Bureau of Mines
Report of Investigations 5350

INVESTIGATION OF SUBBITUMINOUS-COAL BEDS NEAR HOUSTON, WESTWARD EXTREMITY OF MATANUSKA COALFIELD, ALASKA

BY R. R. MAY AND R. S. WARFIELD

United States Department of the Interior — August 1957

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UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

Work on manuscript completed November 1956. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Report of Investigations 5350."

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by

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CONTENTS

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Report of Investigations 5350

ILLUSTRATIONS

TABLES

SUMMARY

A preliminary examination of the Houston strip-coal mine, situated on the Alaska Railroad at milepost 175 (61 rail miles north of Anchorage, Alaska) and a review of all available information resulting from early coal exploration activities in the area resulted in plans to investigate the coal-bearing formations at depth by means of diamond core drilling to indicate the existence of additional reserves of coal in close proximity to railroad transportation, where it would be quickly available to meet rapidly expanding military and civilian fuel requirements.

From the date of mobilization of equipment, August 28, 1951, until date of suspension, August 18, 1952, 2,010 feet of diamond drilling was completed. Ten definable coal beds were cut, of which 2 appear to be persistent and minable over an area of approximately 1/2 square mile. Within this area the 2 minable beds contain approximately 5,000,000 tons of coal in place. Of the remaining beds, at least two others may be minable to the eastward near their projected outcrops; however, these and deeper beds (at least in the vicinity of the drill holes) lie beneath a zone of pressurized gas and brackish water. From a practical standpoint, continued development and utilization of the coal in this vicinity will depend on the operators' ingenuity in developing cheap mining methods and on diligent prospecting for strippable coal under the comparatively light glacial cover.

INTRODUCTION

Since the advent and expansion of military installations in south central Alaska, coupled with the resultant rapid growth of population, the delineation and development of the Matanuska coal field have assumed considerable importance, particularly in those parts of the field that are accessible by existing transportation facilities. Little work of an evaluating nature had been done before this project was undertaken at the western end of the Matanuska field, which abuts the main line of the Alaska Railroad at Houston, approximately 60 miles north of Anchorage.

Although the rank of the exposed beds in the immediate vicinity of Houstin is subbituminous, recent exploration by the Federal Geological Survey indicated a definite tie with the extensive bituminous beds of the Chickaloon coal-bearing formation now in production a few miles eastward. Discovery of additional minable beds not only would augment the Houston-area reserve but might lead to the discovery of nearby reserves which, because of closer proximity to the Talkeetna Mountain uplift, might have bituminous rank.

From observation of past and present workings and of the indicated geological attitude of the coal-bearing formation, it appeared that a very limited drilling program would procure the desired information. The following report presents the data obtained by the drilling program and an interpretation of the data.

ACKNOWLEDGMENTS

Many of the historical data, as well as cooperation in appraisal and sampling before initiation of the project, were furnished by Dr. George Gates and Dr. Farrell Barnes of the Alaskan Geology Branch, Federal Geological Survey. Core and face samples of coal taken before and during the work were analyzed by the Bureau of Mines Coal-Analysis Section, Pittsburgh, Pa., under the direction of R. F. Abernethy, chief. The engineering department of the Alaska Railroad furnished basic alinement and elevation details upon which the survey of the drilling area was based. Tucker & Peterson, lessors, and Duck Flat Co., production contractors, assisted the work by furnishing housing and messing facilities and the occasional use of heavy equipment.

DESCRIPTION OF AREA

Location and Access

The limited area covered by the activities described in this report is within 2 miles of Houston, a station at 240 feet altitude on the main line of the Alaska Railroad at mile 175 (fig. 1). Houston is 61 miles north of Anchorage, near the western toe of the Talkeetna Range, on the edge of the broad Susitna River Valley. When this project was in progress there was no highway access, but a road from Pittman (mile 167 on the Alaska Railroad) has since made the mine accessible over the Alaska highway system.

Topography

The Houston-project area is on the eastern edge of the Susitna River Valley, which is essentially a broad tundra flat cut by many, very small, meandering creeks. The Alaska Railroad follows the toe of the foothills that slope gently upward toward the mountains in an undulating series of benches; the project area is beside the railroad and at the base of this terraced slope. The Susitna Valley, which at this point is fully 25 miles wide, appears to be covered with a semisubmerged, recessional moraine. Tundra areas on this moraine consist of grassy swamps and pools, with patches of scrubby spruce and brushy willow. The rising ground to the eastward is covered by glacial deposits of various types and by a thick forest growth; spruce and birch predominate. As might be expected in an area where bedrock is almost completely concealed, the original coal discovery was made in a cut incidental to railroad construction.

Climate (As It Affects Operations)

The climate here is suitable for outside operations during only about 6 months of the year, unless shop facilities are heated and insulated and unless all-weather roads are constructed and at considerable expense. January and February are the coldest months, with an average daily low of minus 20°. During June, July, and August the daily high usually is in the 60's, but during calm, clear days the temperature often is in the 80's. Annual precipitation records for the immediate vicinity of Houston are not available, but estimates indicate a combined rain and snow content of about 50 inches. Except where it is drifted, winter snows seldom accumulate to depths of more than 3 feet. Summer rains generally are unpredicatable as to monthly intensity; they seldom are heavy but often are persistent enough during early and late summer to hamper hauling and road-maintenance work with heavy equipment.

