HERENDEEN BAY—CHIGNIK COALS, SOUTHERN ALASKA PENINSULA

By
C.N. Conwell and D.M. Triplehorn

SPECIAL REPORT 8

STATE OF ALASKA

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Herendeen Bay—Chignik Coals, Southern Alaska Peninsula

By C.N. Conwell[1] and D.M. Triplehorn[2]

ABSTRACT

There are 17 separate beds in the Herendeen Bay-Chignik coal fields, and they appear to have marked changes in character, thickness, and ash content (Paige, 1906). The coals are high-volatile B bituminous with a high ash content (about 20 percent), but a washed product can be produced with less than 10 percent ash and a Btu value of 12,000. The areal extent of the field is greater than previously reported, extending from Pavlof Bay over 200 miles northeast to Dog Salmon River. The coal field is near tidewater.

INTRODUCTION

Most activity in the Herendeen Bay-Chignik coal fields (fig. 1) occurred in the 1880's, when three known mines were operating: at Herendeen Bay, on the Chignik River, and on Unga Island (Dahl, 1896). Stone (1905) visited the area in 1904 and reported on coal beds in Aniakchak Bay, Whalers Creek, Thompson Creek, Hook Bay, and Chignik River. Only the Chignik River mine appears to have had an extended period of operation, 1893-1911, when it provided coal for the Alaska Packers Association Cannery, located on the south side of Chignik Lagoon (Stone, 1905; Atwood, 1909, 1911).

Interest waned as oil gradually superseded coal, although there are brief descriptions of mining activity by Knappan (1929) and Gates (1944). Then, in 1973, the price of oil increased substantially and interest in coal was renewed. The coal resource became important to the state in terms of coastal zone management and possible commercial development.

The principal author first visited the area in 1974 and obtained samples 75-cc-1 through -17. In 1975 both authors spent 1 week obtaining new samples for ultimate, proximate, calorific - value, major - oxide, and trace-element analyses under a contract with the Coal Division of the USGS. The intent was to collect samples and to measure sections near Herendeen Bay, Chignik River, Hook Bay, and on Unga Island. Unfortunately, the mine on Hook Bay could not be seen from the air and fog prevented landing on Unga Island. Continued poor weather prevented the party from locating the mine and beds at Aniakchak Bay.

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REGIONAL GEOLOGY

The most comprehensive geologic study of the Alaska Peninsula is by Burk (1965). Lyle and Dobey (1974) made minor modifications of Burk's map (pl. 1 and 2). Fairchild (1977) recently studied paleoenvironments of the Chignik Formation, including many outcrops identical with or adjacent to those the authors sampled for coal.

STRATIGRAPHY

All samples but one were obtained from the Coal Valley Member of the Upper Cretaceous Chignik Formation on the Chignik River and from the west side of Herendeen Bay. The exception was from rocks mapped by Burk (1965) as Pliocene marine sandstones and conglomerates; the sample is from an area labeled only as Tertiary marine rocks on plate 1. Generalized stratigraphic relationships of these and other units on the Alaska Peninsula are shown in figure 2.

Upper Cretaceous rocks on the Alaska Peninsula grade upward from nonmarine clastic rocks through marine sandstones to black siltstones and shales (Burk, 1965). The Chignik Formation, with the nonmarine Coal Valley Member at the base, constitutes the lower sandy sequence and the Hoodoo Formation constitutes the upper argillaceous sequence. It unconformably overlies several Upper Jurassic and Lower Cretaceous units, including the Herendeen Limestone, Staniukovich Formation, and Naknek Formation (figs. 1, 2).

The Chignik Formation is highly variable and difficult to distinguish from adjacent units in many areas. The basal Coal Valley Member consists of carbonaceous to lignitic shales, siltstones, and sandstones that are locally bentonitic and weather to orange or reddish brown. The contact between this member and the overlying marine Chignik sandstones is locally gradational and can be located only approximately in many places (Burk, 1965). On the basis of composition and structural relationships, Fairchild (1977, p. 52) suggests that the lower part of the Coal Valley Member at Coal Bluff may belong to the underlying Herendeen Limestone.

Tertiary strata are at least 25,000-30,000 feet thick in the Herendeen Bay area (Burk, 1965, p. 83). Rocks of all Tertiary epochs are present and both marine and nonmarine sediments are represented.

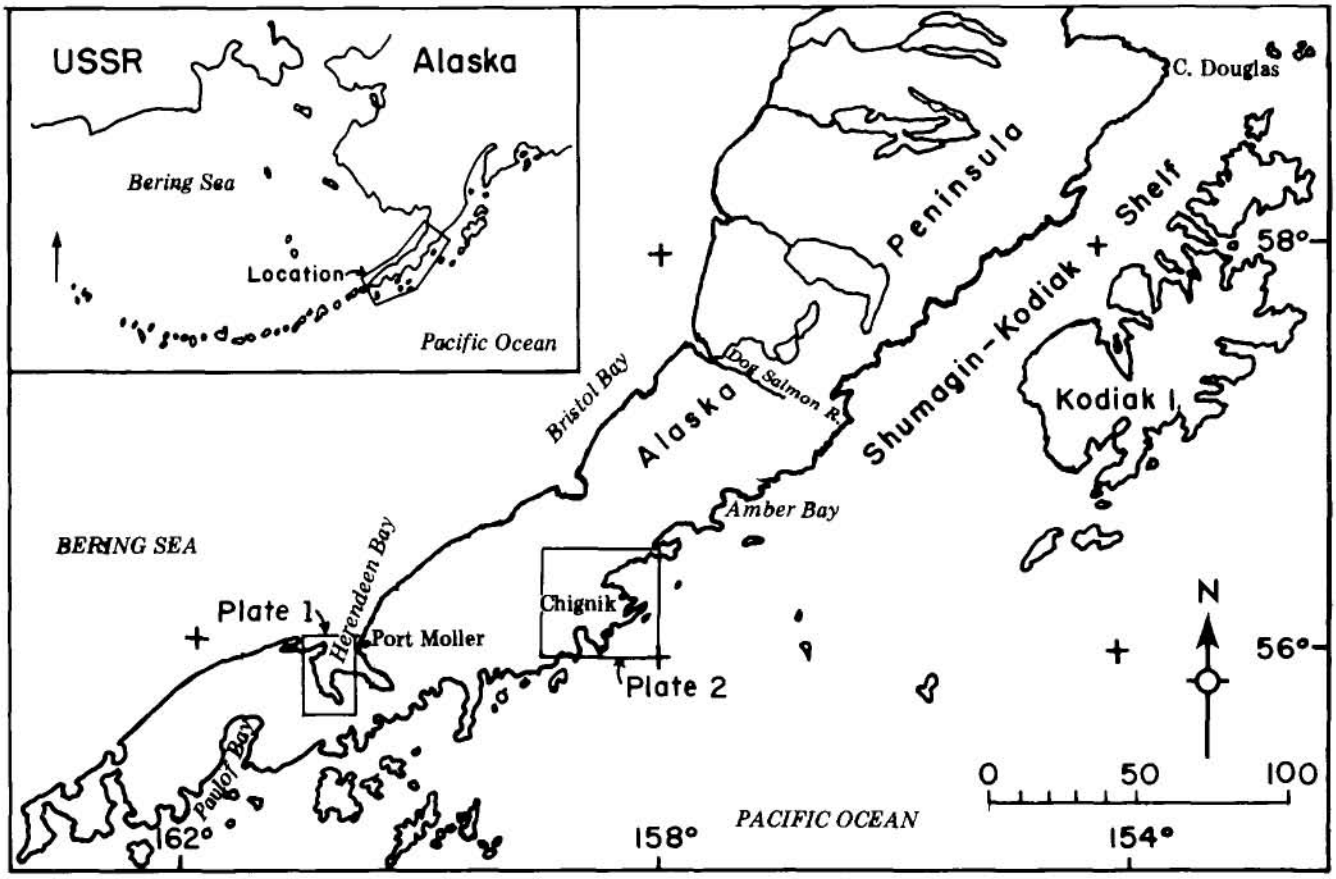

Figure 1. Known extent of the Chignik formation (Fairchild, 1977; modified from Burk, 1965).

