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F.R.L. Report No. 112

DEPARTMENT OF MINES AND RESOURCES
MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH
BUREAU OF MINES

Study of the Physical and Chemical Properties of Two Samples of Coal from the Top Level Workings of Tantalus Butte Mine, Yukon Territory

Operated by

Yukon Coal Co. Ltd., Carmacks, Y.T.

by

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Approved by:
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I

INTRODUCTION

The following report is a sequel to F.R.L. Report No.108[1], and pertains to a study of some of the physical and chemical properties of two samples of coal from Tantalus Butte Mine shipped to Ottawa specifically for combustion tests. These two samples of coal were examined for comparison with the first sample studied, because they represent production from the original top level workings of the mine which has been reopened for continued development and production. The first samples, reported in F.R.L. No. 108, came from the slope development which has since been, at least temporarily abandoned.

II

THE SAMPLES COLLECTED

The samples for this study include a mine run sample as well as a product which was screened over a 1½ in. stationary screen. Four tons of each grade were prepared at the mine on or about September 15, 1948, under the supervision of Mr. G. Miller, Mine Manager, for combustion trials which were conducted locally on September 29, 1948, on one of the river steam boats operated by the British Yukon Navigation Co. (The Yukon White Pass Route). At the conclusion of the steam boat tests the residues of each grade, amounting to approximately 1.5 tons in each case, were shipped from White Horse to Ottawa on October 9, 1948, the coal being sacked and put up in crates. The coal arrived in Ottawa on November 17, 1948, in an unusually wet state and was allowed to air dry for a short period prior to sampling for analysis.

The two samples were as follows:-

1. Mine Run - 3100 lbs. (Laboratory No. A562)
2. Plus 1½ in. lump - 3600 lbs. (Laboratory No. A563)

III

ANALYSES CONDUCTED

As only a small portion of each of the two bulk samples could be spared for this study only certain relavent tests for comparative purposes were conducted, as follows:-

A. Physical Properties

1. Screen Analysis

Each of the two samples were hand screened using a series of standard round-hole screens with openings from 10 inches down to 1/32 inch. The results of these tests are shown in Table I.

2. Bulk Density and Apparent Specific Gravity

The bulk density(weight per cubic foot) of both bulk samples and the apparent specific gravities of several sized fractions from the 1½ in. lump were determined by standard methods. The results are shown in Tables I and II.

3. Resistance to Handling or Friability

The relative resistance of the coal to handling or conversely its friability was determined by two A.S.T.M. methods. The "size stability" of the larger pieces from the mine run sample, namely, the 2-3 inch size, was determined by the tentative Drop-Shatter Test. The "friability" of the smaller lumps, namely 1-1½ in.sq.

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(1) F.R.L. Report No.108 - Physical & Chemical Survey Report No.137 "Study of Coal from Tantalus Butte Mine, Yukon Territory" by E. Swartzman. December, 1948.

size prepared from the mine run sample (A562) was determined by the Standard "Tumbler Test for Coal".

The results of the Drop-Shatter tests are shown in Table III, whereas the data on the Tumbler Test is given in Table IV.

B. Chemical Properties

The various screened sizes from the two main samples as well as the composite Mine Run and 1½ in. lump were subjected to one or more of the following standard analyses.

1. Proximate Analysis

Moisture, volatile matter, fixed carbon and ash, conducted on all the samples.

2. Sulphur

Conducted on Composites only.

3. Calorific Value

Determined only for the composite samples.

4. Fusibility of Ash

This included the determination of the initial, softening and fluid temperatures of the ashes of the composite samples only.

All of the above data for both the mine run and Plus 1½ in. lump samples are shown in Tables V and VI.

C. Laboratory Washing Tests

Washing tests were conducted by the use of the float-and-sink method, washability curves being constructed from the data obtained to indicate the theoretical ash contents and yields of both clean coal and refuse obtainable at a given gravity.