The outdoor working season for stripping overburden usually is mid-May to mid-October, although much subsidiary work can be done a month or so before and after these dates; however, unless expensive methods are adopted, mining operators seldom

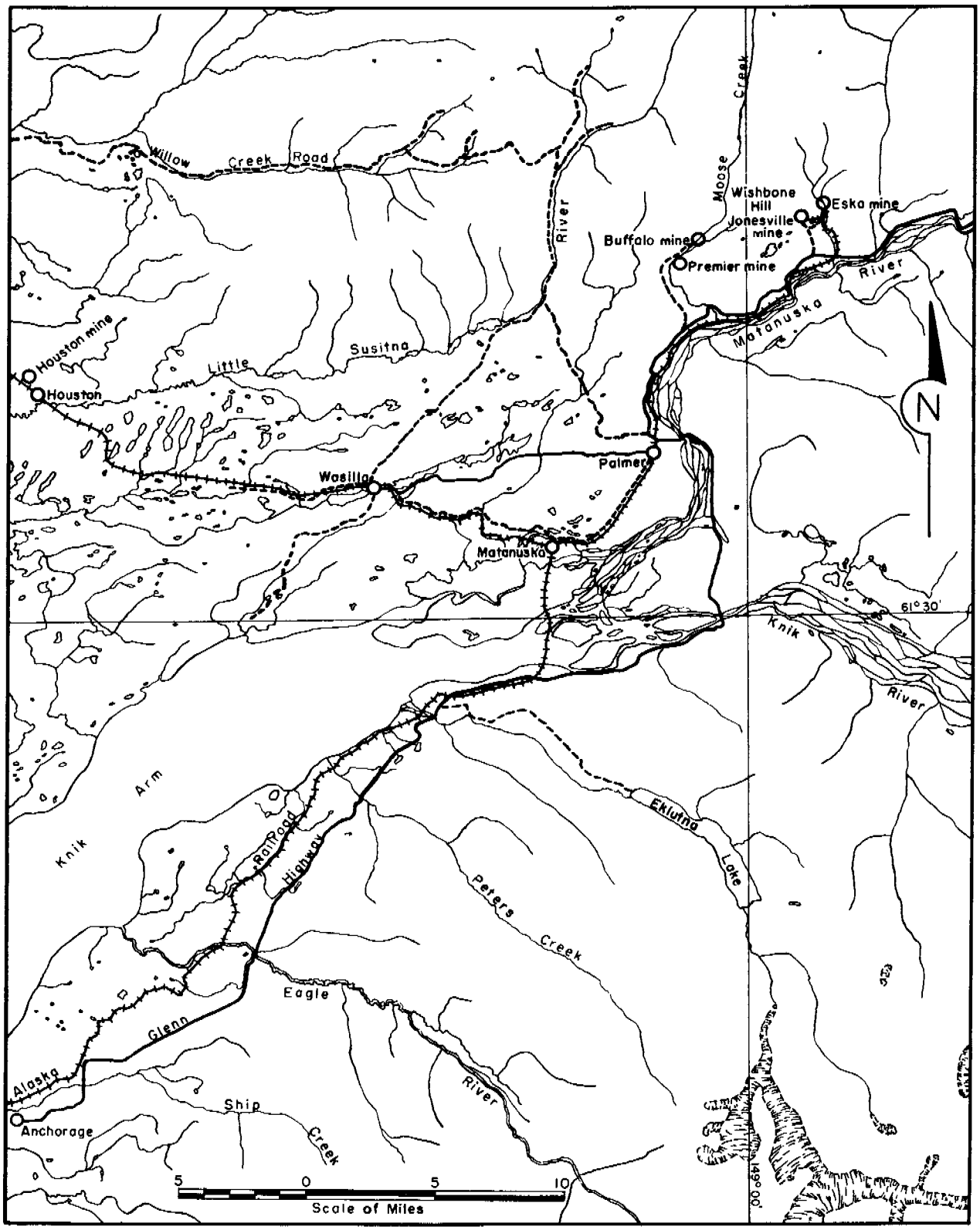

Figure 1. - Location map, Houston coal-drilling project.

strip overburden until June, because the ground usually freezes to a depth of 5 to 7 feet; thawing produces a tremendous amount of surface water, which bogs down most heavy equipment.

HISTORY AND PRODUCTION

Coal was discovered in a right-of-way cut on the Alaska Railroad at Houston station in 1917. Although the early history of the development is somewhat clouded, it is known that, between 1917 to 1920, a coal-prospecting permit was granted on the 10-acre tract at the discovery site and that 2 slopes were driven on the coal measures. According to reports, the slopes entered 2 beds of coal, which were 3-1/2 and 5 feet thick, respectively; the beds dipped 6° to 15° northeasterly. Production during this period is estimated at 10,000 to 15,000 tons of coal, which was sold to the Alaska Railroad and to the domestic market in Anchorage. All of the original workings have long been caved; even the caves are completely obscured by brush and slides. The site of this early activity is approximately one-half mile southeasterly of the present workings, from which it is separated by a low-lying muskeg swamp; therefore correlation of the discovery beds with beds in the project area would require considerable prospecting work beyond the scope of this project.