STRUCTURE AND GEOLOGIC HISTORY

Major structural features of the Alaska Peninsula commonly trend northeast-southwest, roughly aligned with the geographic axis. This includes the strikes and axes of most faults and folds.

According to Burk (1965, p. 145) the history of the Peninsula is not one of continued compressional folding and orogenic deformation. Rather, it is characterized largely by episodes of differential vertical movement following periods of plutonic intrusion. The present structural configuration is apparently due entirely to Pliocene deformation, the only period of strong orogenic movement here.

Current interpretations revolve around events associated with a subducting Pacific plate. Fairchild (1977, p. 89) states that the Chignik Formation possibly was deposited in the fore-arc basin of a plate-subduction arc-trench gap as shown in figure 3. Coals, then, were probably deposited as a penecontemporaneous continental, transitional, and marine shelf complex between a volcanic island arc to the north and an oceanic trench to the south. Tertiary sediments were probably deposited in a similar setting, except that there was a transition from a Mesozoic arc-trench system to the present system during Late Cretaceous or early Tertiary time (Moore, 1974).

COAL CHARACTERISTICS

TESTS

The mode of transportation, helicopter and light aircraft, limited the weight of material that could be collected. The samples (5-15 lb. each) collected were representative of the entire thickness of a bed. Each sample was analyzed for moisture, ash, volatile matter, sulfur, fixed carbon, and calorific value (proximate analyses). Samples collected in 1975 were subjected to additional analyses—ultimate, chemical, and sulfur forms (tables 1 to 5). Washability tests on the 1974 samples were run according to recommendations of the U.S. Bureau of Mines (Staff, 1967). They suggest the following relationship of minimum sample weight to coarsest particle size for specific-gravity (sink-float) analyses of coal (p. 3).

In accordance with the recommended weight-size ratio, the samples were crushed to minus 1/2 inch and combined by geographic area for testing. Each combined sample was then screened to provide three size fractions: +20 mesh, -20 by +65 mesh; and -65 mesh. The two coarser size fractions were in turn separated by different specific gravities. A zinc chloride solution of suitable density was used for the +20 mesh material and the -20 by +65 size fraction was separated

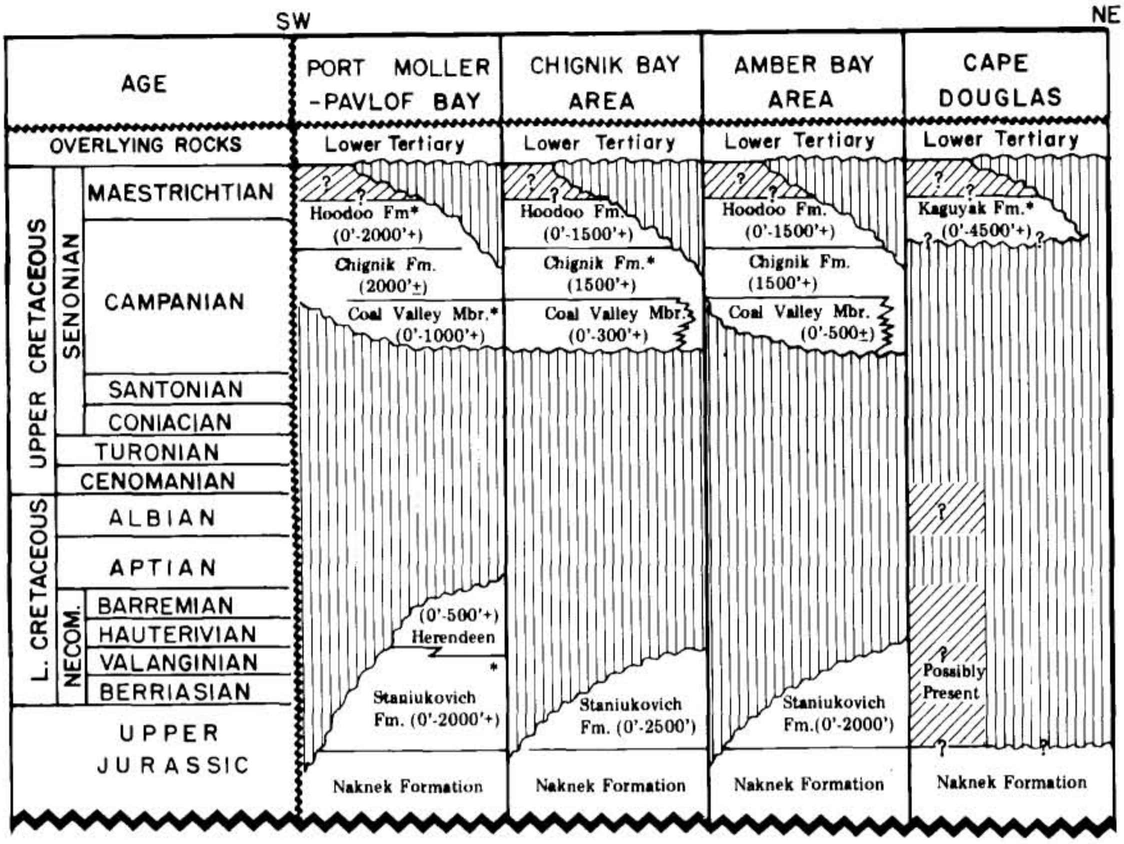

Figure 2. Correlation chart of Cretaceous rocks of Alaska Peninsula. Asterisk indicates type locality (after Burk, 1965).

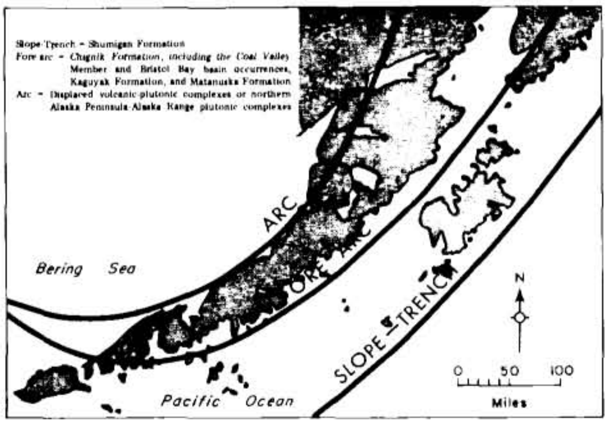

Figure 3. Geometry of the Late Cretaceous subduction system (after Fairchild, 1977).

Top size (in.) and sieve		Weight (lb)
	6	2,000
	4	1,000
	2	325
	1	160
	1/2	75
	1/4	35
Sieve	8	10
	16	3
	30	1/2

with an organic solution. The -65 mesh material contained less than 1 percent of the original weight and was not treated.

HERENDEEN BAY

The location of samples and measured sections are shown in plate 2 and figure 4. Figure 5 shows the sample location. In sections measured by Atwood (1911) in Mine Creek valley, only 1 of 15 beds was as much as 3 feet thick, 1 bed was 2 feet thick, and all others were 1.8 feet or less. A columnar section by Paige (1906) shows 17 beds, one of which was about 7 feet thick.

