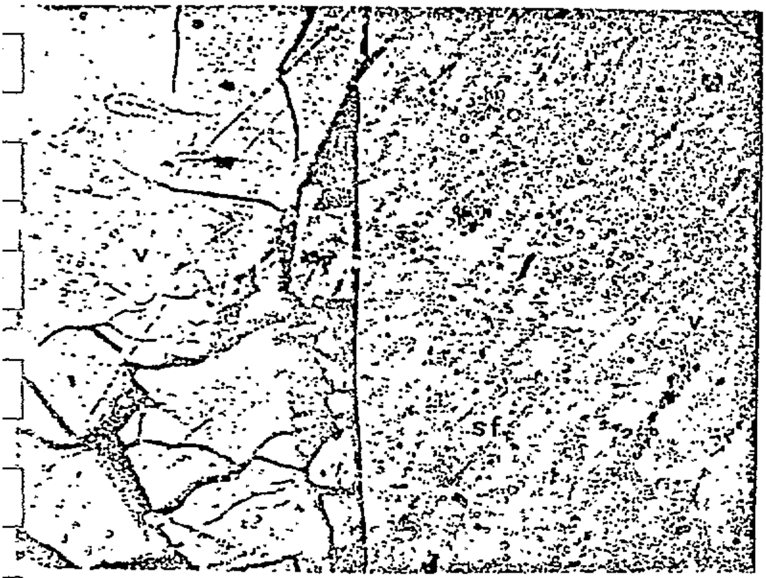
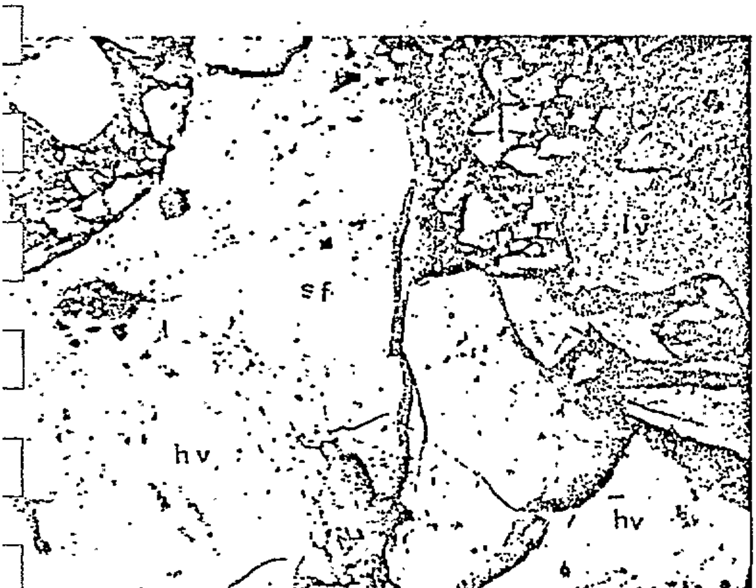


Figure 4. Lodge Pole Adit 1. The same location as in Figure 3 with cross nicol and gypsum compensator. X600



re 5. Lodge Pole Adit 1. Vitrinite (V) and semi-fusinite (S.F.) in coal.

Figure 6. Lodge Pole Adit 1. The same locatio as in Figure 5 with cross nicol and compensator. X600



igure 7. Lodge Pole Adit 1. Structure in coal shows high reflectance vitrinite (H.V.); low reflectance vitrinite (L.V.) and semi-fusinite (S.F.). X600

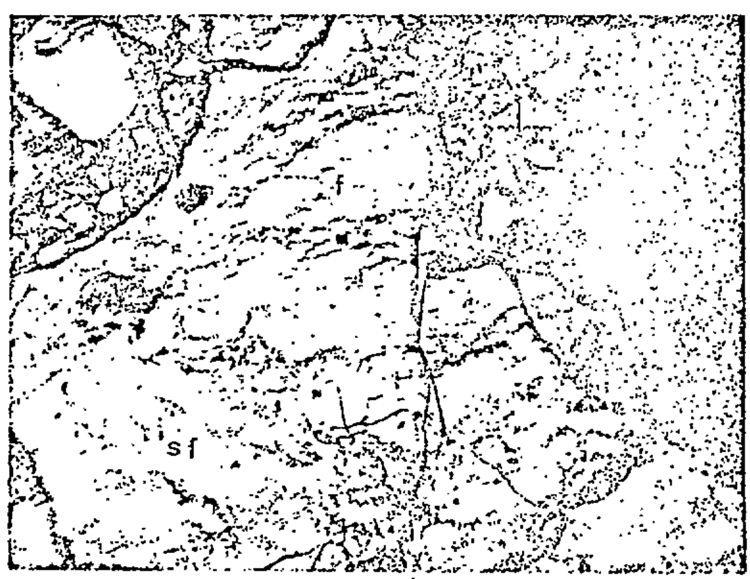


Figure 8. Lodge Pole Adit 1. Same as in Figure 7. Semi-fusinite (S.F.), fusinite (F.) and vitrinite (V). X60