The data obtained as a result of these tests on the 1½-4 in. lump and the 1/8-1½ in. size prepared from the Mine Run Sample are shown in Tables VII and VIII respectively.

In addition to the usual washability curves the "specific gravity distribution" curve suggested by B.M. Bird was also plotted and used to indicate the degree of difficulty of wet washing as shown in the following table:-

±.10 Curve	Degree of Difficulty of Wet Washing	Preparation
Per Cent		
2 - 7	Simple.....	Almost any Process: high tonnage
7 - 10	Moderately difficult.....	Efficient process: high tonnage
10 - 15	Difficult.....	Efficient process; medium tonnage
15 - 20	Very difficult.....	Very efficient process: low tonnage
Above 25	Formidable.....	Limited to a few exceptionally efficient processes

For the ordinary wet washing of a coal, 10 per cent on the curve is used, and the specific gravity representing this point is selected as indicating simple to moderately difficult washing. When applying the float-and-sink data to a dry cleaning study of a coal, 3 per cent on the specific gravity distribution curve is recommended.

Curves showing the ash reduction which is possible under varying conditions of washing the various sizes prepared are presented in Figures I and II.

IV

DETAILS OF RESULTS

The data, discussed in Chapter III, obtained for both the Mine Run and Plus 1½ in. lump samples are presented in the following series of tables.

A. Physical Properties

Table I - Screen Analyses and Bulk Density of both samples.
Table II - Apparent Specific Gravity of Screened Sizes from 1½ in. lump.
Table III - Size Stability (Drop-Shatter Method) of larger Pieces from Mine Run.
Table IV - Friability (Tumbler Test) of the smaller pieces from the Mine Run.

B. Chemical Properties

Table V - Chemical Analyses of various sizes and composites of both samples.
Table VI - Fusibility of ash of composites of both samples.

C. Laboratory Washing Tests

Tables VII & VIII - Float and Sink Data on 1½ - 4 in., and 1/8-1½ in. sizes prepared from Mine Run sample.

TABLE I

SCREEN ANALYSES OF MINE RUN AND PLUS 1½ IN. SCREENED LUMP

	Mine Run % by Wt.	Plus 1½ in. Screened Lump % by Wt.
8 - 10 in.	1.4	7.6
7 - 8 in.	1.4	1.4
6 - 7 in.	4.1	4.1
5 - 6 in.	1.8	3.2
4 - 5 in.	2.5	4.0
2 - 4 in.	12.7	18.6
1½ - 2 in.	4.6	7.6
1 - 1½ in.	8.4	10.8
3/4 - 1 in.	5.6	5.7
½ -3/4 in.	9.0	7.1
¼ - ½ in.	14.3	9.5
1/8 -1/4 in.	11.7	4.1
1/16 -1/8 in.	6.5	4.9
1/32 -1/16 in.	6.5	4.3
0 -1/32 in.	9.5	7.1
Av. Particle Size.. in.	1.472	2.356
Bulk Density.... lb/cu.ft.	55.1	54.7

TABLE II

APPARENT SPECIFIC GRAVITY
(On Sizes from Plus 1½ in. Lump)

	Apparent Specific Gravity	Solid Density* lbs./cu.ft.	Ash %
Plus 4 in.	1.35	84.18	11.8
2 - 4 in.	1.34	83.56	10.7
1½ - 2 in.	1.33	82.93	11.2
1 - 1½ in.	1.30	81.06	11.3

* Wt. of cubic foot of water taken as 62.3566 lbs. avoirdupois.