Between 1920 and 1934 no mining or development work of consequence was done near Houston. In 1934 Arthur Heaven was granted a 160-acre homestead, which included patent rights to underlying coal. In 1935 Evan Jones obtained prospecting permits for 874.82 acres adjoining the homestead in sections 17, 18, and 20; in the same year he started a slope mine near the present position of the southeast corner of the strip pit. About 12,000 tons of coal was produced from the slope and from a few rooms before the operation was suspended in 1940. Between 1938 and 1940 Jones joined in partnership with George Tucker and Ralph Peterson; during this period the Heaven patent was purchased and became the nucleus of later operations. This partnership was terminated in 1940; thereafter permits were allowed to lapse until a revival of interest in 1948, when an expanding military market became apparent.

In 1948 Tucker and Peterson organized the Houston Coal Co. and acquired a permit for access to an additional 1,800 acres next to the Heaven patent; from 1949 through the 1952 season approximately 65,000 tons of coal was marketed. Most of the coal was passed through a crushing, screening, and washing plant, which contained a Forrester-type jig capable of handling 15 to 25 tons per hour. Production during 1951 and 1952 was under a management-sales agreement with the Duck Flat Co., a Los Angeles organization. Virtually all production went to the military installations at Anchorage.

GEOLOGY

The geology of the Matanuska coal field is best known from the writings of G. C. Martin of the Federal Geological Survey, who first made a general reconnaissance of the region in 1905 and subsequently made detailed studies of the lower[3/] and upper[4/] parts of the field in 1910 and 1913, respectively. As defined in early descriptions, the upper or eastern part of the Matanuska field included the Anthracite Ridge and Chickaloon districts; the lower or western part included the Eska and Moose Creek areas, as well as Wishbone Hill. Recent reconnaissance by the Geological Survey along the lower reaches of the Little Susitna River and its tributaries and the work at Houston by the Bureau of Mines indicate that the Matanuska field extends westward

3/ Martin, G. C., and Katz, F. J., Geology and Coalfields of the Lower Matanuska Valley, Alaska: Geol. Survey Bull. 500, 1912, 98 pp.

4/ Martin, G. C., and Mertie, J. B., Jr., Mineral Resources of the Upper Matanuska and Nelchina Valleys: Geol. Survey Bull. 592, 1914, pp. 273-299.

from Moose Creek and includes the northern edge of the lowlands lying north of Knik Arm. Barnes designates these lowlands as the Little Susitna district of the Matanuska coalfield; Houston and the project area are in this district.5/

The following generalized description of the geology of the Matanuska coalfield is summarized from the above-cited publications, to which the reader is referred for details:

All coal measures in the field occur in the Chickaloon formation (Tertiary), which is composed of 3,000 to 5,000 feet of claystone, siltstone, sandstone, thin beds of fine-grained conglomerate, and many beds of coal. The Chickaloon formation is overlain by the Eska conglomerate (Tertiary) and underlain by the Matanuska and Arkose ridge formations (Upper Cretaceous). The Eska conglomerate is not present in the stratigraphic section at Houston. Neither the Matanuska formation nor the Arkose ridge formation is exposed near Houston.

At Houston and throughout the field individual beds in the Chickaloon formation, including the coal, tend to thin out or intergrade within relatively short distances. These changes in bed thickness are believed to be due primarily to the original lenticular structure of the sedimentary deposits but also may be due in part to the crumpling and pinching out of the soft shales incident to folding of parts of the region; correlation of individual beds (including coal) for more than short distances is therefore uncertain or impossible.

Correlation of the coal measures between districts, and often between mines in the same district, is complicated further by differences in the character of the coal that result from differences in the amount of faulting and folding from place to place. The coal at Houston is subbituminous; it occurs in relatively flat lying beds that have suffered little or no deformation.

THE COAL

Coal Sampling and Analysis

The following sections and samples were taken by R. R. May, Bureau of Mines mining engineer, and F. F. Barnes, geologist, Geological Survey, September 26, 1950. Sections and samples were taken in accordance with Bureau of Mines standard procedure and forwarded to Pittsburgh for analysis.

5/ Barnes, Farrell F., and Payne, Thomas G., The Wishbone Hill District, Matanuska Coal Field, Alaska: Geol. Survey Bull. 1016, 1956, p. 2.

TABLE 1. - Section in strip mine, near old Evan Jones slope
(top bench of strip-mine bed)

		Feet	Inches
Roof:	Gray claystone, silty.		
	Coaly shale to bone	0	2-1/2
	Coal		1-1/2
	Coaly shale		1
	Coal		10
	Bone		7
	Coal, bright	1	1-1/2
	Bony coal		3-1/2
	Coaly shale[1/]		2
	Claystone, thin coal stringers[1/]		8
	Claystone[1/]	2	0
	Bony coal (top of lower bench)	Partly exposed.	