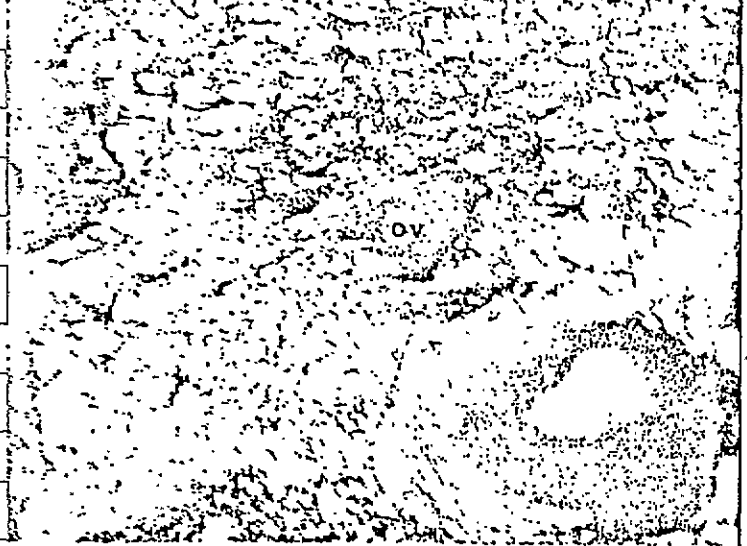


Figure 9. Lodge Pole Adit 1. Structure of semi-coke, showing oxidized vitrinite (O.V.). X600

Figure 10. Lodge Pole Adit 1. Structure of semi-coke, oxidized vitrinite (O.V.). X600

Figure 11. Lodge Pole Adit 1. Low reflectance semi-fusinite (lsf) in the semi-coke. X600

Figure 12. Lodge Pole Adit 1. Same as Figure cross nicol and gypsum compensator. X600

Figure 13. Lodge Pole Adit 1. High reflectance semi-fusinite in the semi-coke. X600

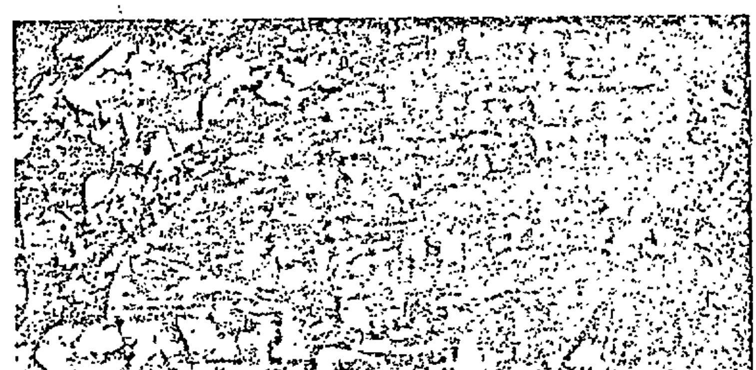


Figure 14. Lodge Pole Adit 1. Same as Figure cross nicol and gypsum compensator. X600