TABLE III

SIZE STABILITY OF LARGER PIECES OF COAL FROM MINE RUN
(Drop-Shatter Test Method)

Screen Sizes	Screen Analyses Before and After Drop-Shatter Test 2-3 in. Size		
	Before Test %	After 2 drops %	After 4 drops %
2 - 3 in.	100.0	48.0	33.0
1½ - 2 in.		15.0	14.5
1 - 1½ in.		9.0	12.5
3/4 - 1 in.		4.5	5.0
½ - 3/4 in.		6.0	7.5
0 - 1/2 in.		17.5	27.5
Av. Size..in.	2.500	1.696	1.386
Size Stability.%		67.8	55.4

TABLE IV

FRIABILITY OF SMALLER LUMPS FROM MINE RUN
(Tumbler Test)*

Coal	Mine Run (A562)
Friability.....%	48.4

* Test conducted on lumps 1-1½ in. sq. screen size.

TABLE V

CHEMICAL ANALYSES OF COAL: PROXIMATE, SULPHUR, AND CALORIFIC VALUE

Screen Sizes	Mine Run						Plus 1½ in. Lump					
	Moisture (as rec'd) %	Dry Basis					Moisture (as rec'd) %	Dry Basis				
		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value BTU/Lb		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value BTU/Lb
Plus 4 in.	5.5	9.5	34.1	56.4	-	-	5.4	11.8	35.8	52.4	-	-
2 - 4 in.	4.5	11.3	33.7	55.0	-	-	3.9	10.7	34.0	55.3	-	-
1½ - 2 in.	3.9	11.7	33.8	54.5	-	-	3.5	11.2	34.0	54.8	-	-
1 - 1½ in.	4.2	11.8	33.9	54.3	-	-	3.8	11.3	34.3	54.4	-	-
3/4- 1 in.	4.2	12.3	33.2	54.5	-	-	3.3	11.0	33.7	55.3	-	-
1/2- 3/4 in.	4.4	11.6	35.1	53.3	-	-	4.0	11.2	33.8	55.0	-	-
1/4- 1/2 in.	4.4	12.1	33.8	54.1	-	-	4.3	10.1	34.6	55.3	-	-
0 - 1/4 in.	4.1	33.4	33.6	53.0	-	-	3.5	10.7	34.9	54.4	-	-
Composite	4.5	12.1	33.4	54.5	0.5	12,070	4.5	11.3	34.3	54.4	0.4	12,005
Composite as received	4.5	11.6	31.9	52.0	0.4	11,525	4.5	10.8	32.7	52.0	0.4	11,465

TABLE VI

FUSIBILITY OF ASH

Screen Sizes	Mine Run					Plus 1½ in. Lump				
	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Ash %	Initial Deformation °F	Softening-Temperature °F	Fluid Temperature °F.	Melting Range °F.	Ash %
Composite	2150	2250	2290	140	121	2210	2300	2340	130	11.3

TABLE VII

Float and Sink Data on 1½ in. 4 in. Lump* (See Fig.I)

-Ash-

Specific Gravity			Weight	Ash	Cumulative Floats		Cumulative Sinks		±.10 Specific Gravity Distribution	
					Weight	Ash	Weight	Ash	Gravity	Calculated Ordinate
			%	%	%	%	%	%		
	Floats	1.32	10.6	6.9	10.6	6.9	100.0	10.6	1.40	91.2
Sinks 1.32	"	1.40	66.5	8.9	77.1	8.6	89.4	11.1	1.45	41.1
" 1.40	"	1.50	14.1	8.8	91.2	8.7	22.9	17.4	1.55	12.8
" 1.50	"	1.60	7.3	28.0	98.5	10.1	8.8	31.2	1.65	4.9
" 1.60			1.5	46.7	100.0	10.6	1.5	46.7	1.75	0.2
Curve No.		4		2	1,2,4	1	3	3	5	5

TABLE VIII

Float and Sink Data on 1/8-1½ in. Size*. (See Fig.II)

