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AN INVESTIGATION OF THE COKING PROPENSITIES OF TWO COAL SAMPLES FROM THE QUINTETTE PROJECT, NORTH EASTERN BRITISH COLUMBIA SUBMITTED BY DENISON MINES LIMITED

Project 03-5-1/6-22
Job No. 3387R

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by

J.G. Jorgensen*, T.A. Lloyd**and A.B. Fung***

INTRODUCTION

The evaluation of coals for Denison Mines Limited is a continuing divisional project in which periodic investigations are undertaken as requested by the company.

This investigation includes evaluation data on coals specified in a letter dated February 9, 1982 from R. Sagi, Chief Geologist, Coal Division, Denison Mines Limited. A copy of this letter appears in Appendix 1.

The two coals which were carbonized are identified as follows:

a) Blend No. 1 - DEN 1516 CM
- Quintette - Babcock/Sheriff Metallurgical Coal
- Seams D,E,F and G

b) Blend No. 2 - DEN 1516 CM

The cleaned coal samples received from Birtley Coal and Mineral Testing, Calgary, were crushed, blended, and carbonized in the 18-inch width Carbolite movable-wall coke oven, located at the Western Research Laboratory at Edmonton. Representative samples were taken for chemical, physical, thermal rheological, and petrographical analyses which were carried out at the Energy Research Laboratories located at the CANMET Bells Corners Complex near Ottawa. The results of the testing program are tabulated in Tables 1 to 6.

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BIBLIOGRAPHY

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2. ASTM Designation: D388-66, "Classification of Coals by Rank".

3. ASTM Designation: D720-67, "Test for Free Swelling Index of Coal".

4. ASTM Designation: D2639-71, "Test of Plastic Properties of Coal by the Constant-Torque Gieseler Plastometer." (Constant torque plastometer used with a torque of 40 gram-inch; start, 1 dd/m; fusion, 5 dd/m; final, 1 dd/m; solidification, no movement; range-temp., between start and final temperatures).

5. Burrough, E.J., "Specific Volatile Index", Fuels Division Memorandum 97/58-CG, Fuels and Mining Practice Division, Mines Branch, Dept. of M. and T.S., Ottawa, Canada (1958).

6. ASTM Designation: D409-71, "Grindability of Coal by the Hardgrove-Machine Method".

7. ASTM "Proposed Method of Test for Measuring the Coking Pressures of Coals by a Movable-Wall Slot Oven" (presently under consideration for adoption as a standard method of test by Sub-Committee XV of ASTM Committee D-5).

8. ASTM Designation: D291-60, "Cubic Foot Weight of Crushed Bituminous Coal" Procedure A - Procedure for Uncompacted Cubic Foot Weight).

9. ASTM Designation: D293-69, "Test for Sieve Analysis of Coke".

10. ASTM Designation: D294-64, "Tumbler Test for Coke".

11. Japanese Drum Test for Coke, Designated as J.I.S. (Japanese Industrial Standard) K 2151-1972, pp. 12-16).

12. Burrough, E.J., Strong, R.A. and Swartzman, E., "Report of Investigation on the Method Now in Use at the Fuel Research Laboratories for Determination of the Apparent Specific Gravity of Coke", R.I. C.S. 35, Division of Fuel Testing, Department of Mines, Ottawa, August 24, 1934.

13. ASTM Designation: D2014-71, "Expansion or Contraction of Coal by the Sole-Heated Oven".

14. German Industrial Specification No. DIN 51739/March 1951.

15. ASTM Designation: D-2797-72, "Preparing Coal Samples for Microscopical Analysis by Reflected Light".

16. ASTM Designation: D-2798-72, "Microscopical Determination of the Reflectance of the Organic Components in a Polished Specimen of Coal".

17. ASTM Designation: D-2799-72, "Microscopical Determination of Volume Percent of Physical Components of Coal".

18. Shapiro, N., Gray, R.J., "Petrographic Classification Applicable to Coals of all Ranks", Proc. 111, Min. Inst., 1960, 68, 83-97.