gure 15. Lodge Pole Adit 1. High temperature coke. X600

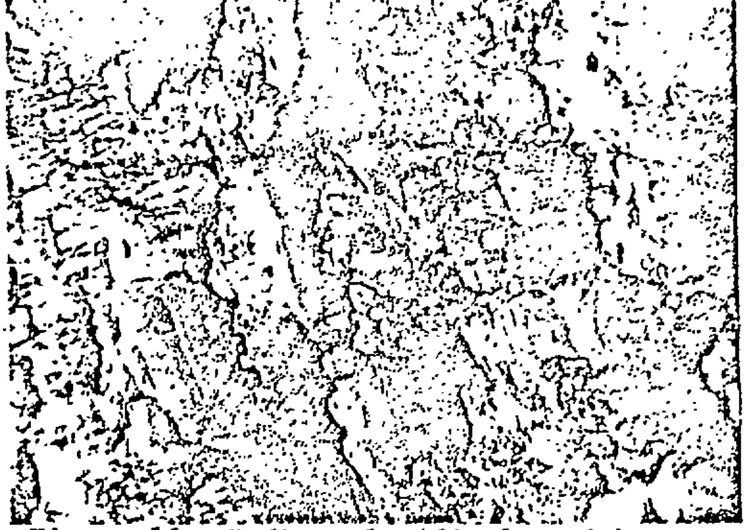


Figure 16. Lodge Pole Adit 1. High temperature coke. X600

e 17. Lodge Pole Adit 1. High temperature coke. X600

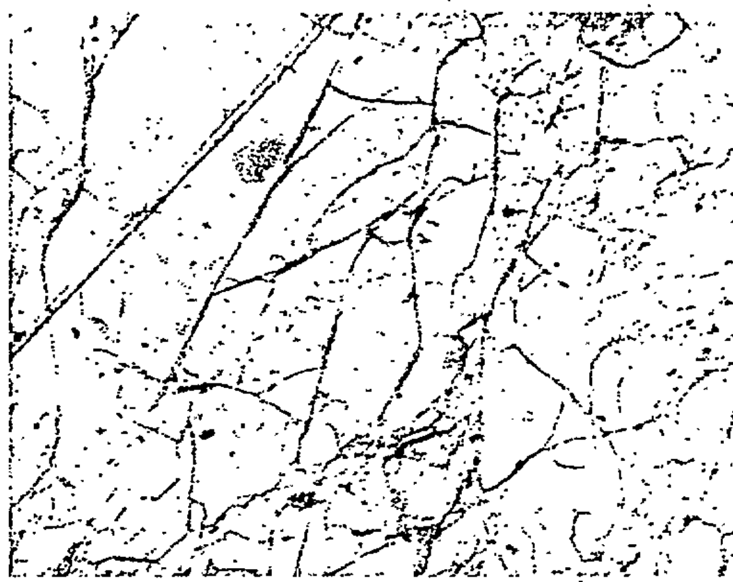
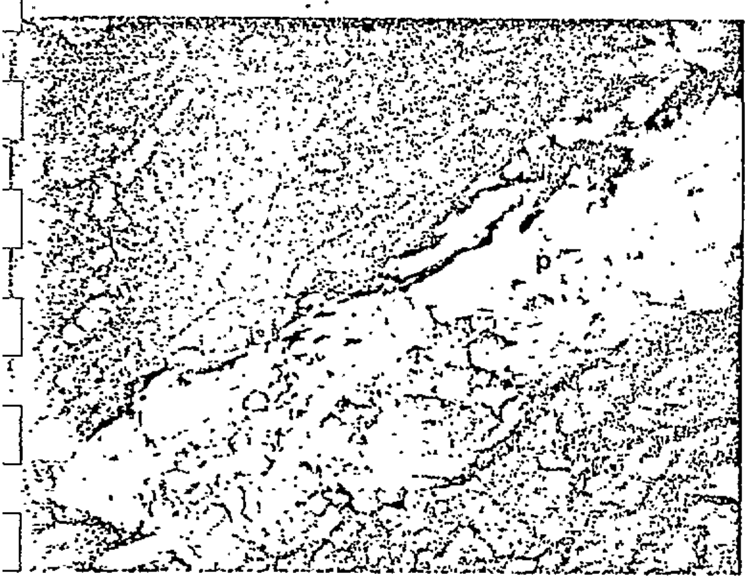


Figure 18. Lodge Pole Adit 2. Vitrinite fissures. X600



igure 19. Lodge Pole Adit 2. Vitrinite with fissures filled with pyrites (p). X600

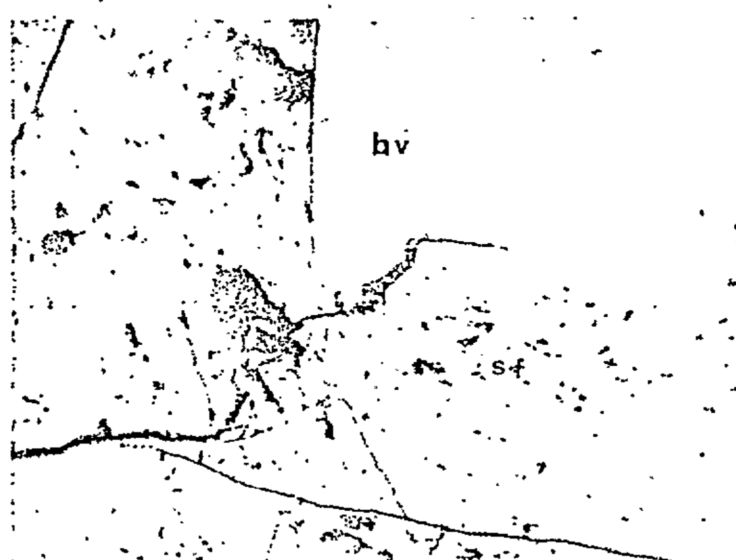


Figure 20. Lodge Pole Adit 2. High reflectanc vitrinite (hv) in coal. X600

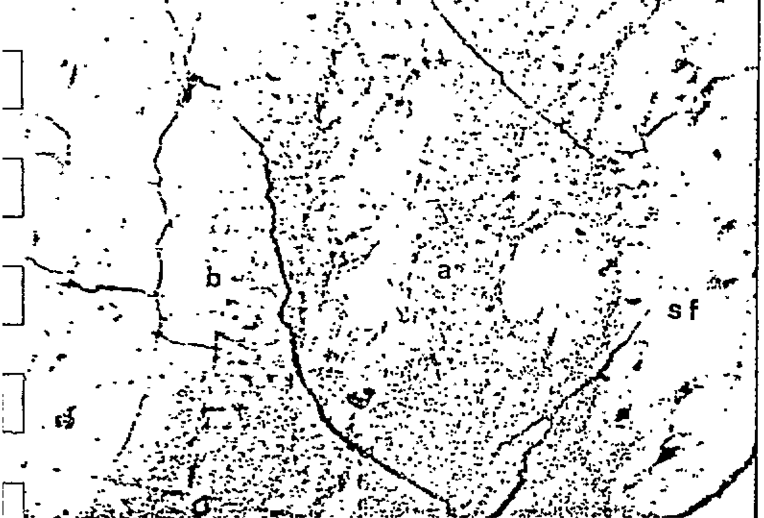


Figure 21. Lodge Pole Adit 2. Semi-fusinite (s.f.) a and b - vitrinite (V) in coal. X600

Figure 22. Lodge Pole Adit 2. Same as Figure 21. a and b semi-fusinite structure with cross nicol. X600