-Ash-

Specific Gravity			Weight	Ash	Cumulative Floats		Cumulative Sinks		±.10 Specific Gravity Distribution	
					Weight	Ash	Weight	Ash	Gravity	Calculated Ordinate
			%	%	%	%	%	%		
	Floats	1.32	12.0	4.3	12.0	4.3	100.0	12.2	1.40	92.2
Sinks 1.32	"	1.40	55.7	7.3	67.7	6.8	88.0	13.2	1.45	52.0
" 1.40	"	1.50	20.5	12.6	88.2	8.1	32.3	23.5	1.55	12.3
" 1.50	"	1.60	4.5	23.4	92.7	8.9	11.8	42.5	1.65	3.1
" 1.60			7.3	54.2	100.0	12.2	7.3	54.2	1.75	1.5
Curve No.		4		2	1,2,4	1	3	3	5	5

*Prepared from Mine Run Sample (A562)

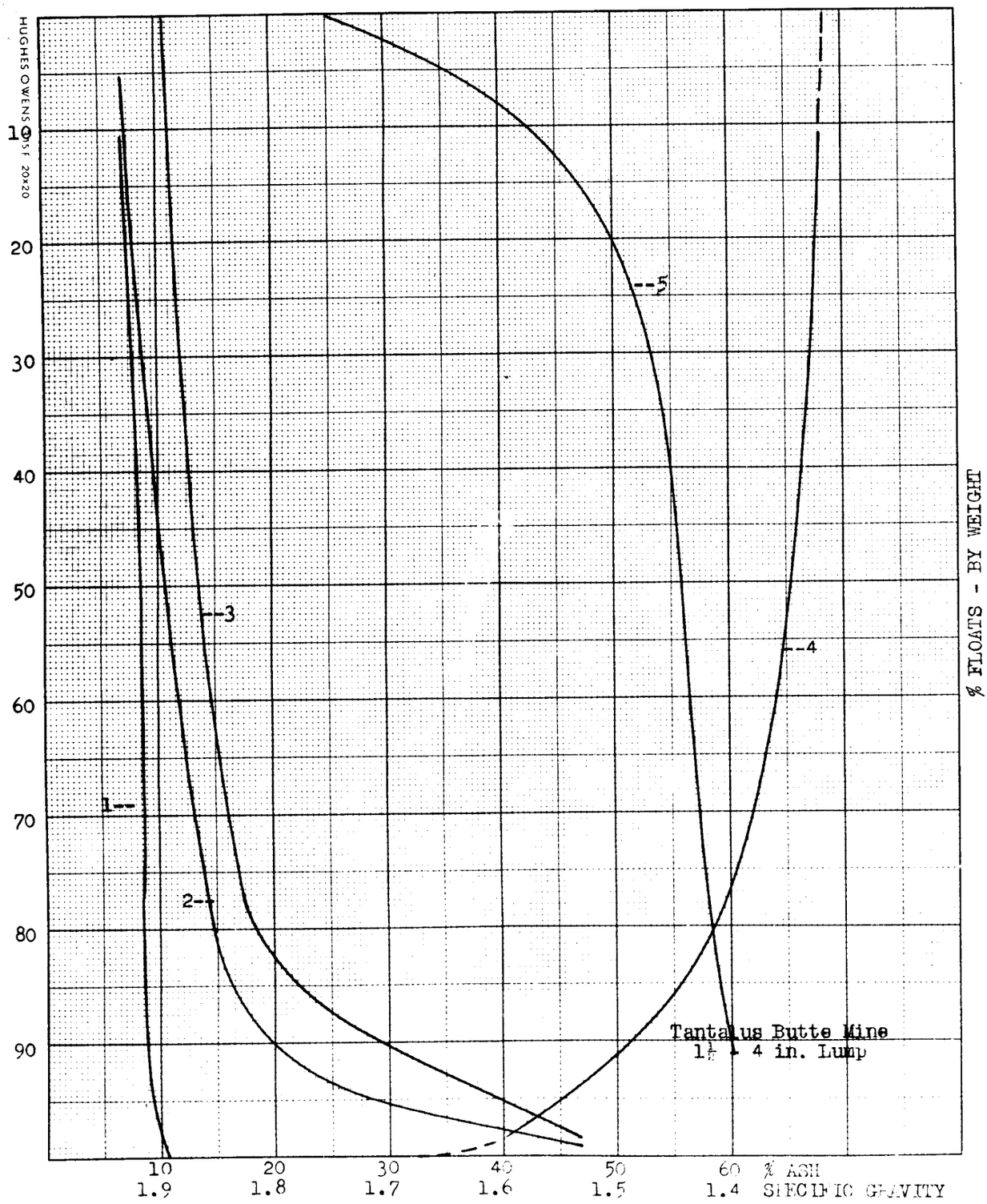

Fig. 1 - [illegible] 1 & - 1½ inch - TANTALUS BUTTE MINE

Curve 1 - Cumulative coal-ash percentage (Floats)
Curve 2 - Actual ash percentage
Curve 3 - Cumulative slate-ash percentage
Curve 4 - Specific gravity
Curve 5 - ±.10 Specific gravity distribution