Table 1. *Ash and chemical analyses on coal as received (in ppm except where noted).*

Sample 75-cc-	Ash(%)[1]	As[2]	F[3]	Hg[4]	Sb[5]	Se[6]	Th[7]	U[7]
37	32.3	5.0	45	0.12	0.2	0.4	< 3	1.2
38	12.8	3.0	40	0.07	0.3	0.4	< 3	0.6
39	32.3	3.0	110	0.07	0.3	0.3	6.4	1.6
40	14.6	2.0	65	0.03	0.4	0.6	< 3	0.7
41	71.9	2.0	180	0.02	0.6	0.7	< 3	1.7
42	27.7	2.0	40	0.04	0.7	0.8	< 3	2.7
43	51.3	9.5	400	0.11	0.9	0.9	< 3	2.0
44	18.7	8.5	30	0.04	1.8	0.7	< 3	0.8

Table 2. *Chemical analyses on coal ash, major oxides, and chlorine (%).*

Sample 75-cc-	Al_2O_3[6]	SO_3[6]	Cl[6]	CaO[6]	SiO_2[6]	P_2O_5[2]	MnO[6]	Fe_2O_3[6]	K_2O[6]	MgO[8]	Na_2O[8]	Ti[9]
37	32	4.8	< 0.2	3.8	46.0	<1.0	0.05	3.5	0.61	1.75	0.15	1.0
38	21	10.0	< 0.2	6.1	37.0	<1.0	0.10	10.0	0.63	3.33	0.18	1.1
39	35	3.0	< 0.2	2.0	42.0	< 1.0	0.07	3.2	0.36	1.39	0.15	0.9
40	34	1.5	< 0.2	1.2	46.0	< 1.0	0.05	1.7	0.38	0.35	0.12	1.2
41	30	0.4	< 0.2	0.1	62.0	< 1.0	0.05	0.7	0.86	0.48	0.10	1.2
42	38	1.0	< 0.2	0.5	48.0	< 1.0	0.05	1.0	0.13	0.66	0.18	1.9
43	23	2.2	< 0.2	2.3	49.0	< 1.0	0.14	7.1	1.90	1.96	1.79	0.9
44	13	3.4	0.2	23.0	21.0	< 1.0	0.05	3.3	0.18	5.45	0.19	0.8

Table 3. *Chemical analyses on coal ash, trace elements (ppm).*[11]

Sample 75-cc-	B[10]	Ba[10]	Cd[9]	Co[9]	Cr[10]	Cu[6]	Ga[9]	La[10]	Li[9]	Mn[9]
37	200	300	<1	15	50	72	30	N	202	295
38	700	500	<1	< 10	100	79	30	N	125	720
39	300	300	<1	15	15	82	30	< 100	250	350
40	300	2,000	<1	50	30	64	30	<100	144	40
41	70	300	<1	10	70	111	30	N	47	30
42	100	700	<1	50	15	75	30	N	131	40
43	300	1,000	<1	1,000	1,000	108	30	N	73	235
44	70	300	<1	300	15	46	15	N	44	1,000

Sample 75-cc-	Mo[10]	Ni[10]	Pb[6]	Sc[9]	Sr[9]	V[9]	Y[9]	Yb[9]	Zn[9]	Zr[10]
37	7	20	35	20	150	150	50	5	79	200
38	7	30	<25	50	150	300	70	7	81	150
39	7	30	40	20	150	70	50	7	88	300
40	N	70	40	30	1,500	150	70	7	141	300
41	N	15	<25	15	150	200	15	2	44	150
42	7	50	70	30	150	150	70	7	113	500
43	7	50	<25	20	700	200	30	5	128	150
44	300	30	45	20	500	70	70	3	265	150

[1] Determined gravimetrically (ashed at 525°C) by G.D. Shipley.
[2] Determined by graphite furnace-atomic absorption method by G.O. Riddle and J.G. Crock.
[3] Determined by specific ion electrode method by J. Gardner.
[4] Determined by wet oxidation - atomic absorption method by J.A. Thomas and G.O. Riddle.
[5] Determined by Rhodamine-B method by G.T. Burrow.
[6] Determined by X-ray fluoresence by J.S. Walber.
[7] Determined by delayed neutron method by H.T. Millard.
[8] Determined by atomic absorption by V. Merritt.
[9] Determined by atomic absorption by G.D. Shipley.
[10] Determined by semiquantitative six-step spectrographic analysis by J.C. Hamilton. N - Not determined or below detection.
[11] Elements searched for but not detected or below limit of determination include Ag, Au, Bi, Cd, Pd, Pt, Sb, Te, W, Ce, Ge, Hf, In, Li, Re, Ta, Th, Tl, Eu, Pr, Nd, Sm, Gd, Tb, Dy, Ho, Er, Tm, and Lu. Financial support was in part provided by the USGS (contract 14-08-6001-G-207). Major-oxide and trace-element analyses were performed by the USGS.

Table 4. *Proximate and ultimate analyses and calorific value.*

Sample 75-cc-	Condition[1]	Proximate analyses(%) Moist.	Vol. mat.[2]	FC[3]	Ash	Ultimate analyses(%) Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Calorific value (Btu)
37	1	2.1	32.1	36.9	28.9	4.3	52.4	0.5	12.8	1.1	9,140
	2	2.3	32.1	36.8	28.8	4.3	52.3	0.5	13.0	1.1	9,130
	3		38.8	37.7	29.5	4.2	53.5	0.5	11.2	1.1	9,340
	4		46.6	53.4		5.9	75.9	0.7	15.9	1.6	13,260
38 and 39	1	2.0	33.8	41.1	23.1	4.8	57.0	0.5	13.2	1.4	10,100
Combined 1:1	2	2.2	33.7	41.1	23.0	4.8	56.9	0.5	13.5	1.3	10,090
	3		34.5	42.0	23.5	4.6	58.2	0.5	11.8	1.4	10,310
	4		45.1	54.9		6.1	76.0	0.7	15.4	1.8	13,490
40 and 41	1	3.7	33.6	45.3	17.4	4.9	60.5	0.7	16.2	0.3	10,420
Combined 3:1	2	4.1	33.4	45.2	17.3	4.9	60.2	0.7	16.6	0.3	10,370
	3		34.9	47.0	18.1	4.7	62.8	0.7	13.4	0.3	10,810
	4		42.5	57.5		5.7	76.6	0.9	16.4	0.4	13,190
43	1	2.3	23.5	25.3	48.9	3.4	36.9	0.3	9.9	0.6	6,380
	2	2.5	23.5	25.2	48.8	3.4	36.8	0.2	10.2	0.6	6,360
	3		24.1	25.9	50.0	3.2	37.7	0.3	8.2	0.6	6,530
	4		48.2	51.8		6.4	75.5	0.5	16.4	1.2	13,060

[1]Condition: 1 - air dried; 2 - as received; 3 - moisture free; 4 - moisture free and ash free.
[2]Volatile matter.
[3]Fixed carbon.

Table 5. *Fusibility of ash and sulfur forms and free-swelling index (FSI).*

Sample 75-cc-	Condition	Fusibility(°F) I.D.[1]	Soft	Fluid	Sulfur(%) Sulfate	Pyritic	Organic	FSI
37	2	2,575	2,685	2,770	0.02	0.57	0.49	1
	3				0.02	0.58	0.50	
	4				0.03	0.83	0.71	
38 and 39	2	2,800+			0.2	0.57	0.76	0
Combined 1:1	3				0.2	0.58	0.78	
	4				0.3	0.76	1.01	
40 and 42	2	2,800+			0.2	0.05	0.23	0
Combined 3:1	3				0.3	0.05	0.24	
	4				0.3	0.06	0.29	
43	2	2,165	2,250	2,330	0.2	0.42	0.16	0
	3				0.2	0.43	0.16	
	4				0.4	0.86	0.33	

[1]Initial deformation.

On the left fork of Mine Creek he shows a 3-foot bed, a 2.7-foot bed, a bed of crushed coal 7 feet thick, and one 10-foot-thick section of fairly solid coal. We measured nine coal beds and sampled seven. Samples 75-cc-7 through -11 were collected by W.M. Lyle of DGGS and the principal author in 1974. (An approaching grizzly bear precluded the collection of additional samples.) The samples were analyzed by assayer D.R. Stein of DGGS for moisture, ash, volatile matter, sulfur, fixed carbon, and calorific values (table 6).