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TABLE 1. Chemical Analyses of Component Coals

Identification		
Laboratory Number	2890-82	2891-82
Description	Blend No. 1	Blend No. 2
Classification		
Rank (ASTM)	mvb	mvb
International System	433	433
Specific Volatile Index	191	191
Carbon (dmmfb) %	89.1	87.8
Proximate Analysis (db)		
Ash %	7.9	9.8
Volatile Matter %	22.8	22.8
Fixed Carbon %	69.3	67.4
Gross Calorific Value (db)		
Btu per pound	14245	13945
Ultimate Analysis (db)		
Carbon %	81.3	78.3
Hydrogen %	4.4	4.2
Sulphur %	0.44	0.46
Nitrogen %	1.6	0.9
Ash %	7.9	9.8
Oxygen (by difference) %	4.4	6.3
Ash Analysis (db)		
SiO_2 %	53.9	53.1
Al_2O_3 %	23.5	23.8
Fe_2O_3 %	5.3	5.8
TiO_2 %	1.0	1.0
P_2O_5 %	1.1	1.1
CaO %	5.0	6.2
MgO %	1.1	1.7
SO_3 %	4.6	4.2
Na_2O %	0.5	0.4
K_2O %	1.1	1.0

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

Identification				
Laboratory Number			2890-82	2891-82
Description			Blend No. 1	Blend No.2
Coal Pulverization				
Sieve Analysis				
Passing	Retained On			
	1/4 in.	%	3.4	2.5
1/4 in.	6 mesh	%	12.3	14.4
6 mesh	12 mesh	%	23.3	26.1
12 mesh	20 mesh	%	20.4	21.1
20 mesh	.....	%	40.6	35.9
Total Passing	6 mesh	%	84.3	83.1
Grindability				
Hardgrove Index			79	75
Fusibility of Ash				
Initial Deformation Temp. ...		°F	2205	2260
Softening Temp. Spherical ...		°F	2475	2370
Softening Temp. Hemispherical		°F	2580	2430
Fluid Temp.		°F	2680	2585

TABLE 3. Thermal Rheological Properties of Component Coals

Identification		
Laboratory Number	2890-82	2891-82
Description	Blend No. 1	Blend No. 2
Linear Expansion		
Bd. 52 lb/ft^3 at 2% moisture...%		
Gieseler Plasticity		
Start .....°C	427	429
Fusion Temp. .....°C	443	443
Max. Fluid Temp. .....°C	464	464
Final Fluid Temp. .....°C	486	487
Solidification Temp. .....°C	491	489
Melting Range .....°C	59	58
Max. Fluidity .....dd/m	61	88
Torque .....g.in.	40	40
Dilatation		
Ti - Softening Temp. .....°C	396	393
Tii - Max. Contraction Temp.°C	452	452
Tiii - Max. Dilatation Temp.°C	476	476
Contraction .....%	25	26
Dilatation .....%	15	15
Free Swelling Index		
F.S.I.	7	7½

TABLE 4. Petrographic Analysis of Component Coals

Identification		
Laboratory Number	2890-82	2891-82
Description	Blend No.1	Blend No.2
Distribution of Vitrinite Types		
V-6 %		
V-7 %		
V-8 %		
V-9 %		0.5
V-10 %	4.8	4.8
V-11 %	23.8	17.2
V-12 %	30.9	28.4
V-13 %		2.7
V-14 %		
V-15 %		
V-16 %		
V-17 %		
V-18 %		
Reactive Components		
Total Vitrinite %	59.5	53.6
Reactive Semi-fusinite (1/2) %	14.0	16.3
Exinite %	0.2	0.0
Total %	73.7	69.9
Inert Components		
Inert Semi-fusinite (1/2) %	14.0	16.3
Micrinite %	4.3	3.3
Fusinite %	3.6	5.0
Mineral Matter %	4.4	5.5
Total %	26.3	30.1
Petrographic Indices		
Mean Reflectance %	1.19	1.20
Balance Index	1.27	1.56
Strength Index	4.58	4.59
Stability Index	59.7	54.9