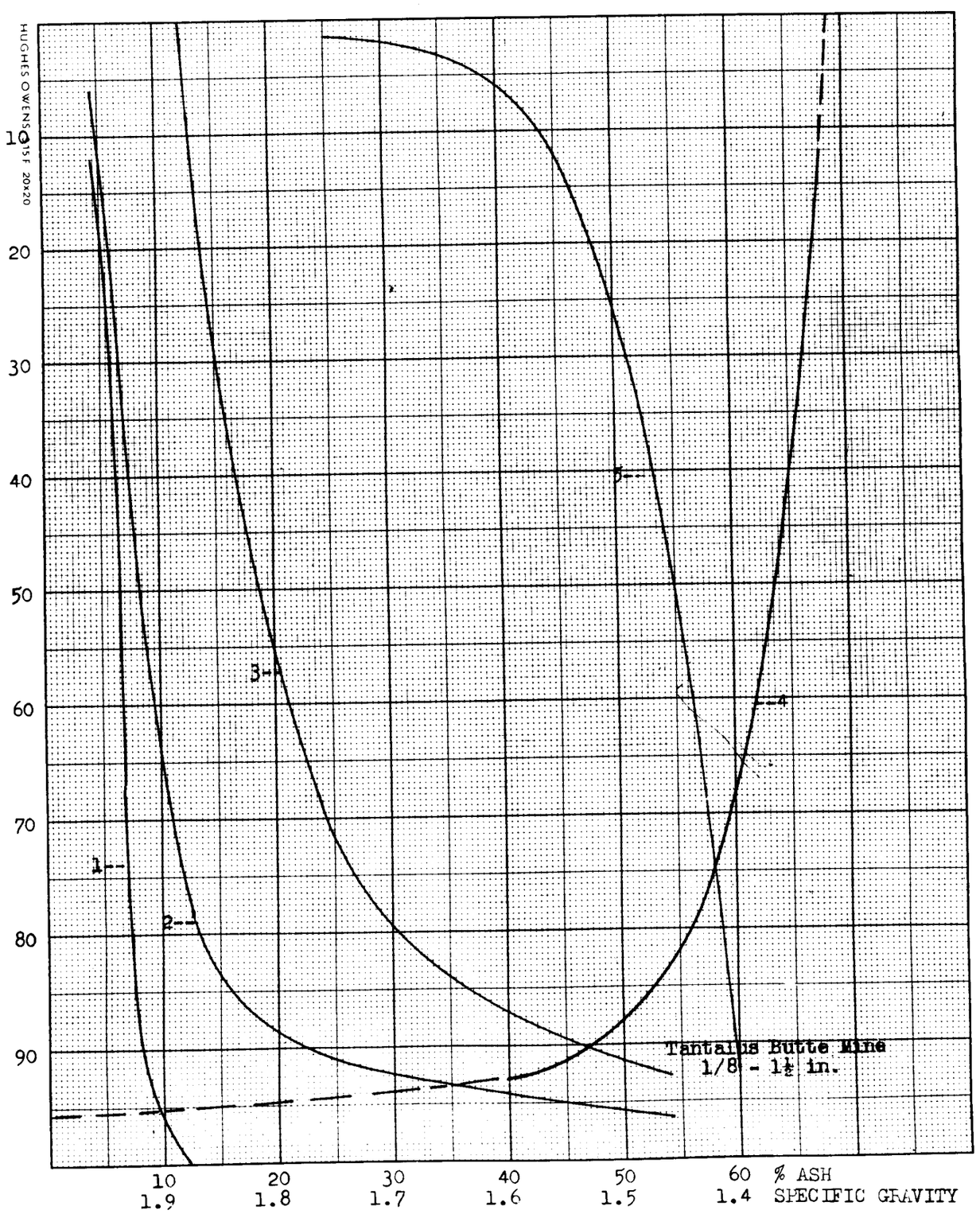

Fig. II - WASHABILITY CURVES FOR 1½ - 4 inch Lump - TANTALUS BUTTE MINE

Curve 1 - Cumulative coal-ash percentage (Floats)
Curve 2 - Actual ash percentage
Curve 3 - Cumulative slate-ash percentage
Curve 4 - Specific gravity
Curve 5 - ±.10 Specific gravity distribution

V

DISCUSSION OF RESULTS

The two samples, used in this study, namely Mine Run and Plus 1½ in. lump coal from the Tantalus Butte mine were collected and prepared at the mine by mine officials from coal coming from the top level workings. The previous sample examined, with which these are to be compared, came from the slope development. Each of the two samples were bagged and the bags were then packed in crates for shipment with a view to reducing to a minimum degradation as a result of handling. It should be noted, however, that the samples became wet in transit a factor which may have resulted in some degradation especially on drying.

A. Physical Properties

(1) Sizing As Received

The results of the screening tests on each of the two samples of coal after delivery to Ottawa are shown in Table I. The table below shows the main size divisions of the samples in comparison to the Slope Mine Run Sample (See Report F.R.L. No. 108)

Comparative Screen Analyses

Location of Sample	Top Level		Slope
Date Sample	Sept.15/48		July 22 & 23/48
Size Designation	Plus 1½" Lump	Mine Run	Mine Run
Plus 4 in.....%	20.3	11.2	8.8
1½-4 in.....%	26.2	17.3	10.0