The coal rank was computed in accordance with the American Society for Testing and Materials standard D388 (1973) by using the Parr approximate formulas. On the basis of these calculations the coal is high-volatile B bituminous (table 7).

In 1975 samples 75-cc-40 through -45 were collected specifically for the USGS coal sampling program (tables 1-5).

Sample 75-cc-44 is from what was considered to be the Miocene Bear Lake Formation—an age confirmed by palynology by Shell Oil geologists encountered in the field. However, Burk (1965) had mapped this outcrop as Pliocene marine clastics. To add to the confusion, the coal analyses indicate a bituminous rank similar to that of the Chignik samples and suggest an Upper Cretaceous age.

Samples 75-cc-7 through -11 were combined for the specific-gravity separations. The tests (figs. 6, 7; tables 8, 9) are indicative of what might be expected in beneficiation. The analyses performed by Stein must be examined with full consideration of the analyses of samples 75-cc-40, -41, and -42, analyzed by the USGS and USBM (tables 1-5). We believe that samples 75-cc-40 and -42 are better samples of the ash content. It appears that a washed product with a specific gravity of -1.5 would contain less than 8 percent ash and have a Btu rating above 12,200. If the 17.4-percent ash reported by USBM (samples 75-cc-40 and -42 combined) is representative of the bed, the clean product should have less than 8 percent ash and an acceptable loss in the reject (15 percent).

CHIGNIK RIVER

Nine samples were taken at the mouth of the Chignik River (pl. 2). The most noticeable characteristic of the coal sequence is the lateral and transverse variation in quality of the coal (figs. 8 and 9). The figures are

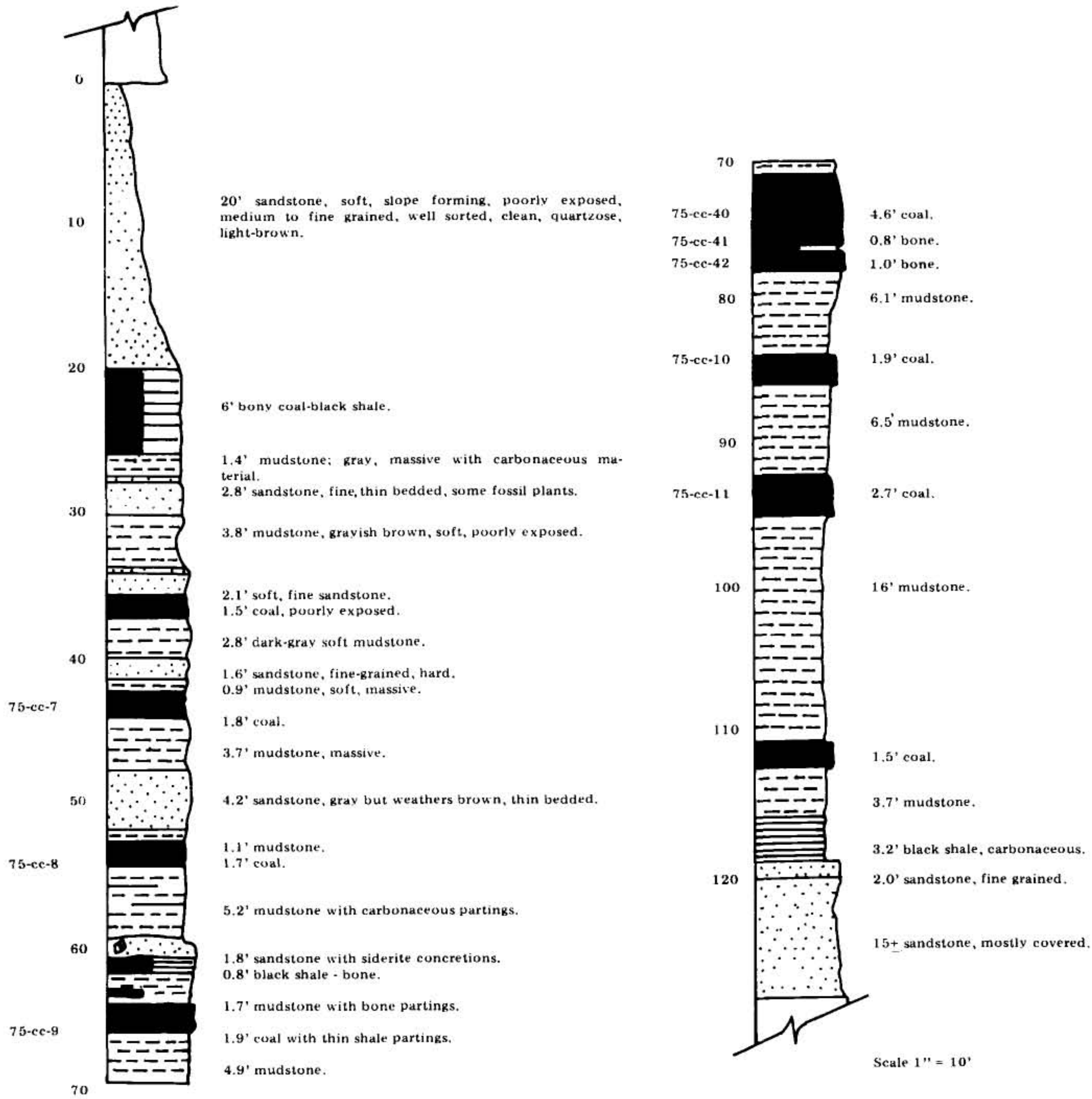

Figure 4. Measured section of coal sequence, Mine Harbor, Herendeen Bay.

Figure 5. Sample location, Herendeen Bay.

Table 6. *Proximate analyses, Herendeen Bay (in percent except where noted).*

Sample 75-cc-	Moisture	Ash	Volatile matter	Sulfur	Fixed carbon	Calorific value (Btu)
7	2.97	9.37	36.50	0.40	52.24	12,252
8	2.79	5.53	38.82	0.39	52.86	12,695
9	2.52	11.61	37.71	0.33	50.16	11,683
10	2.65	9.43	34.83	0.34	53.09	12,054
11	2.42	12.76	35.03	0.27	49.79	11,615

Table 7. *Parr formula rank determination, Herendeen Bay coal.*

Sample 75-cc-	Fixed carbon(%)[1]	Volatile matter(%)[1]	Calorific value (Btu)[2]
7	59.88	40.12	13,726
8	58.03	41.96	13,523
9	59.22	40.78	13,398
10	61.06	38.94	13,454
11	59.26	40.74	13,907

[1]Dry mineral, matter-free basis.
[2]Moist mineral, matter-free basis.

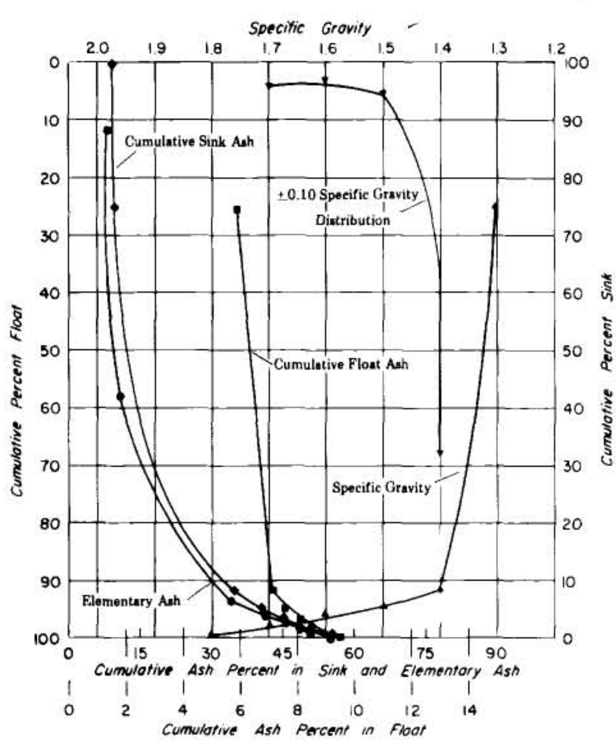

Figure 6. Washability characteristics of +20 mesh fraction of raw coal from Herendeen Bay.