TABLE 5- Carbonization Conditions

Test Identification Number		C-131	C-132	C-138	C-139
Date of Test		Feb.25/82	March 2/82	March 30/82	April 1/82
Coke Oven Identification					
Description		DEN.1516CM Blend No. 1	DEN.1516CM Blend No. 1	DEN.1517CM Blend No. 2	DEN.1517CM Blend No. 2
CHARGE PROPERTIES					
Proximate Analysis (db)	Ash....%	7.9	7.9	9.8	9.8
	Volatile Matter....%	22.8	22.8	22.8	22.8
	Fixed Carbon....%	69.3	69.3	67.4	67.4
Moisture in Charge....%		2.8	2.7	2.3	2.2
Minus 1/8 in. (6 mesh)....%		83.6	85.2	83.1	83.1
Other:....(db). Sulphur..%		0.44	0.44	0.46	0.46
CARBONIZATION CONDITIONS					
Net Weight of Charge (wet)....lb		650.5	648.7	653.1	650.7
ASTM Cone Bulk Density (wet)....lb/ft^3		49.2	49.1	48.8	48.8
Calc. Charge Dry Bulk Density in Oven...lb/ft^3		51.0	50.9	51.5	51.3
Flue Temp Control					
Charge Push (Centre Temp:Soak Time)....^{o}C:hr		950:3	950:3	950:3	950:3
Quenched Coke Conditioning Drop....ft		10	10	10	10
CARBONIZATION RESULTS					
Gross Coking Time (at Push)....hr:min		17:49	17:44	17:42	17:19
Final Centre Temp....^{o}C		1038	1065	1053	1062
Time to 900^{o}C Centre Temp....hr:min		14:17	14:03	14:02	13:58
Time to 950^{o}C Centre Temp....hr:min		14:49	14:44	14:42	14:19
Time to 1000^{o}C Centre Temp....hr:min		15:57	15:34	15:36	15:24
Maximum Wall Pressure....lb/in^2		0.62	0.68	0.81	0.70
Coke Yield Actual....%		78.2	78.6	75.5	75.9

TABLE 6.- Coke Properties

Test Identification Number.....	C-131	C-132	C-138	C-139
SCREEN ANALYSIS OF COKE (cum % retained on)				
4 inch sieve.....	2.0	2.9	4.4	1.8
3 inch sieve.....	15.8	16.9	25.3	24.2
2 inch sieve.....	63.6	63.8	70.4	70.5
1½ inch sieve.....	86.6	83.8	86.4	85.0
1 inch sieve.....	95.1	95.0	94.4	94.0
3/4 inch sieve.....	96.6	96.5	06.0	95.9
½ inch sieve.....	97.3	97.3	96.9	97.0
Percentage -½ inch (breeze).....	2.7	2.7	3.1	3.0
Mean Coke Size.....in.	2.30	2.31	2.46	2.42
COKE CHEMICAL ANALYSIS				
Proximate Analysis (db)				
Ash.....%	9.9	9.9	11.4	11.6
Volatile Matter.....%	2.0	2.4	2.0	2.2
Fixed Carbon.....%	88.1	87.7	86.6	86.2
Sulphur (db).....%	0.41	0.39	0.40	0.43
COKE APPARENT SPECIFIC GRAVITY.....	0.98	0.98	1.00	0.98
ASTM COKE TUMBLER TEST				
Stability Factor.(cum % + 1 in.).....	53.4	53.4	45.9	44.4
Hardness Factor.(cum % + 1/4 in.).....	67.2	66.6	64.3	63.6
JIS COKE TUMBLE TEST (cum % retained on)				
30 revs: 50 mm sieve.....	20.0	16.6	14.1	14.7
25 mm sieve.....	87.8	87.8	82.8	81.9
15 mm sieve.....	93.0	93.2	91.4	90.7
150 revs: 50 mm sieve.....	6.6	3.6	1.7	3.0
25 mm sieve.....	71.2	72.4	59.7	59.7
15 mm sieve.....	82.0	81.8	77.0	76.5
OTHER				