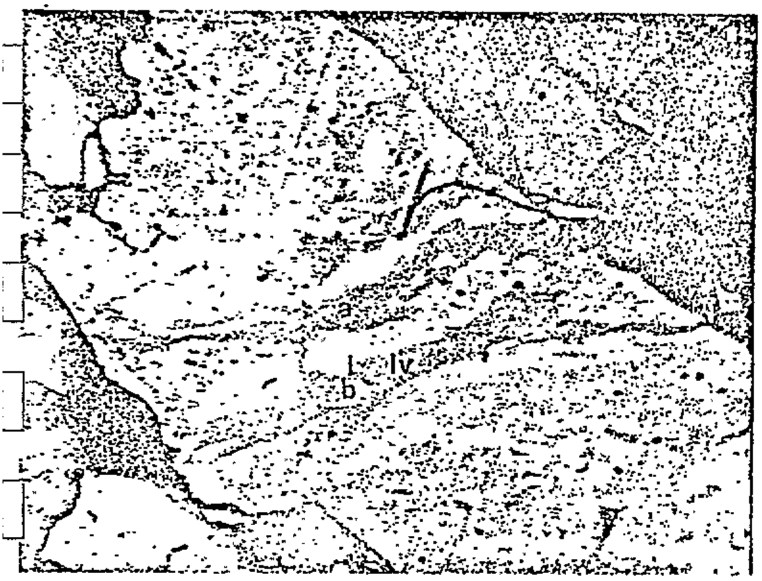


Figure 23. Lodge Pole Adit 2. Structure of semi-coke. Semi-fusinite (s.f.). a and b low reflectance vitrinite (lv). X600

Figure 24. Lodge Pole Adit 2. Same as Figure 23, a and b - structure of semi-fusinite with cross nicol and gypsum compensator. X600

Figure 25. Lodge Pole Adit 2. Structure of semi-coke. Oxidized vitrinite. X600

Figure 26. Lodge Pole Adit 2. Same as in Figure 25. Structure of semi-coke with cross nicol and compensator O.V. oxidized vitrinite. X600

gure 27. Lodge Pole Adit 2. Structure of semi-fusinite in semi-coke. (sf) X600

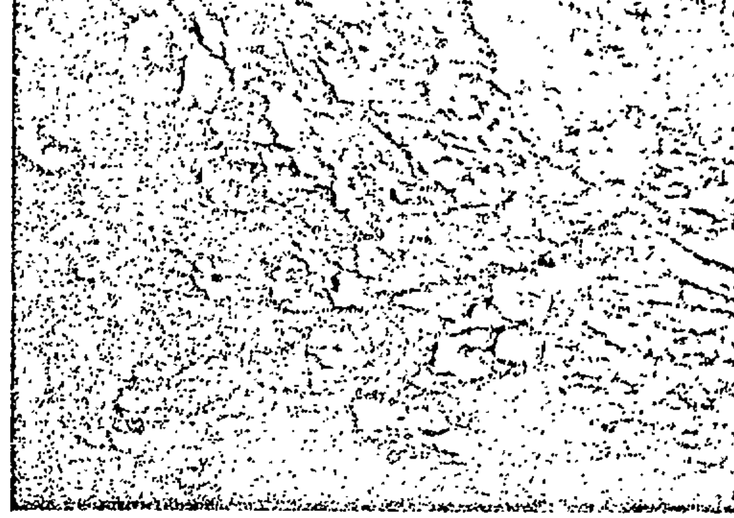
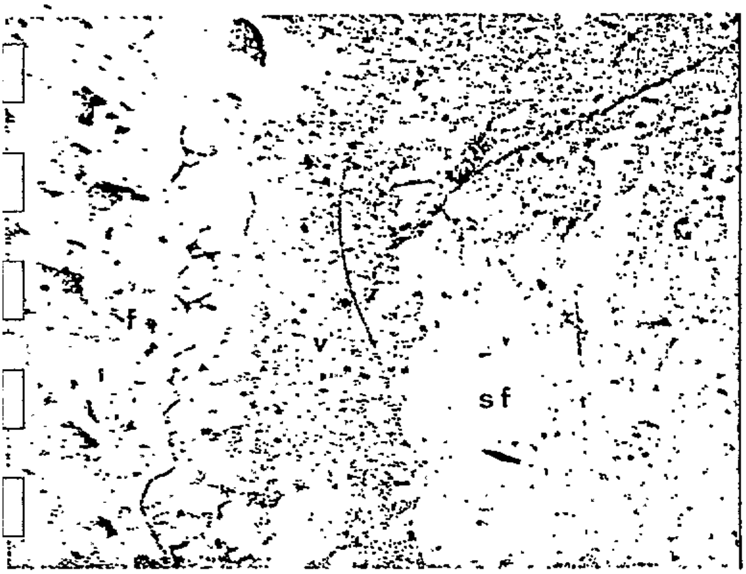


Figure 28. Lodge Pole Adit 2. Same as in Figure 27, showing formation of grain of coke in semi-fusinite with cross nicol. X600



gure 29. Lodge Pole Adit 3. Structure of coal V = Vitrinite, F = Fusinite S.F. = Semi-fusinite. X600

Figure 30. Lodge Pole Adit 3. Same as in Figure 29. X600

igure 31. Lodge Pole Adit 3. Structure of semi-coke. P.O.V. = partially oxidized vitrinite. X600