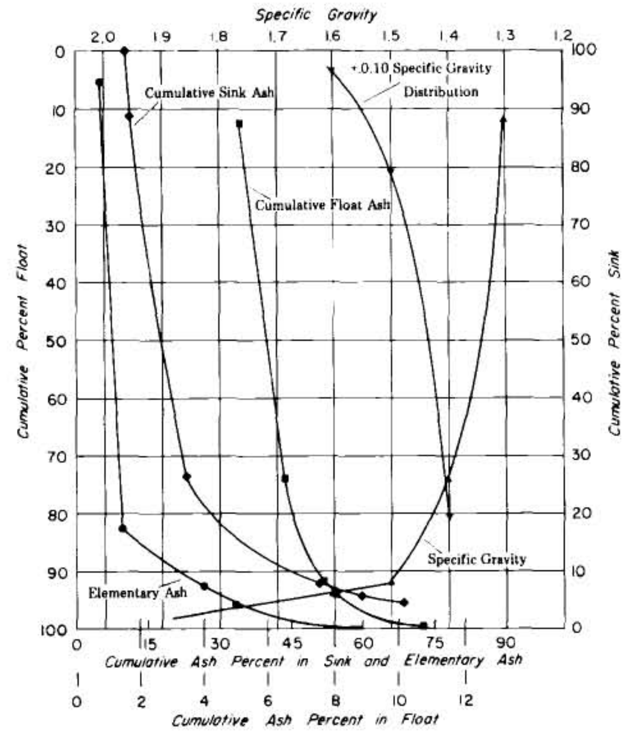

Figure 7. Washability characteristics of -20 by +65 mesh fraction of raw coal from Herendeen Bay.

intended to display this difference. Again, two sets of samples were taken—75-cc-1 through -6 in 1974 (analyzed by Stein), and 75-cc-37, -38, and -39 for the USGS coal program. Tables 10 and 11 show the proximate analyses and the Parr rank determination of the first set of samples.

Samples 75-cc-1 through 6 were taken for the specific-gravity separation; about 3 lb of material were taken per foot of section. As indicated in figure 9, the ash resulting from a composite 9-ft 7-in. bed would be 25.7 percent. The samples were further analyzed as described for Herendeen Bay coals (p. 5).

Table 12 and figure 10 show the respective sink-float products and washability characteristics of the +20 mesh fraction. At a specific gravity of 1.6, 72.9 percent of the coal was floated; it had an ash content of 11.7

Table 8. *Sink-float results of +20 mesh fraction of raw coal from Herendeen Bay (94% of raw coal).*

Specific gravity		Actual product		Cumulative float		Cumulative sink		±0.10 Sp. Gr.	
Sink	Float	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Material (%)	Ordinate D[1]
--	1.3	25.88	5.9	25.88	5.9	100.00	9.5	--	12.9
1.3	1.4	65.84	7.7	91.73	7.2	74.12	10.7	68.6	58.6
1.4	1.5	2.80	21.7	94.52	7.6	8.28	34.9	4.5	93.6
1.5	1.6	1.67	32.3	96.19	8.1	5.48	41.6	2.9	95.3
1.6	1.7	1.26	39.6	97.45	8.5	3.81	45.7	3.1	96.8
1.7	1.8	1.83	46.1	99.28	9.2	2.55	48.7	---	98.3
1.8	--	0.72	55.4	100.00	9.5	0.72	55.4	---	99.7

[1]Ordinate D, according to ASTM.

percent. Extrapolating tables 10 and 12 incidates that a float product of 1.6 specific gravity should provide a coal with a calorific value over 12,400 Btu.

Table 13 records the sink-float results of the -20 by +65 mesh fraction. At a specific gravity of 1.6, 68.6 percent of the material will float and have 8.4 percent ash. Figure 11 shows the washability characteristics of the same size fractions, developed from a small

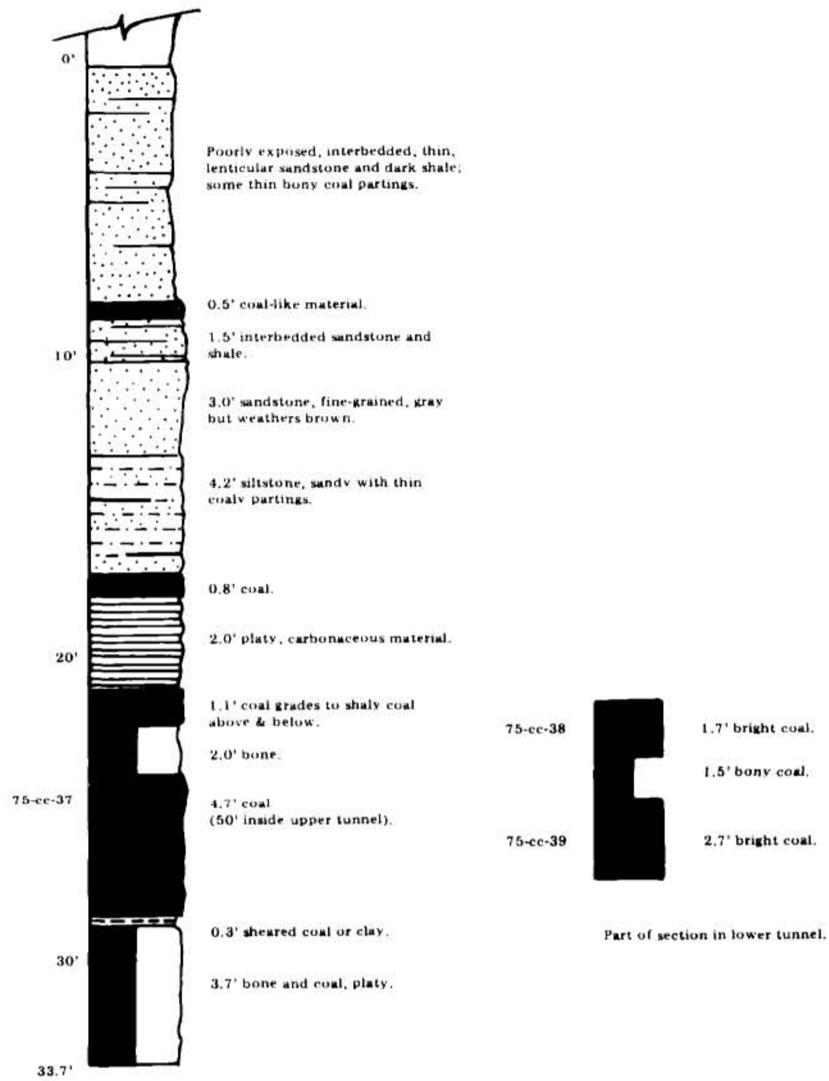

Figure 8. Geologic section of exposed rock, Chignik River. (Note changes in thickness of coal and partings.)