1/ Denotes parting between upper and lower benches.

TABLE 2. - Section in strip mine 1,200 feet northeast of old Evan Jones slope
(full section, both benches)

		Feet	Inches
Roof:	Gray shale, coaly at base.		
	Coal, dull glossy[1/]	0	9
	Bone, bright-coal streaks		7
	Coal, bright[1/]	1	0-1/2
	Coaly shale[2/]	1	4
	Coaly shale and bone[2/]	2	4
	Coal[3/]	1	0
	Coaly shale[3/]		4
	Coal, clay slips[3/]		6
	Bone		2
Floor:	Coaly shale	Partly exposed.	

1/ Included in analysis, lab. No. D-51894 (table 3).
2/ Denotes parting between benches.
3/ Included in analysis, lab. No. D-51895 (table 3).

TABLE 3. - Analyses of face samples from section 1,200 feet northeast of old Evan Jones slope

Sample	Air-drying loss	Condition	Moisture	Vol. matter	Fixed Carbon	Ash	Sulfur	B.t.u.
D-51894	7.6	A	20.3	31.6	38.9	9.2	0.4	9,210
		B	13.7	34.2	42.1	10.0	.5	9,970
		C		39.6	48.9	11.5	.5	11,550
		D		44.8	55.2		.6	13,060
D-51895	6.7	A	17.4	32.5	36.6	13.5	.4	9,160
		B	11.5	34.8	39.3	14.4	.5	9,820
		C		39.3	44.4	16.3	.5	11,090
		D		47.0	53.0		.6	13,250

Condition: A - as received.
B - air-dried.
C - moisture-free.
D - moisture- and ash-free.

Analyses by H. M. Cooper, Bureau of Mines, Pittsburgh, Pa.

Mining and Preparation

Coal at the Houston mine (see table 1 for average section) is stripped and then mined in successive benches by drilling vertical blast holes with a portable electric auger on 5-foot centers; these holes are blasted lightly with 20-percent gelatin. After being broken, the coal is loaded by power shovel onto trucks, which haul it to the washing plant approximately 1 mile from the pit. The raw coal tends to be coarse and slabby, with many iron-silica-sulfur concretions; therefore it requires preliminary breaking before being fed to the rolls. This breaking is accomplished by using a small crawler tractor to crush oversize through an 8-inch grizzly into the roll-crusher feed bin. Crushed coal for jig feed is sized to suit current contract specifications, which usually require 2-1/2 inches top size. This product is fed either directly to through surge bins to a steam-driven Forrester-type coal jig with a 4- by 4-foot plunger section and a 4- by 6-foot bed section. The washed-coal discharge passes over a double-deck shaker sizing screen, with impinging sprays. Screen sizing varies with contract purchase specifications; fines may be optionally recovered in an Esperanza-type classifier in closed circuit with washer and screen or discarded separately. Because the plant level at the screen discharge is 30 feet or more above the car-loading siding, gondolas are loaded by chuting the coal to the cars. For best washing results plant capacity is 15 to 20 tons per hour, but careful mining often permits considerable overloading without appreciable detriment to the quality of finished coal.

Observation of the plant operation under varying conditions indicates that the Forrester jig is not an ideal medium for separating this coal and its inherent impurities. Although the tendency of this coal to break in thin slabs undoubtedly affects jigging separation, it is apparent that there is a rather narrow differential in specific gravity between the shale-bone-coal components in this particular bed system.

WORK BY THE BUREAU OF MINES

Preliminary Examination

In September 1950, accompanied by F. F. Barnes of the Geological Survey, the writer inspected the mining activity at Houston. Bed sections were recorded, and samples were taken from the strip pit (see tables 1, 2, and 3). After the prevalent strike and dip of the measures (which were partly exposed for nearly a mile along the railroad) were ascertained, it was tentatively concluded that numerous beds on very moderate dips probably were present in the area.

Before this examination the current lessors had put down several shallow auger holes in a mile-long area that extended a half mile or so from the railroad; these holes penetrated the overburden into bedrock until coaly material was found. Because this coaly material was encountered within narrow ranges in a high percentage of the holes, it was assumed that the coal bed was undulating in some conformance with the existing topography and that the bed would be strippable throughout a large area. However, later evidence disproved this assumption; consequently, it was decided that a core-drilling pattern that would consist of 2 or 3 holes at intervals downdip would be required to clarify the situation.