Figure 32. Lodge Pole Adit 3. Structure of semi-coke. O.V. = oxidized vitrinite. X600

gure 33. Lodge Pole Adit 3. Structure of semi-coke, semi-fusinite (S.F.) in the semi-coke. X600

Figure 34. Lodge Pole Adit 3. Same as in Figure 33 with cross nicol. X600

gure 35. Lodge Pole Adit 3. Structure of semi-coke with cross nicol. X250

Figure 36. Lodge Pole Adit 3. Structure of high temperature coke, S.F. semi-fusinite, f.v. - fused vitrinite. X250

igure 37. Lodge Pole Adit 3. Same as in Figure 36 with cross nicol. F.V. - fused vitrinite. X250

Figure 38. Lodge Pole Adit 3. Same in Figure 37, showing bonding between semi-fusinite and vitrinite and formatio of coke grain in the semi-fusinite. X600

gure 39. Lodge Pole Adit 3. Structure of high temperature coke showing poor bonding between fusinite (F) and vitrinite.

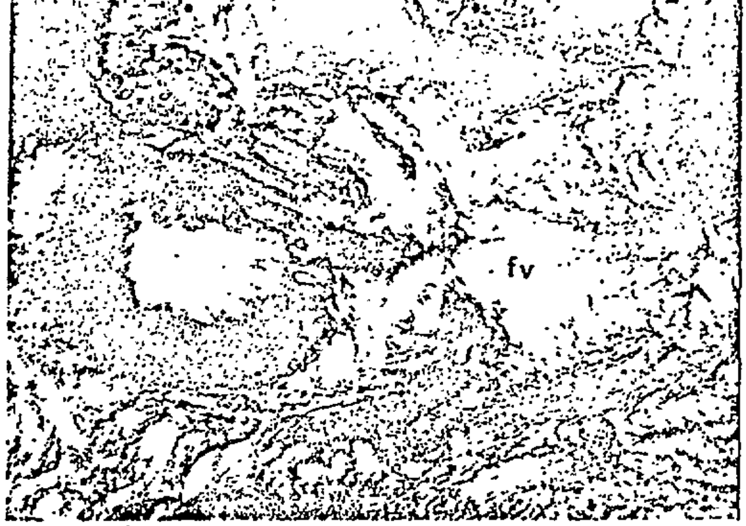


Figure 40. Lodge Pole Adit 3. Structure of high temperature coke showing the flaky A flow type structure of fused vitrinite (F.V.).

TABLE I

ANALYSIS OF

FLATHEAD, ADIT # 6

X-CUT @ 87' SEAM THICKNESS 9.7'

SEAM NO. 6

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	17.1	6.5
Volatile Matter	%	19.1	21.0
Fixed Carbon	%	63.8	72.5
Free Swelling Index		#7	#7½
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.58	0.62
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	449°	446°
Fusion Temp.	°C	470°	461°
Maximum Fluid Temp.	°C	477°	475°
Final Fluid Temp.	°C	498°	498°
Solidification Temp.	°C	501°	505°
Melting Range	°C	49°	52°
Maximum Fluidity	ddm	9.0	24.0

TABLE II

SCREEN ANALYSIS

ADIT # 6
FLATHEAD

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	21.5	20.2	21.5	20.2
-3/8" + 28M	55.6	18.0	77.1	18.6
-28M + 100M	15.8	11.7	92.9	17.4
-100M + 0	7.1	12.8	100.0	17.1

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	11.7	24.5	11.7	24.5
-3/8" + 28M	54.3	17.6	66.0	18.8
-28M + 100M	15.5	13.4	81.5	17.8
-100M + 0	18.5	13.2	100.0	16.9

TABLE I

ANALYSIS OF
FLATHEAD RIDGE ADIT #5
X-CUT @ 88 ft. SEAM THICKNESS 19.5'
NUMBER 7 SEAM

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	5.3	3.7
Volatile Matter	%	22.4	21.5
Fixed Carbon	%	72.3	74.8
Free Swelling Index			
Gross Calorific Value (dmmfb)		7½	7½
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.42	0.45
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	453°	451°
Fusion Temp.	°C	471°	471°
Maximum Fluid Temp.	°C	483°	483°
Final Fluid Temp.	°C	496°	497°
Solidification Temp.	°C	501°	503°
Melting Range	°C	43°	46°
Maximum Fluidity	ddm	7.0°	5.8°

TABLE II

SCREEN ANALYSIS

FLATHEAD RIDGE ADIT #5 NUMBER 7 SEAM
X-CUT @ 88 feet SEAM THICKNESS 19.5'

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	31.8	7.2	31.8	7.2
-3/8" + 28M	49.3	3.9	81.1	5.2
-28M + 100M	13.6	4.5	94.7	5.1
-100M + 0	5.3	8.2	100.0	5.3

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	17.5	9.2	17.5	9.2
-3/8" + 28M	52.2	4.9	69.7	6.0
-28M + 100M	17.9	3.8	87.6	5.5
-100M + 0	12.4	7.3	100.0	5.8