Table 9. *Sink-float results of -20 by -65 mesh fraction of raw coal from Herendeen Bay (5% of raw coal).*

Specific gravity		Actual product		Cumulative float		Cumulative sink		±0.10 Sp. Gr.	
Sink	Float	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Material (%)	Ordinate D[1]
---	1.3	11.82	5.1	11.82	5.1	100.00	10.8	---	5.9
1.3	1.4	61.58	6.9	73.40	6.6	88.18	11.6	80.2	42.6
1.4	1.5	18.57	10.0	91.97	7.3	26.60	22.6	20.4	82.7
1.5	1.6	1.87	25.9	93.84	7.7	8.03	51.8	3.3	92.9
1.6	1.7	1.43	32.5	95.27	8.0	6.16	59.6	---	94.6
1.7	---	4.73	67.8	100.00	10.8	4.73	67.8	---	97.6

[1]Ordinate D, according to ASTM.

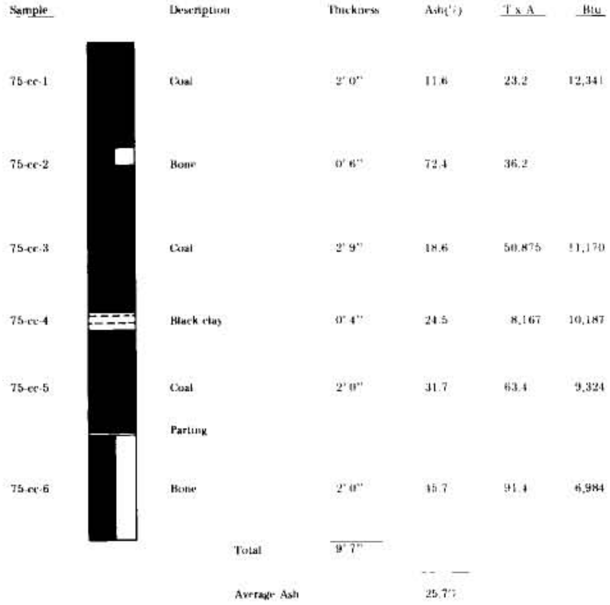

Figure 9. Measured coal section in tunnel near Chignik River.

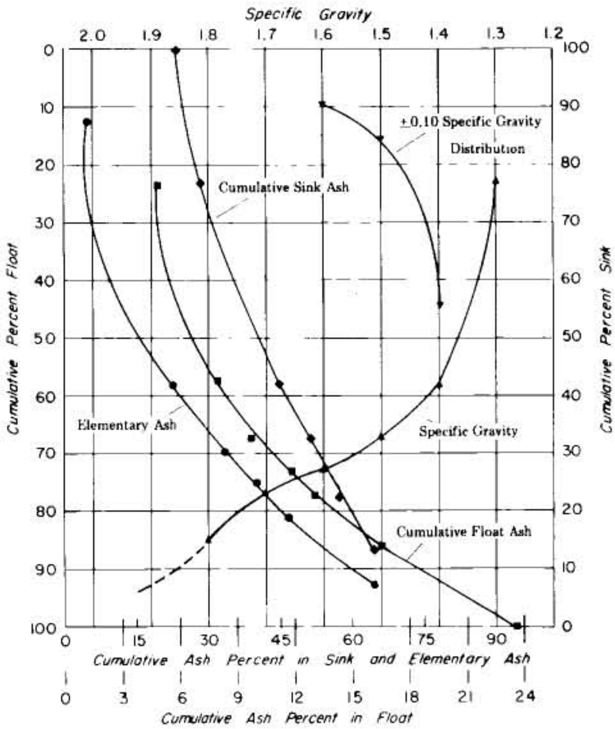

Figure 10. Washability characteristics of +20 mesh fraction of raw coal from Chignik River tunnel.

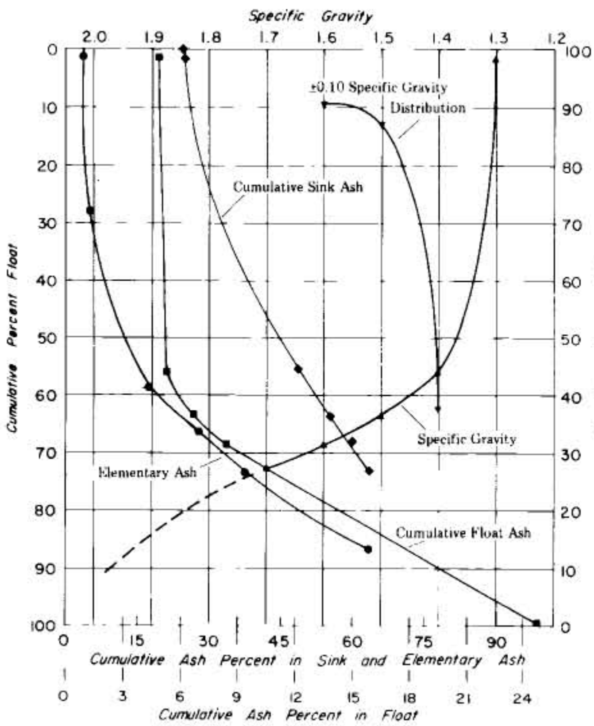

Figure 11. Washability characteristics of -20 by +65 mesh fraction of raw coal from Chignik River tunnel.

sample. Over 70 percent of the coal in the 9-ft, 7-in. section can probably be recovered, and the product would have a calorific value of more than 12,000 Btu and less than 12 percent ash. The analyses of the Chignik River coal may be more indicative of the actual values than the previous values because of the better correlation between DGGS (table 9) and USBM test results (table 4). This is related to the increased time and care taken in obtaining the 1975 samples.

The raw coal has a free-swelling index of 1, which might be raised by reducing the ash by washing or by testing a fresher sample. The sample in the tunnel is from a face exposed at least 70 years. Although it shows less weathering than an outcrop, it is not as good as a fresh sample.

There is about 1,152,000 tons of bituminous coal per foot of bed thickness per square mile. Thus, the equivalent of a 7-foot bed recovered over 8 square miles would yield 60 million tons. The 3° to 8° dip of beds in the northeastern part of the Chignik Lagoon and indications of a syncline make this area appear favorable for exploration, even though mining might extend under water.

Table 10. *Proximate analyses, Chignik River coal (in percent except where noted).*

Sample 75-cc-	Moisture	Ash	Volatile matter	Sulfur	Fixed carbon	Calorific value (Btu)
1	1.16	11.53	37.25	2.75	47.30	12,486
2	1.67	69.40	16.40	-	13.53	-
3	1.65	18.10	35.35	1.37	44.90	11,170
4	1.50	23.55	32.61	0.31	42.34	10,186
5	1.35	31.59	29.54	0.50	37.53	9,199
6	1.35	45.54	24.34	0.58	28.77	6,889

Table 11. *Parr formula rank determination, Chignik River coal.*

Sample 75-cc-	Fixed carbon(%)[1]	Volatile matter(%)[1]	Calorific value (Btu)[2]
1	55.07	44.93	13,848
3	58.03	41.97	13,970
4	58.47	41.53	13,753
5	58.77	41.23	14,109
6	59.32	40.68	13,820

[1]Dry mineral, matter-free basis.
[2]Moist mineral, matter-free basis.

Table 12. *Sink-float results of +20 mesh fraction of raw coal from Chignik River tunnel (91% of raw coal).*

Specific gravity		Actual product		Cumulative float		Cumulative sink		±0.10 Sp. Gr.	
Sink	Float	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Material (%)	Ordinate D[1]
-	1.3	22.67	4.8	22.67	4.8	100.00	23.4	-	11.3
1.3	1.4	35.11	9.8	57.78	7.8	77.3	28.8	44.2	40.3
1.4	1.5	9.11	22.0	66.89	9.8	42.2	44.6	15.1	58.3
1.5	1.6	6.03	32.8	72.92	11.7	33.1	50.9	9.6	69.9
1.6	1.7	3.58	39.8	76.50	13.0	27.1	54.9	-	74.7
1.7	1.8	8.92	45.9	85.42	16.4	23.5	56.8	-	81.0
1.8	-	14.58	64.1	100.00	23.4	14.6	64.1	-	92.7

[1]Ordinate D, according to ASTM.