Diamond Drilling

A Bureau of Mines diamond drill was shipped to Houston in late August 1951. The first hole was started near the strip pit highwall. This location (see fig. 2) was

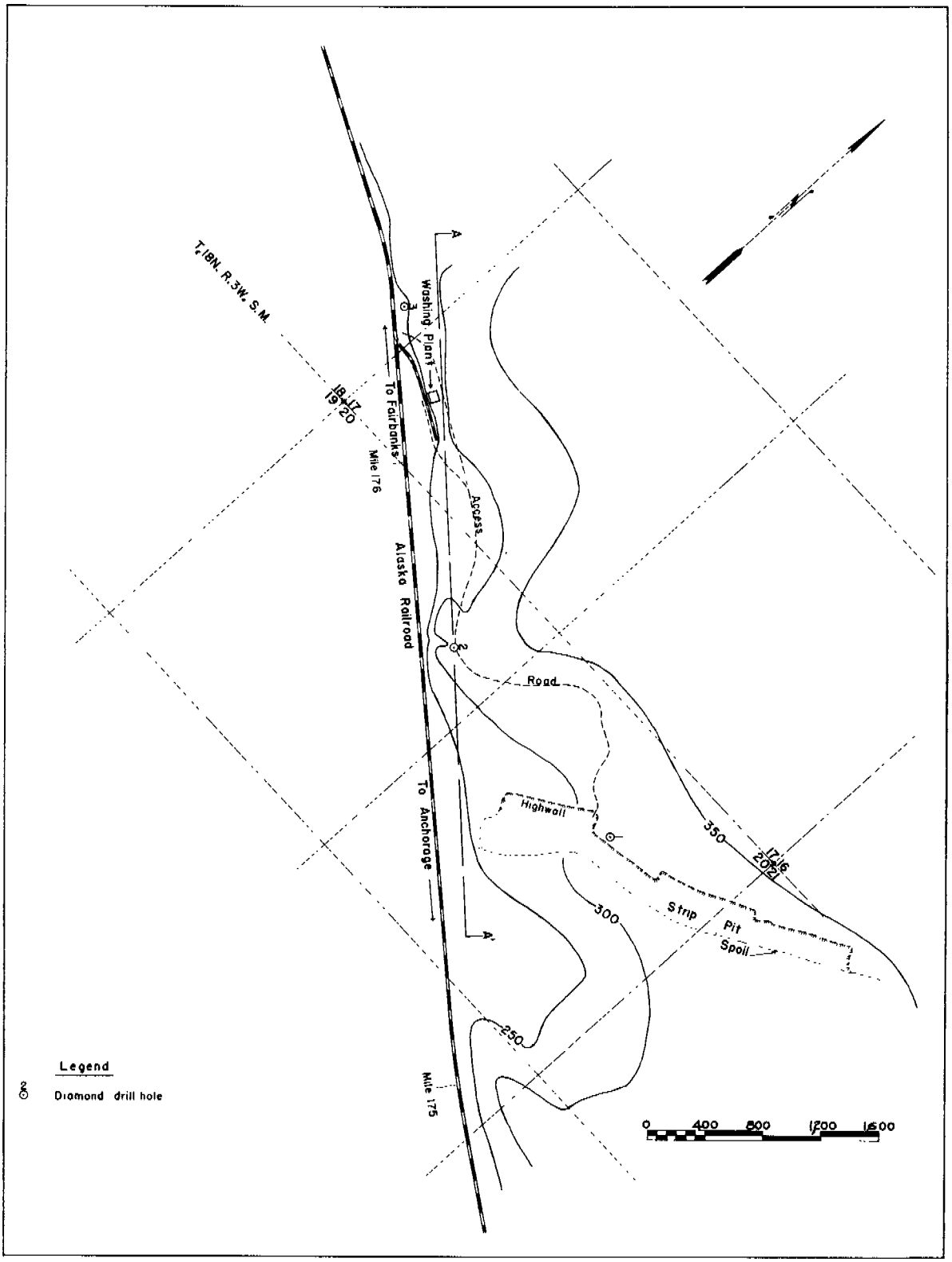

Figure 2. - Plan, Houston coal-drilling project.

chosen to establish initial correlation of the coal measures with reference to the existing mine workings. Drilling conditions were difficult from the start; consequently, progress was slow. A heavy flow of gas and brackish water, which was encountered during freezing weather, caused a shutdown November 10 at a hole depth of 481 feet 7 inches. The condition of the hole precluded resumption of drilling at this location at the beginning of the next season.

Hole 2 was started May 29, 1952, at a new location; it reached a depth of 1,142 feet, which was considered sufficient to intercept any coal beds likely to outcrop or to come within practical mining depth within a radium of a mile or so. Hole 2 was completed August 5, 1952, and the drill was moved to the third location farther downdip, where drilling was resumed August 10.

Hole 3 was completed August 18 at a depth of 386 feet. Termination at this relatively shallow depth was decided upon as soon as it appeared that a positive point of correlation with beds in hole 2 had been reached.

Holes 2 and 3 were spaced at intervals of 2,050 and 2,910 feet, respectively, which was considered the maximum distance allowable for accurate correlation. Depths were governed by practical considerations of possible future mining operations within the immediate Houston area.

The locations of the drill holes, pit, and washing plant and the topography of the Houston area are shown in figure 2. Graphic logs and a section through the drill holes are shown in figure 3. Analyses of core-drill samples are presented in table 4. Detailed descriptive logs of the drill holes and the results of megascopic examination of coal core sections are given in the appendix.