1/4-1½ in.....%	33.1	37.3	29.4
0 - 1/4 in.....%	20.4	34.2	51.8
Av. Particle Size..in.	2.356	1.472	1.017

The mine run coal from the top level was coarser than that received earlier from the slope development, but even so it still contained 71.5% of 1½ in. slack in comparison to 81.2% of the same size slack in the mine run coal from the slope.

The plus 1½ in. screened lump, due partially to inefficient screening at the mine and partially to degradation as a result of handling and weathering, contained 53.5% of 0-1½ in. slack, an undoubtedly excessive quantity for a screened lump. This is quite definitely indicative of a naturally very friable coal.

(2) Density of the Coal

The apparent specific gravity and solid density of various sizes from the Top level 1½ in. lump in comparison to similar sizes from the original slope Mine Run are shown below:-

Comparison of Density of Coals.

Screen Size	Plus 4 in.	2-4 in.	1½-2 in.	1-1½ in.
Top level Lump				
App. Sp. Gravity	1.35	1.34	1.33	1.30
Solid Density...lb/cu.ft.	84.2	83.6	82.9	81.1
Ash.....%	11.8	10.7	11.2	11.3
Slope Mine Run				
App. Sp. Gravity	1.39	1.39	1.38	1.36
Solid Density...lb/cu.ft.	86.7	86.7	86.1	84.8
Ash.....%	23.4	17.7	20.2	19.4

The overall lower density of the Top Level coal appears to be definitely related to its lower ash content, but it should be noted that, as in the case of the slope coal as the size decreases the density decreases irrespective of the ash content.