TABLE I

ANALYSIS OF FLATHEAD

#5 SEAM ADIT # 4

2nd X-CUT @ 108 ftSEAM THICKNESS 36.6'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	13.4	7.4
Volatile Matter	%	20.8	22.3
Fixed Carbon	%	65.8	70.3
Free Swelling Index		6	6
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.22	0.24
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	447°	460°
Fusion Temp.	°C	474°	
Maximum Fluid Temp.	°C	476°	476°
Final Fluid Temp.	°C	495°	490°
Solidification Temp.	°C	503°	497°
Melting Range	°C	48°	30°
Maximum Fluidity	ddm	5.5	2.7

TABLE II

SCREEN ANALYSIS

ADIT # 4 Flathead

2nd x-cut @ 108 ft. Seam Thickness 36.6'

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	25.6	19.1	25.6	19.1
-3/8" + 28M	50.9	11.6	76.5	14.1
-28M + 100M	14.9	8.5	91.4	13.2
-100M + 0	8.6	11.0	100.0	13.0

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	15.5	21.3	15.5	21.3
-3/8" + 28M	45.7	14.3	61.2	16.1
-28M + 100M	19.4	9.7	80.6	14.5
-100M + 0	19.4	10.6	100.0	13.8

TABLE 1

ANALYSIS OF

FLATHEAD RIDGE ADIT #3

X-CUT @ 85 FT. SEAM THICKNESS 22.6 FT.

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	18.8	9.4
Volatile Matter	%	18.4	18.9
Fixed Carbon	%	62.8	71.7
Free Swelling Index		#4	#5
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.66	0.69
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	462°	455°
Fusion Temp.	°C		
Maximum Fluid Temp.	°C	479°	480°
Final Fluid Temp.	°C	482°	485°
Solidification Temp.	°C	498°	495°
Melting Range	°C	20°	30°
Maximum Fluidity	ddm	1.6	2.0

TABLE II

SCREEN ANALYSIS

ADIT #3, (FLATHEAD RIDGE)

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	31.9	24.3	31.9	24.3
-3/8" + 28M	41.8	19.5	73.7	21.6
-28M + 100M	17.9	10.7	91.6	19.5
-100M + 0	8.4	12.7	100.0	18.9

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	18.9	27.9	18.9	27.9
-3/8" + 28M	44.2	20.4	63.1	22.6
-28M + 100M	17.3	12.3	80.4	20.4
-100M + 0	19.6	11.0	100.0	18.6

TABLE I

FLATHEAD RIDGE ADIT #2

X-CUT @ 145'; SEAM THICKNESS 30.6'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	22.5	10.4
Volatile Matter	%	17.8	18.0
Fixed Carbon	%	59.7	71.6
Free Swelling Index		#1	#1
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.52	0.77
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start.	°C	No Movement	No Movement
Fusion Temp.	°C		
Maximum Fluid Temp.	°C		
Final Fluid Temp.	°C		
Solidification Temp.	°C		
Melting Range	°C		
Maximum Fluidity	ddm		

TABLE II

SCREEN ANALYSIS

SEAM ADIT #2, FLATHEAD RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	10.4	30.3	10.4	30.3
-3/8" + 28M	66.6	24.2	77.0	25.0
-28M + 100M	12.8	16.2	89.8	23.8
-100M + 0	10.2	12.7	100.0	22.6

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	3.3	37.6	3.3	37.6
-3/8" + 28M	34.8	35.2	38.1	35.4
-28M + 100M	29.6	17.8	67.7	27.7
-100M + 0	32.3	13.4	100.0	23.1

Note: Coal being extremely friable, it was impossible to run washabilities on raw coal. Therefore, the coal was put through attrition tests and washabilities run oh +28M, -28M + 100M and -100M + 0, as shown in Table III.

TABLE I

FLATHEAD RIDGE ADIT #1

SEAM THICKNESS 46.0 FT.; X-CUT @ 118 FT.

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	26.1	11.3
Volatile Matter	%	15.7	17.7
Fixed Carbon	%	58.2	71.0
Free Swelling Index		#1	2.5
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.63	0.69
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
a Start	°C (1ddm)		
b Fusion Temp.	°C (5ddm)		
c Maximum Fluid Temp.	°C	482	477
d Final Fluid Temp.	°C (1ddm)		
e Solidification Temp.	°C (d-a)	500	502
f Melting Range	°C		
g Maximum Fluidity	ddm	1.0	1.0

TABLE II

SCREEN ANALYSIS

ADIT #1 FLATHEAD RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	25.6	35.0	25.6	35.0
-3/8" + 28M	50.7	24.9	76.3	28.3
-28M + 100M	16.4	20.5	92.7	26.9
-100M + 0	7.3	17.5	100.0	26.2

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	17.3	35.6	17.3	35.6
-3/8" + 28M	45.2	30.1	62.5	31.6
-28M + 100M	19.8	19.8	82.3	28.8
-100M + 0	17.7	16.5	100.0	26.6

MARTEN RIDGE ADITS

TABLE I

MARTEN RIDGE ADIT #4

SEAM THICKNESS 22.7 FT.; X-CUT @ 90 FT.