Interpretation of Drilling Results

The area of conclusive results, particularly with regard to estimation of reserves, should be limited to no more than a rectangular area, approximately 1 mile by 1/2 mile, whose long axis is roughly along the line of the 3 holes drilled. A number of thin coal beds dip 5° to 10° northwesterly; these beds may overlie or underlie the strip bed. Within this area no appreciable faulting or folding is apparent, but some minor folds or displacements may be concealed by the cover of glacial deposits and forest growth.

Although several beds appear to be minable and an appreciable tonnage is indicated, it would be inadvisable to accept the reserve estimates without careful consideration of local peculiarities. Some of the factors that might modify the reserve estimates follow:

(1) Washer recovery varies widely according to the type of cleaning equipment and mining practice.

(2) It has been many years since underground mining has been practiced at this location; consequently, no accurate recovery factor is assignable.

(3) Because of adverse drilling conditions, friability of the cored material, and the haphazard distribution of concretions in the coal measures, considerable difficulty was experienced in recovering core samples for other than visual inspection and for comparison with coal currently being mined; therefore, core-drill samples may not be exactly representative of the thickness and character of the coal beds drilled.

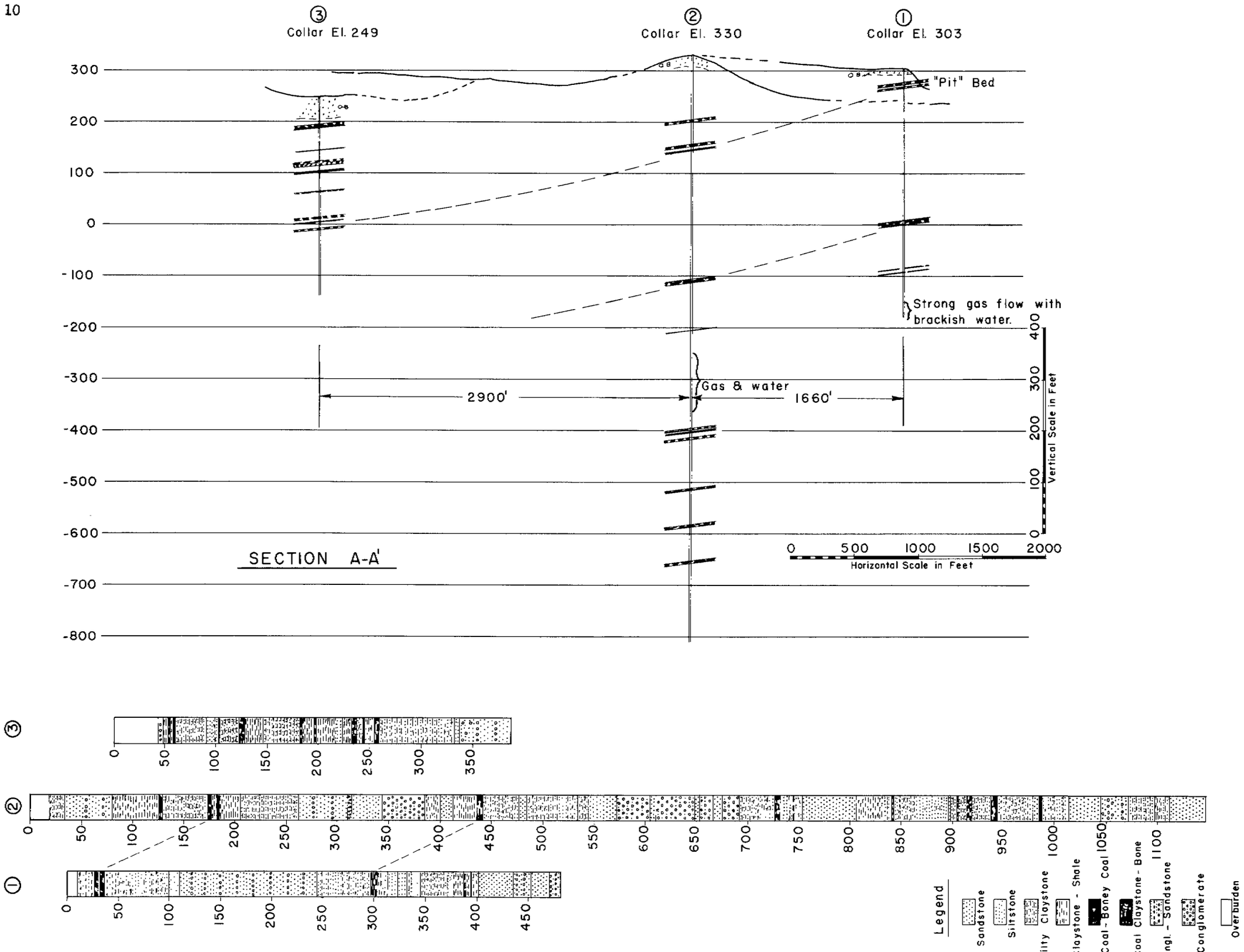

Figure 3. - Section A-A' and graphic logs, Houston coal-drilling project.