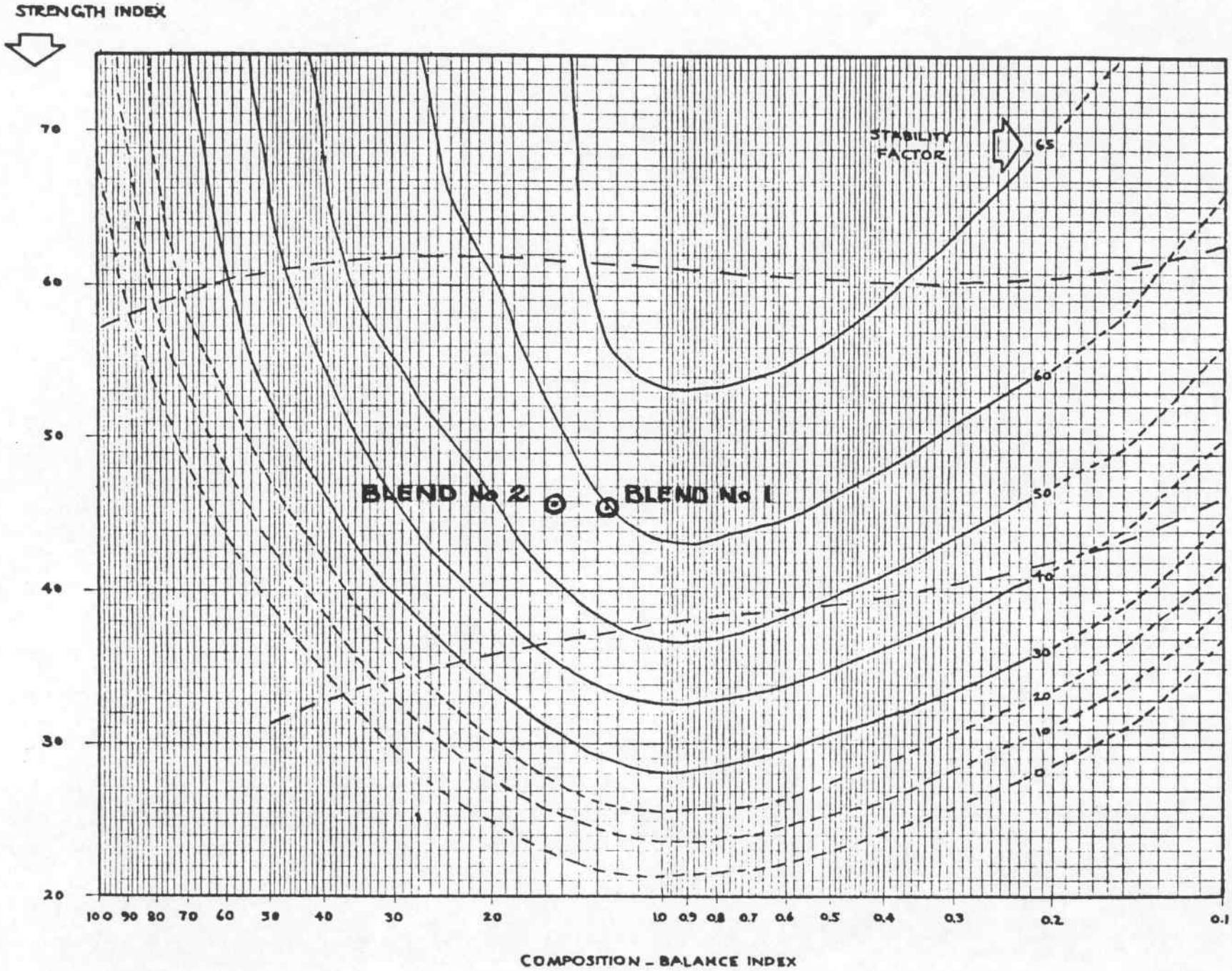