			RAW COAL	CLEAN COAL
Proximate Analysis (db)				
Ash	%		8.5	7.3
Volatile Matter	%		31.4	31.6
Fixed Carbon	%		60.1	61.1
Free Swelling Index			6.5	6.5
Gross Calorific Value (dmmfb)				
Btu Per Pound				
Ultimate Analysis (db)				
Carbon	%			
Hydrogen	%			
Sulphur	%		0.95	0.97
Nitrogen	%			
Ash	%			
Oxygen (by difference)	%			
Ash Fusion				
Initial Deformation Temp.	IT			
Softening Temp.	ST			
Fluid Temp.	FT			
Grindability				
Hardgrove Index				
Giesler Plasticity				
a Start	°C (1ddm)		420.0	418.0
b Fusion Temp.	°C (5ddm)		431.0	428.0
c Maximum Fluid Temp.	°C		451.0	449.0
d Final Fluid Temp.	°C (1ddm)		470.0	466.0
e Solidification Temp.	°C		478.0	473.0
f Melting Range	°C (d-a)		50.0	48.0
g Maximum Fluidity	ddm		91.0	44.0

TABLE II

SCREEN ANALYSIS

ADIT #4 MARTEN RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	10.3	14.0	10.3	14.0
-3/8" + 28M	57.7	7.3	68.0	8.3
-28M + 100M	22.6	8.7	90.6	8.4
-100M + 0	9.4	10.4	100.0	8.6

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	4.2	18.5	4.2	18.5
-3/8" + 28M	54.2	8.4	58.4	9.1
-28M + 100M	28.3	8.4	86.7	8.9
-100M + 0	13.3	8.9	100.0	8.9

TABLE I

NOTE: Upper 8' coal zone followed by 6.6' shale, then 17.6' coal. See separate washability for 17.6' coal zone.

ANALYSIS OF

UPPER MARTEN RIDGE, ADIT #5

X-CUT @ 90' SEAM THICKNESS 8'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	30.7	8.5
Volatile Matter	%	25.8	29.6
Fixed Carbon	%	43.5	61.9
Free Swelling Index		#1	#1½
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.48	0.50
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	428°	433
Fusion Temp.	°C		
Maximum Fluid Temp.	°C	443°	438
Final Fluid Temp.	°C	450°	452
Solidification Temp.	°C	471°	465
Melting Range	°C	22°	19
Maximum Fluidity	ddm	3.0	1.6

TABLE II

SCREEN ANALYSIS

SEAM ADIT #5, UPPER MARTEN RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	43.8	28.9	43.8	28.9
-3/8" + 28M	38.0	34.3	81.8	31.4
-28M + 100M	11.6	27.0	93.4	30.9
-100M + 0	6.6	32.5	100.0	31.0

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	17.3	32.2	17.3	32.2
-3/8" + 28M	47.9	35.9	65.2	34.9
-28M + 100M	18.4	28.1	83.6	33.4
-100M + 0	16.4	21.1	100.0	31.4

TABLE 1

ANALYSIS OF MARTEN RIDGE

ADIT #6

X-CUT @ 150 FTSEAM THICKNESS 29.5 FT.

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	29.9	10.3
Volatile Matter	%	26.3	30.7
Fixed Carbon	%	43.8	59.0
Free Swelling Index		#3	3½
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.50	0.49
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	416	427
Fusion Temp.	°C	428	442
Maximum Fluid Temp.	°C	446	444
Final Fluid Temp.	°C	465	462
Solidification Temp.	°C	470	471
Melting Range	°C	49	35
Maximum Fluidity	ddm	16.0	6.0

TABLE II

SCREEN ANALYSIS
SEAM ADIT #6 MARTEN RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	6.4	42.9	6.4	42.9
-3/8" + 28M	45.1	36.4	51.5	37.2
-28M + 100M	34.1	25.6	85.6	32.6
-100M + 0	14.4	19.6	100.0	30.7

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	1.1	43.5	1.1	43.5
-3/8" + 28M	45.8	40.2	46.9	40.3
-28M + 100M	28.2	24.3	75.1	34.3
-100M + 0	24.9	16.8	100.0	29.9

TABLE I

ANALYSIS OF MARTEN RIDGE

UPPER ADIT # 7

X-CUT @ 100' SEAM THICKNESS 9.5'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	14.2	7.2
Volatile Matter	%	31.0	32.4
Fixed Carbon	%	54.8	60.4
Free Swelling Index		3	3½
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.56	
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	418	
Fusion Temp.	°C	432	
Maximum Fluid Temp.	°C	446	
Final Fluid Temp.	°C	460	
Solidification Temp.	°C	465	
Melting Range	°C	42	
Maximum Fluidity	ddm	14.5	

TABLE II

SCREEN ANALYSIS

SEAM ADIT # 7MARTEN RIDGE (UPPER)

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	31.5	18.2	31.5	18.2
-3/8" + 28M	36.2	16.7	67.7	17.4
-28M + 100M	16.2	9.1	83.9	15.8
-100M + 0	16.1	8.1	100.0	14.6

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	29.6	21.6	29.6	21.6
-3/8" + 28M	26.2	14.8	55.8	18.4
-28M + 100M	23.2	9.1	79.0	15.7
-100M + 0	21.0	8.0	100.0	14.1