TABLE 4. - Analyses of diamond-drill core samples from Houston coal-drilling project

Lab. No.[1]	Condition[2]	Proximate analysis, percent				Ultimate analysis, percent						Calorific value British thermal units	Fusability of ash, °F.			Real specific gravity
		Moisture	Volatile matter[3]	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Ash		Initial deformation temperature	Softening temperature	Fluid temperature	
D-74890 (Hole 1)	1	10.8	32.9	37.3	19.0	5.3	53.1	1.4	20.8	0.4	19.0	9,290	2,310	2,620	2,740	1.53
	2	13.0	32.1	36.4	18.5	5.4	51.8	1.3	22.7	.3	18.5	9,070				
	3		36.9	41.8	21.3	4.6	59.5	1.5	12.7	.4	21.3	10,420				
	4		46.9	53.1		5.8	75.6	2.0	16.1	.5		13,240				
D-74891 (Hole 1)	1	9.5	30.9	33.2	26.4	4.9	48.0	1.2	19.2	.3	26.4	8,400	2,330	2,620	2,840	1.61
	2	12.1	30.0	32.2	25.7	5.0	46.7	1.2	21.1	.3	25.7	8,160				
	3		34.1	36.7	29.2	4.2	53.1	1.4	11.8	.3	29.2	9,280				
	4		48.2	51.8		5.9	75.0	1.9	16.8	.4		13,100				
D-99651 (Hole 2)	1															
	2	10.2	30.9	38.1	20.8					.2		9,140	2,570	2,690	2,890	
	3		34.5	42.3	23.2					.3		10,180				
	4		44.8	55.2						.3		13,250				

1/ Pittsburgh laboratory number; see table following and logs for description of samples.
2/ 1, Air-dried; 2, as received; 3, moisture-free; 4, moisture- and ash-free.
3/ Determined by modified method.

Description of drill-core samples, Houston project:

Lab. No. D-74890: Hole 1; core logged 27 feet 3 inches to 30 feet 3 inches; core received 32 inches; 3-3/4 inches bone rejected; 4 inches coal loss in drilling; 28-1/4 inches coal in this sample.

Lab. No. D-74891: Hole 1; core logged 33 feet 1 inch to 35 feet 8 inches; core received 30 inches; 6-1/2 inches bone rejected, 1 inch bone loss in drilling; 23-1/2 inches coal in this sample.

Lab. No. D-99651: Hole 2; core logged 437 feet 6-1/2 inches to 441 feet 0 inch; core received 41-1/2 inches; 8-1/2 inches bone rejected; 33 inches coal in this sample.

As a basis for calculating tons of coal in place, the common factor for Alaskan subbituminous coals is 1 ton of mined raw coal (plant feed) per cubic yard in place in the mine. Two beds known to average 42 inches and more are the "pit" bed and a bed lying approximately 250 feet (stratigraphically) below. Other beds are simply grouped in the category "14 inches and more"; 2 of these may be 42 or more inches thick; however, the minability of the beds should not be inferred without more thorough investigation. On the above basis, the total amount of coal in the drilled area is estimated to be as follows:

	Tons in place
Pit bed, average 5 ft. of coal.....	2,580,000
250 bed, average 4 ft. of coal.....	2,000,000
Other[1/], average total, 19 ft., 6 in.	10,000,000
Total.....	14,580,000

1/ Appearance and specific gravity comparable to pit product.

Study of the drilling logs, projection of the limited geologic evidence, and consolidation of known historical evidence in this locality indicates that investigation to the southeast for 1/2 to 1 mile might expose strippable beds amenable to more economical mining. As noted in the logs and elsewhere in this report, a considerable quantity of gas was encountered at a well-defined horizon in holes 1 and 2. Study of this phenomenon was beyond the scope of this investigation. The gas was predominantly methane.

APPENDIX

Log, Drill Hole 1

Location: 832.5 feet S. and 1,080 feet W. of NE. corner, sec. 20, T. 18 N., R. 3 W., Seward Meridian, Houston, Alaska.

Elevation: Collar of hole - 303 feet.

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
0	0	11	0	Clay overburden.	11	0	Thin glacial cover previously stripped.
11	0	22	9	Interbedded fine sandstone and silty claystone.	11	9	
22	9	23	1	Ironstone.		4	
23	1	27	3	Interlaminated fine sandstone and silty claystone.	4	2	Roof, "Pit" bed.
27	3	27	4½	Bone.		1½	
27	4½	30	¾	COAL, dull; thin anthraxylon bands and lenses.	2	8¼	Core loss, 4 in.
30	¾	30	3	Bone.		2¼	
30	3	30	9	Shale, dark gray, coaly streaks.		6	
30	9	31	6	Claystone, dark gray, coaly		9	Core loss, 7 in.
31	6	31	9	Shale, dark gray, carbonaceous.		3	
31	9	32	2½	COAL, dull, thin anthraxylon lenses.		5½	
32	2½	32	4	Shale, dark gray, carbonaceous.		1½	
32	4	33	1	Claystone, coaly.		9	
33	1	35	½	COAL, dull; thin anthraxylon streaks and lenses.	1	11½	

Hole 1 (Con.)