Table 13. *Sink-float results of -20 by +65 mesh fraction of raw coal from Chignik River tunnel (8% of raw coal).*

Specific gravity		Actual product		Cumulative float		Cumulative sink		±0.10 Sp. Gr.	
Sink	Float	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Material (%)	Ordinate D[1]
-	1.3	1.48	4.9	1.48	4.9	100	24.4	-	0.7
1.3	1.4	54.20	5.1	55.68	5.1	98.6	24.7	62.0	28.6
1.4	1.5	7.80	18.4	63.48	6.7	44.4	48.6	12.9	59.6
1.5	1.6	5.09	28.1	68.57	8.4	36.6	55.0	9.3	66.0
1.6	1.7	4.16	37.8	72.73	10.0	31.5	59.4	-	72.7
1.7	-	27.27	62.8	100.00	24.4	27.3	62.8	-	86.4

[1]Ordinate D, according to ASTM.

THOMPSON VALLEY

Our stay in Thompson Valley was brief, less than 2 hours. A head frame or timbered tunneled entrance to what probably was an old mine was visible from the air, but later attempts to penetrate the dense ground cover and find the entrance were unsuccessful.

A coal outcrop was located on the north side of the ridge between Thompson and McKinsey Valleys near the top of the ridge in a small drainage. The coals had a shaley appearance and a shale-like cleavage. This section was measured (fig. 12) and six samples were collected proximate analyses by DGGS (table 14).

According to the Parr formula, the coal is high-volatile B bituminous (table 15) from samples 75-cc-12, -16, and -17.

Correlation of coal beds within the Thompson Valley area is questionable. From the air, there appeared to be an old mine at a level stratigraphically lower than from where our samples were taken (fig. 12). Atwood (1911) describes a sample as taken in a tributary stream. To us, there appear to be coal beds in addition to the three that were sampled in 1974. For example, Atwood's (1911) sample 6956 had 14.87 percent ash, indicating a much higher quality coal than those sampled more recently (table 14).

All samples were combined to determine washability. Although the coal was crushed in a roll crusher set at 3/8 inch, platey coal of 1/2-inch length passed through. The coals were separated into +4, +20, and +65 mesh fractions. Tables 16-18 and figures 13-15 show the sink-float results and washability characteristics of the +4, -4 by +20, and -20 by +65 mesh sizes.

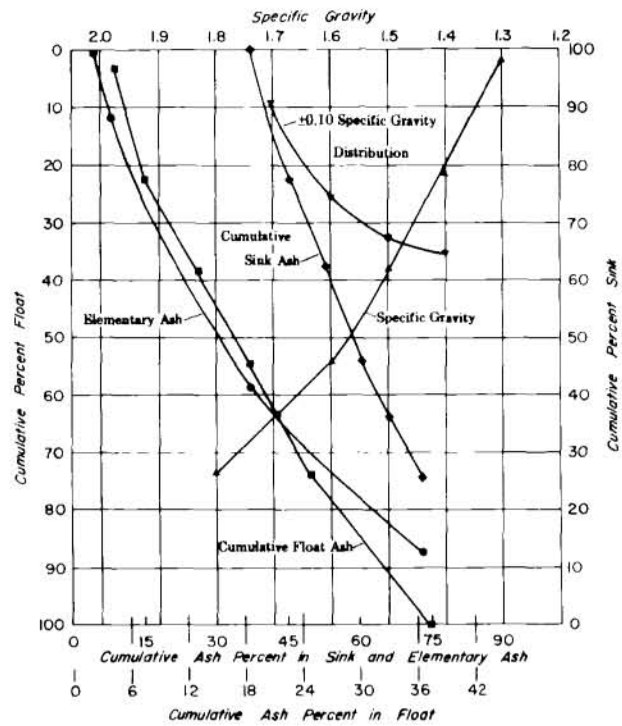

Figure 13. Washability characteristics of +4 mesh fraction of raw coal from Thompson Valley.

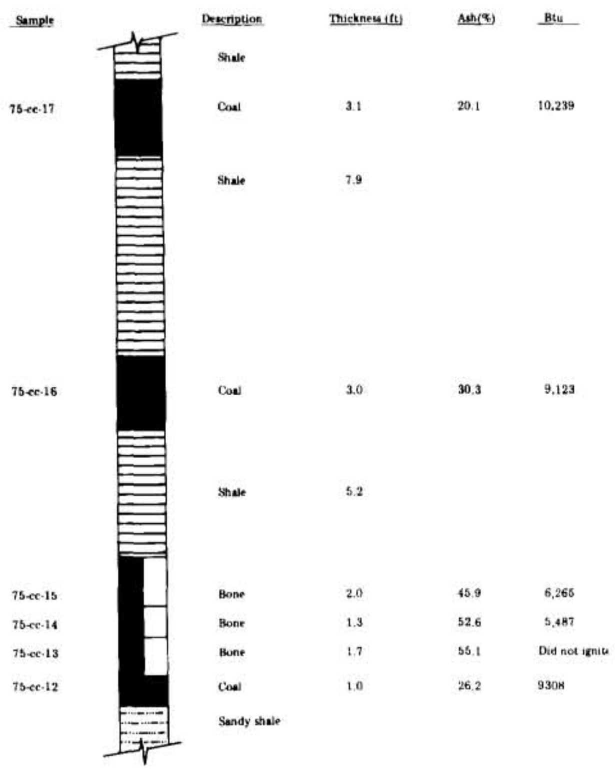

Figure 12. Measured section of coal outcrop, Thompson Valley.

COMMENTS

The washability studies are limited because of the small size of samples that could be transported, and the results should be interpreted accordingly. Nevertheless, the coals appear amenable to washing (beneficiation) and a product with an acceptable ash content might be produced.

Because the cost of mining and washing a coal near tidewater will offset the cost of transporting cleaner coals several hundred miles by rail, the development of Chignik Formation coals might be profitable. The value of Chignik coals will be determined by the cost of competative coals, possibly from the high plains of Wyoming and Montana. The higher quality and location near tidewater favor the Chignik coals, but Wyoming and Montana coals are not mined underground or washed.

Table 14. *Proximate analyses, Thompson Valley coal (in percent except where noted).*

Sample 75-cc-	Moisture	Ash	Volatile matter	Sulfur	Fixed carbon	Calorific value (Btu)
12	2.76	26.25	27.84	0.55	43.14	9,308
13	1.81	55.07	19.08	-	24.03	-
14	1.83	52.60	20.85	0.27	24.72	5,488
15	2.25	45.90	22.21	0.34	29.64	6,409
16	2.57	30.03	29.00	1.38	38.40	9,373
17	2.45	20.95	32.13	1.12	44.47	10,239

Table 15. *Parr formula rank determination, Thompson Valley coal*

Sample 75-cc-	Fixed carbon(%)[1]	Volatile matter(%)[1]	Calorific value (Btu)[2]
12	63.15	36.85	13,097
16	59.76	40.24	14,291
17	59.78	40.22	13,325

[1]Dry mineral, matter-free basis.
[2]Moist mineral, matter-free basis.