TABLE I

ANALYSIS OF MARTEN RIDGE

ADIT # 9

X-CUT @ 70'   SEAM THICKNESS 18'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	10.0	3.9
Volatile Matter	%	35.0	36.4
Fixed Carbon	%	55.0	59.7
Free Swelling Index		4½	6
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.29	0.38
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	415	416
Fusion Temp.	°C	427	430
Maximum Fluid Temp.	°C	445	447
Final Fluid Temp.	°C	463	463
Solidification Temp.	°C	469	471
Melting Range	°C	48	47
Maximum Fluidity	ddm	66.0	31.0

TABLE 11

SCREEN ANALYSIS

ADIT #9, MARTEN RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	36.0	12.2	36.0	12.2
-3/8" + 28M	45.8	9.5	81.8	10.7
-28M + 100M	13.7	6.9	95.5	10.2
-100M + 0	4.5	8.1	100.0	10.1

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	18.7	15.3	18.7	15.3
-3/8" + 28M	62.5	9.1	81.2	10.5
-28M + 100M	13.4	6.9	94.6	10.0
-100M + 0	5.4	6.0	100.0	9.8

TABLE I

ANALYSIS OF MARTEN RIDGE

ADIT #10

X-CUT @ 70' SEAM THICKNESS 11'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	9.1	5.4
Volatile Matter	%	34.4	37.2
Fixed Carbon	%	56.5	57.4
Free Swelling Index		5½	5½
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.38	0.42
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	413	417
Fusion Temp.	°C	429	430
Maximum Fluid Temp.	°C	450	445
Final Fluid Temp.	°C	466	465
Solidification Temp.	°C	471	469
Melting Range	°C	53	48
Maximum Fluidity	ddm	49.5	68.0

TABLE II

SCREEN ANALYSIS

ADIT #10, MARTEN RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	39.0	10.0	39.0	10.0
-3/8" + 28M	46.1	7.7	85.1	8.8
-28M + 100M	11.7	6.5	96.8	8.5
-100M + 0	3.2	9.0	100.0	8.5

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	17.8	10.5	17.8	10.5
-3/8" + 28M	51.4	9.0	69.2	9.4
-28M + 100M	17.9	7.0	87.1	8.9
-100M + 0	12.9	9.4	100.0	9.0

TABLE I

ANALYSIS OF MARTEN RIDGE

ADIT #11

X-CUT @ 66'   SEAM THICKNESS 19.1'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	14.3	5.0
Volatile Matter	%	32.6	34.6
Fixed Carbon	%	53.1	60.4
Free Swelling Index		#6	6
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.38	0.42
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	415	413
Fusion Temp.	°C	429	429
Maximum Fluid Temp.	°C	449	444
Final Fluid Temp.	°C	465	461
Solidification Temp.	°C	470	465
Melting Range	°C	50	48
Maximum Fluidity	ddm	50.0	18.0

TABLE II

SCREEN ANALYSIS

ADIT #11, MARTEN RIDGE

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	11.6	33.4	11.6	33.4
-3/8" + 28M	54.2	14.2	65.8	17.6
-28M + 100M	24.2	7.0	90.0	14.7
-100M + 0	10.0	7.6	100.0	14.0

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	5.6	38.3	5.6	38.3
-3/8" + 28M	53.1	17.5	58.7	19.5
-28M + 100M	23.5	8.6	82.2	16.4
-100M + 0	17.8	7.5	100.0	14.8

TABLE I

ANALYSIS OF MARTEN RIDGE (UPPER SEAM)

ADIT #12

X-CUT @ 103' SEAM THICKNESS 19.5'

		RAW COAL	CLEAN COAL
Proximate Analysis (db)			
Ash	%	23.1	7.5
Volatile Matter	%	28.5	33.5
Fixed Carbon	%	48.4	59.0
Free Swelling Index		3	3
Gross Calorific Value (dmmfb)			
Btu Per Pound			
Ultimate Analysis (db)			
Carbon	%		
Hydrogen	%		
Sulphur	%	0.53	0.55
Nitrogen	%		
Ash	%		
Oxygen (by difference)	%		
Ash Fusion			
Initial Deformation Temp.	IT		
Softening Temp.	ST		
Fluid Temp.	FT		
Grindability			
Hardgrove Index			
Giesler Plasticity			
Start	°C	416	413
Fusion Temp.	°C	429	427
Maximum Fluid Temp.	°C	443	448
Final Fluid Temp.	°C	460	461
Solidification Temp.	°C	466	466
Melting Range	°C	44	48
Maximum Fluidity	ddm	16.0	18.0

TABLE II

SCREEN ANALYSIS

ADIT # 12

Screen Analysis (Raw Coal, Hand Broken to -4")

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	17.9	38.4	17.9	38.4
-3/8" + 28M	52.7	20.5	70.6	25.0
-28M + 100M	20.9	14.5	91.5	22.6
-100M + 0	8.5	13.8	100.0	21.9

Attrition Test

Three hundred pounds of coal tumbled in ASTM COKE Tumbler for 30 minutes in batches of 50 pounds or 786 revolutions per batch. Total coal was mixed and screen analysed. Results are shown below.

SIZE	WT. %	ASH %	CUMULATIVE WT. %	CUMULATIVE ASH %
-4" + 3/8"	10.3	42.1	10.3	42.1
-3/8" + 28M	49.2	23.5	59.5	26.7
-28M + 100M	23.0	16.2	82.5	23.8
-100M + 0	17.5	14.4	100.0	22.1