(3) Size Stability or Friability of the Coal

The stability to handling of the larger lumps was determined by the Drop-Shatter test method, using only the 2-3 inch size from the Mine run Sample, the results being shown in Table III. The results of the four-drop test are shown below in comparison to that obtained for the same size lumps from the Slope Mine Run sample. (See Report F.R.L. NO.108)

Size Stability - Four Drop Shatter

Origin of Sample	Top Level Mine Run	Slope Mine Run
Size Tested	2 - 3 in.	2 - 3 in.
Size Stability.....%	55.4	62.2
Fines on Shattering ($-\frac{1}{2}$")....%	27.5	23.5
Slack on Shattering ($-1\frac{1}{2}$")...%	52.5	45.0
Av. Particle Size After Shattering.....in.	1.39	1.56
Proportion remaining in original Size.....%	33.0	43.0

It is of interest to note that the Top Level 2 - 3 in. lumps are appreciably less stable to handling than similar size lumps from the original mine run sample collected from the slope. The Top level sample apparently was exposed to less handling from the time of sampling to delivery at Ottawa, and thus the lumps exhibited a stability more in line with the natural friability of the coal as indicated by the screen analyses of the mine run samples. Less careful handling of the sample would have undoubtedly resulted in more slack, but the remaining lumps might have been more resistant.

The friability of the smaller lumps, namely 1-1½ in. size, from the Top level Mine Run sample, as determined by the Tumbler test is shown in Table IV. The table below compares this data with that obtained for the bottom section of a channel sample collected at the bottom of the slope (see Report F.R.L. No. 108)

Friability (Tumbler Test)

	Top Level Mine Run	Bottom Section Channel Sample
Friability.....%	48.4	56.0

These results would appear to indicate that the smaller lumps of the Top level coal are more stable than those taken from coal mined in the slope. This may account for the fact that the Top level mine run sample showed a somewhat lower slack and fines content than the mine run sample collected earlier in the year from the slope workings.

B. Chemical Properties of the Coal

Table V shows, comparatively, the proximate analysis of the various screened sizes from both the mine run and 1½ in. lump samples taken from the Top level workings. Down to the ½ in. screen size the analyses of the two samples compare very favourably the ash contents varying only from 9.5% to 12.3% without any variation with size. The minus ½ in. size of the lump sample is substantially

lower in ash than the same size in the mine run, as the former is merely a degradation product from the lower ash lumps.

The analyses of the composites of the two samples in comparison to the No.5 Raise coal from the Slope production (See Table VI F.R.L. Report No.108) are as follows:

Chemical Analyses
(As Received Basis)

	Top Level Coal		Slope Coal
	1½" Lump	Mine Run	Mine Run
Proximate analysis			
Moisture.....%	4.5	4.5	4.9
Ash.....%	10.8	11.6	12.5
Volatile Matter.....%	32.7	31.9	33.6
Fixed Carbon.....%	52.0	52.0	49.0
Sulphur.....%	0.4	0.4	0.5
Calorific Value..BTU/lb	11,465	11,525	11,675
Coking Properties (by Volatile button at 950°C.).....	Poor	Poor	Poor

In so far as chemical quality is concerned there appears to be little difference between the Top level and the normal slope coal, with the exception that the volatile matter and the calorific value of the slope coal would appear to be somewhat higher than in the case of the Top level coal.

According to the Specific Volatile Index method of coal classification by rank, where rank is based on the unit heating valve of the volatile matter evolved at 950°C. the Top level coal has an average index of 126.2 which places it in the Subbituminous class bordering on the Black Lignites. The slope coal showed an average index of 139 indicating a somewhat higher rank.

According to the A.S.T.M. Classification by rank the top level coal is classed as High Volatile B bituminous near the border of the High Volatile C bituminous.