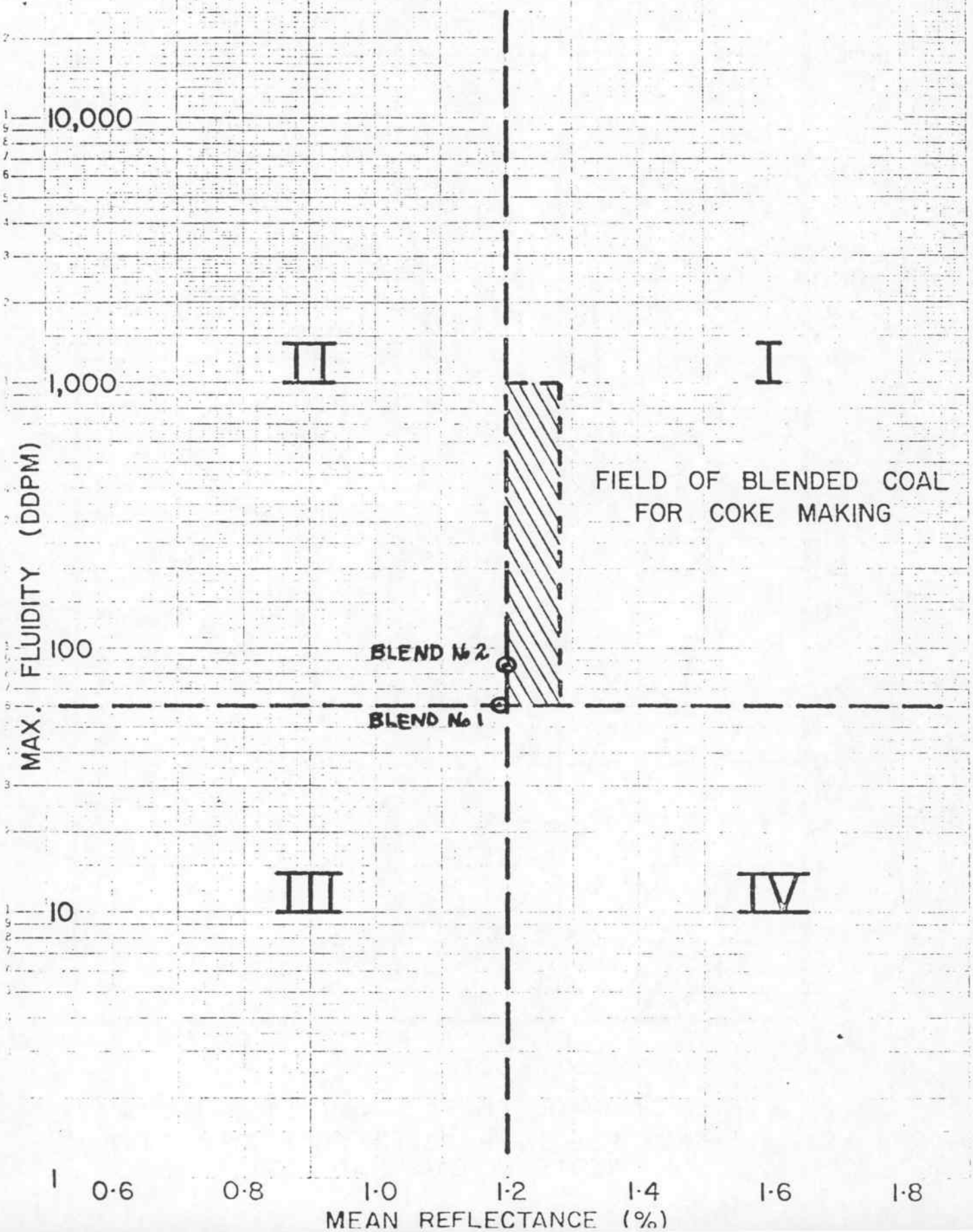