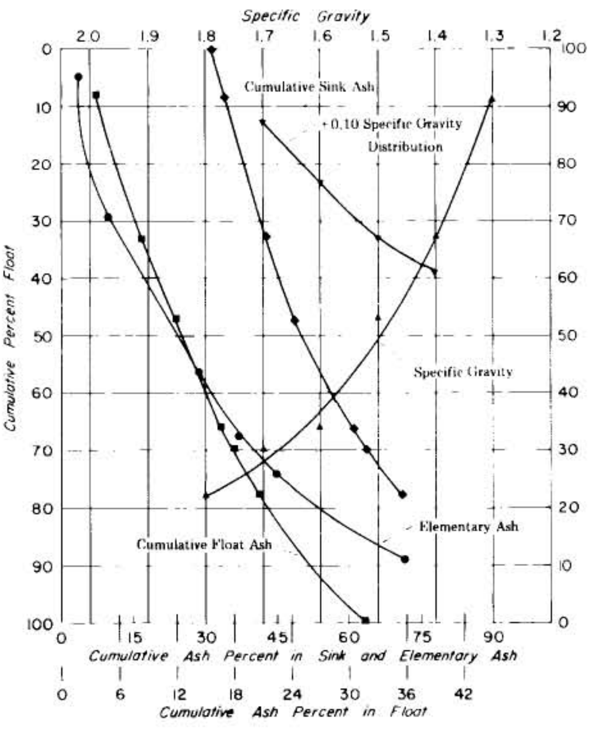

Figure 14. Washability characteristics of +4 by +20 mesh fraction of raw coal from Thompson Valley.

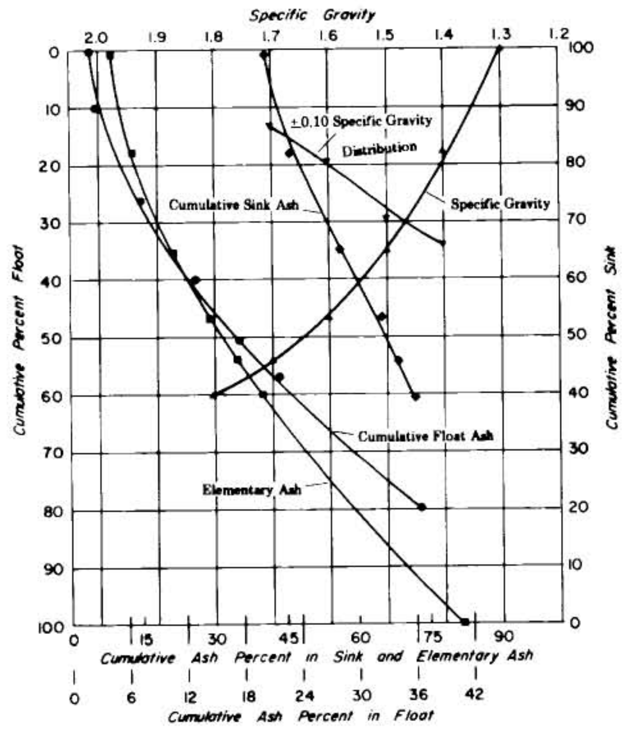

Figure 15. Washability characteristics of -20 by +65 mesh fraction of raw coal from Thompson Valley.

Table 16. *Sink-float results of +4 mesh fraction of raw coal from Thompson Valley (55.2% of raw coal).*

Specific gravity		Actual product		Cumulative float		Cumulative sink		±0.10 Sp. Gr.	
Sink	Float	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Material (%)	Ordinate D[1]
--	1.3	2.06	4.6	2.06	4.6	100	37.4	---	1.0
1.3	1.4	19.13	8.2	21.19	7.8	97.5	38.3	34.6	11.6
1.4	1.5	16.52	20.5	37.71	13.4	78.4	45.6	32.4	29.3
1.5	1.6	15.93	29.9	53.64	18.3	61.9	52.3	25.4	45.7
1.6	1.7	9.44	37.7	63.08	21.2	46.3	59.6	9.8	58.4
1.7	1.8	10.37	46.6	73.45	24.8	36.9	65.1	---	68.3
1.8	---	26.55	72.3	100	37.4	26.5	72.4	---	86.7

Table 17. *Sink-float results of -4 by +20 mesh fraction of raw coal from Thompson Valley (37.9% of raw coal).*

Specific gravity		Actual product		Cumulative float		Cumulative sink		±0.01 Sp. Gr.	
Sink	Float	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Material (%)	Ordinate D[1]
--	1.3	8.21	3.9	8.21	3.9	100	31.5	---	4.1
1.3	1.4	24.19	9.8	32.40	8.3	91.8	34.0	38.6	29.3
1.4	1.5	14.40	19.9	46.80	11.9	67.6	42.7	33.4	39.4
1.5	1.6	19.00	28.3	65.80	16.6	53.2	48.8	23.0	56.3
1.6	1.7	4.03	36.8	69.83	17.8	34.2	60.3	12.2	67.8
1.7	1.8	8.21	45.3	78.04	20.7	30.2	63.4	---	73.9
1.8	---	21.96	70.1	100.00	31.5	22.0	70.1	---	89.0

Table 18. *Sink-float results of -20 by +65 mesh fraction of raw coal from Thompson Valley (5.3% of raw coal).*

Specific gravity		Actual product		Cumulative float		Cumulative sink		±0.01 Sp. Gr.	
Sink	Float	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Wt. (%)	Ash (%)	Material (%)	Ordinate D[1]
--	1.3	0.84	4.3	0.84	4.3	100.0	41.0	---	0.42
1.3	1.4	16.76	5.8	17.60	5.7	99.2	41.3	33.7	9.2
1.4	1.5	16.90	14.9	34.50	10.2	82.4	48.5	29.4	26.1
1.5	1.6	12.46	26.1	46.96	14.4	65.5	57.2	19.6	40.7
1.6	1.7	7.18	34.2	54.14	17.1	53.0	64.5	13.4	50.5
1.7	1.8	.6.21	43.0	60.35	19.7	45.9	69.3	---	57.2
1.8	---	39.65	73.4	100.00	41.0	39.7	73.4	---	80.2

[1]Ordinate D, according to ASTM.

Thus, the competitive position of the Chignik coals in the northern Pacific market will depend on the net differences in transportation costs, mining costs, and product quality. Additional exploration and metallurgical testing is warranted.

Samples 75-cc-37 through -44 were obtained specifically for chemical analysis (tables 1-3). One sample is high in strontium, two are high in barium, and one has high levels of cobalt and chromium. There do not appear to be high concentrations of any elements that would volatilize on combustion and be environmentally deleterious. The sodium content of the ash is low and there does not seem to be anything present that would foul boiler tubes.

In the USBM analyses (tables 4 and 5) two of four samples tested had sulfur exceeding 1 percent of the raw coal. Part of the sulfur is in pyrite and might be partially removed in washing. The free-swelling index on two samples is 1—but these were high in ash and weathered; possibly a cleanly washed product would have a higher free-swelling index. Microscopic analysis from an unweathered sample might indicate if the coal has any blending characteristics for a coke.

RESOURCE-RESERVE

The Chignik Formation crops out intermittently for over 200 miles on the Alaska Peninsula from Pavlof

Bay northeast to Dog Salmon River. Perhaps 14 coal beds thicker than 14 inches are present. In any small area (10 square miles) there may be three beds in the 28- to 42-inch-thick category and one bed over 42 inches.

Present knowledge is insufficient to project a resource-reserve for the field. However, if the USBM-USGS coal classification system is used (Staff, 1976), the resource, including beds over 14 inches thick, may be substantial; the reserve base, 28 inches or more, will be limited to a small percentage of the resource. The reserve base is further eroded by the difficulties of isolating areas for mining because of the folds and faults in the area. Nevertheless, there is a good possibility of finding areas of up to 12 square miles with reserves of over 60 million tons at a 75-percent recovery factor.

CONCLUSIONS AND RECOMMENDATIONS

This study expands previous knowledge of the Chignik coal field; specifically we conclude:

1. That the coals in the fields rank as high-volatile B bituminous.
2. That the coals in general have a high ash content: about 20 percent.
3. That a finished product with an ash of less than 10 percent and Btu value of more than 12,000 could be obtained by washing.
4. That the reject from a wash plant might contain as much as 50 percent combustible material.
5. That there are no trace elements or major oxides that would become environmental hazards.
6. That additional exploration and testing are warranted.

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