The calorific Value of the Top level coal is substantially lower on the dry mineral-matter-free basis than the slope coal. The Top level coal shows an average calorific value of 13,792 B.t.u./lb, whereas the slope coal showed a value of 14,337 B.t.u./lb.

All the indications are that the Top level coal is somewhat oxidized in comparison to the slope coal.

The caking properties of the Top level coal is similar to the slope coal, the smalls and fines showing poor coking, whereas the large lumps are either non-agglomerating or weakly agglomerating.

C. Washing Characteristics

Washing tests, by the standard float-and-sink method using heavy media prepared from an admixture of organic liquids, were conducted on the 1½-4in. lumps and the 1/8-1½ in. smalls prepared from the Mine Run Sample. The results are shown in Tables VII and VIII.

The table below compares the inherent ash contents of the two sizes of the Top level coal as indicated by the fractions floating at the lowest gravity of separation, with that of the Slope coal.

Inherent Ash

	Floats 1.32 to 1.33	
	Yield-%	Ash-%
Top Level Coal		
1½-4 in lump	10.6	6.9
1/8-1½ in. smalls	12.0	4.3
Slope Coal		
1½-4 in. lump	5.7	4.8
1/8-1½ in. smalls	10.1	5.4

In all cases the inherent ash is high and the quantity of coal reclaimed at the low gravity is very low.

Using 10% on the ±.10 specific gravity distribution curves shown in Figures I and II, an indication of the equivalent gravity at which moderately simple wet washing may be effected, with the production of only two products, namely clean coal and refuse, is obtained. These gravities and the quantity and quality of products that may be produced from the Top level coal in comparison to the Composite Slope Coal (See Report F.R.L. No.108 page 30) is shown below:-

Moderately Simple Wet Washing

	Gravity of Separation	Clean Coal		Ash In Raw Coal %
		Yield %	Ash %	
Top Level Coal				
1½-4 in. Lump	1.575	97.3	10.0	10.6
1/8-1½ in. Smalls	1.570	92.5	9.0	12.2
Slope Coal				
1½-4 in. Lump	1.665	81.0	13.0	18.5
1/8-1½ in. Smalls	1.710	74.5	14.8	25.2

The results indicate that both sizes of the top level coal may be washed down to from 9.0% to 10.0% ash with an increasing loss as refuse as the raw coal ash increases. The Top level coal appears to react somewhat more favourably to washing than the Slope coal, but in the case of the latter it should be noted that the sample washed was unusually high in ash due to contamination. In neither case can this coal be considered to be very amenable to wet cleaning, and processing by dry methods would no doubt be even less favourable.

Concluding Remarks

The Top level coal dealt with in this report is very similar in all respects to the coal previously obtained for examination from the now abandoned slope development. Although the mine run sample was somewhat coarser than the original slope sample, there is every reason to believe that if the coal from both sections were mined and handled in the same manner there would be no difference in their average particle size. All the coal so far examined is naturally very friable and soft and produces on ordinary handling an excessive quantity of slack and fines.

From a chemical viewpoint there is little to choose between the coal coming from the different areas of the mine. The coal varies between 10% and 13% in ash content with some concentration in the fines. In some sections of the mine the coal may be locally contaminated due in some cases to the proximity of faults, but this is apparently the exception rather than the rule. The coal as a whole is high in volatile matter, and classified according to the North American Coal Classification as High Volatile B bituminous bordering on the High Volatile C bituminous. According to the Specific Volatile Index method of classification as well as by Seyler's classification, this latter based on carbon and hydrogen, the coal is subbituminous. The coal from both the top level and the slope workings shows only poor caking properties, the lump sizes being even poorer in this quality than the fines, some samples being entirely non-agglomerating.

Washing tests indicate that both the top level and slope coal samples were not very amenable to cleaning, the intermediate bone fraction being rather high. With efficient wet processes the best that could be expected is a cleaned coal with approximately 10% to 13% ash. By selective mining a product approaching this could in all probability be readily produced.