Figure 1 - Plot of the Stability Factors of the Component Coals from Petrographic Data.

Figure 2. RELATIONSHIP BETWEEN MAX. FLUIDITY AND MEAN REFLECTANCE.



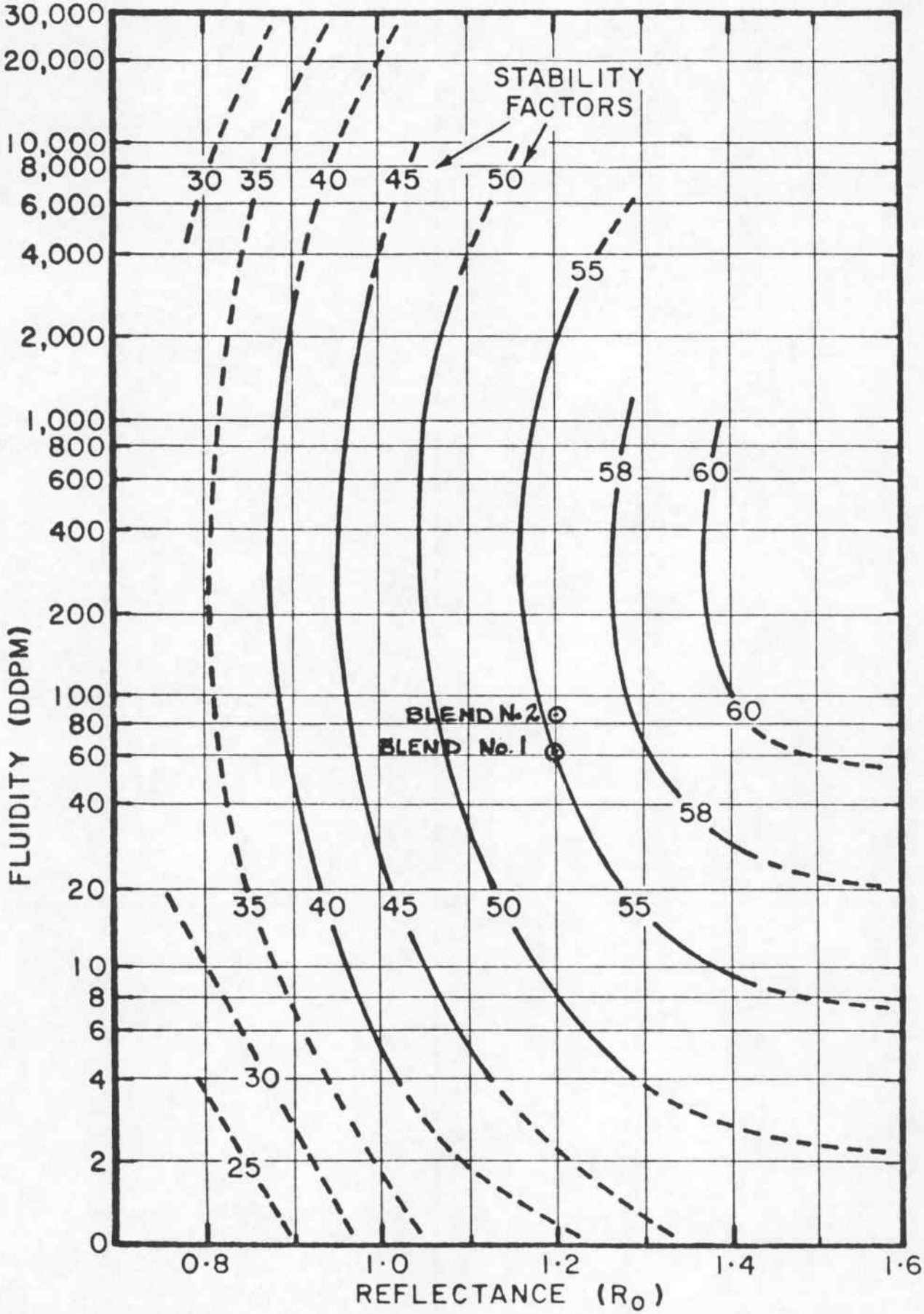


Figure 3. PREDICTION OF COKE STABILITY FACTORS.
– REGRESSION RESULTS FROM CANMET DATA ON WESTERN CANADIAN COALS.

APPENDIX 1

Letter dated February 9, 1982
from R. Sagi, Chief Geologist,
Coal Division, Denison Mines Ltd.

DENISON MINES LIMITED
COAL DIVISION

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February 9, 1982

Dr. David Brown
Acting Director
Coal Research Laboratories
555 Booth Street
Ottawa, Ontario
K1A 0G1

Dear Dave:

In continuation of the evaluation of coal samples from our coking coal developments in North East British Columbia, our company requests two technical-scale coke oven tests (in duplicate) and, as per our previous requests, complete routine support analyses, on a cleaned bulk sample from our Quintette property. In addition to the routine analyses, we would also like the reactivity and strength-after-reactivity of the resultant coke.

The Quintette sample is currently being processed by Birtley Coal and Minerals Testing in Calgary and a two-drum sample should be available in about two weeks time. At that time we can provide shipping information and other relevant matters necessary for its evaluation.

We appreciate the assistance which your Laboratory has provided in the evaluation of our coking coal deposits and hope that this work can be fitted into your schedule at your earliest convenience.

Yours truly,

DENISON MINES LIMITED

R. Sagi
Chief Geologist
Coal Division

RS:smc

cc: Ms. J. Picard, Western Research Laboratory
J. Jorgensen, CANMET, Ottawa
A. Fung, Western Research Laboratory