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
35	½	35	3	Bone, broken.	0	2½	Core loss, 1 in.
35	3	35	8	Bone.		5	
35	8	38	0	Claystone, few coaly streaks.	2	4	Floor, "Pit" bed.
38	0	39	4	Claystone, coaly.	1	4	
39	4	43	7	Claystone.	4	3	
43	7	46	8	Claystone, silty streaks.	3	1	
46	8	47	0	Ironstone.		4	
47	0	49	2	Claystone.	2	2	
49	2	52	2	Claystone, silty streaks.	3	0	
52	2	52	5	Ironstone, concretionary.		3	
52	5	53	3	Claystone, silty.		10	
53	3	53	8	Bone.		5	
53	8	75	2	Claystone, silty.	21	6	Bedding almost horizontal; infrequent crossbedding.
75	2	77	2	Sandstone, medium, grading into upper and lower strata.	2	0	
77	2	80	10	Claystone, silty.	3	8	
80	10	81	8	Sandstone, silty.		10	
81	8	82	1	Claystone, silty.		5	
82	1	86	2	Sandstone, silty.	4	1	
86	2	86	5	Claystone, silty.		3	
86	5	87	9	Sandstone, silty.	1	4	
87	9	90	5	Claystone.	2	8	
90	5	92	1	Claystone, silty; sandy streaks and coal fragments.	1	8	
92	1	99	6	Claystone, silty; occasional coaly fragments	7	5	
99	6	109	6	Sandstone, clayey matrix.	10	0	Core loss, 2 ft. 5 in.
109	6	242	0	Sandstone, soft, medium to fine, containing multiple beds of hard pebbles (quartz, chert, rhyolite, felsite, basalt) and occasional coal fragments.	132	6	Core loss, 111 ft.
242	0	243	9	Claystone, bone streaks.	1	9	
243	0	258	9	Claystone, silty	15	0	Core loss, 2 ft.
258	9	296	9	Interbedded fine sandstone, siltstone, and claystone; occasional coaly streaks.	38	0	Core loss, 1 ft.
296	9	300	5	Claystone, coaly; many bright-coal bands.	3	8	Core loss, 2 in.
300	5	302	6	Claystone, coaly; few bright-coal bands up to 1 in. thick.	2	1	
302	6	312	8	Interbedded claystone and siltstone; occasional coaly fragments.	10	2	
312	8	322	11	Siltstone, sandy streaks.	10	3	
322	11	323	7	Claystone, coaly.		8	
323	7	332	2	Interbedded siltstone and fine sandstone.	8	7	
332	2	333	10	Interbedded siltstone and claystone.	1	8	

Hole 1 (Con.)

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
333	10	334	5	Siltstone.	0	7	
334	5	334	9	Shale, soft, dark.		4	
334	9	335	2	Claystone.		5	
335	2	336	0	Shale, soft, dark, occasional coal fragments.		10	
336	0	341	2	Interbedded siltstone and fine sandstone.	5	2	
341	2	341	9	Sandstone, soft.		7	
341	9	342	3	Interbedded siltstone and fine sandstone.		6	
342	3	345	2	Sandstone, soft.	2	11	
345	2	351	5	Interbedded siltstone and claystone.	6	3	
351	5	353	0	Claystone, soft, dark.	1	7	
353	0	353	6	Siltstone.		6	
353	6	372	0	Interbedded claystone, siltstone, and fine sandstone.	18	6	
372	0	376	9	Sandstone, soft.	4	9	Core loss, 6 in.
376	9	387	6	Interbedded claystone and shale, silty streaks.	10	9	
387	6	387	7	COAL, hard, bright; conchoidal fracture.		1	
387	7	388	8	Claystone, coaly.	1	1	
388	8	393	8	Claystone, silty streaks.	5	0	
393	8	394	4	COAL, hard, bright, bony streaks.		8	
394	4	402	1	Interbedded claystone and siltstone.	7	9	
402	1	403	4	Sandstone, medium fine.	1	3	
403	4	435	10	Sandstone, medium fine; soft layers and occasional coaly streaks.	32	6	
435	10	453	4	Sandstone, soft, few pebble bands.	17	6	Core loss, 16 ft. 2 in.
453	4	456	4	Sandstone, soft, medium fine.	3	0	
456	4	471	1	Sandstone, porous, poorly cemented.	14	9	Core loss, 8 ft. 9 in. Gas flow accompanied by brackish water, static pressure in excess of 15 lb. per sq. in.
471	1	481	7	Sandstone, alternating soft and dense, pebble bands, bottom of hole in hard, fine sandstone.	10	6	Bedding remains almost horizontal; little distortion evident.

Log, Drill Hole 2

Location: 710 feet S. and 2,150 feet E. of NW. corner, sec. 20, T. 18 N., R. 3 W., Seward Meridian, Houston, Alaska.

Elevation: Collar of hole - 330 feet.

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
0	0	19	0	Overburden, soil and gravel.	19	0	
19	0	21	6	Sandstone, medium coarse; iron stains.	2	6	
21	6	21	11	Shale, carbonaceous.		5	
21	11	33	6	Interbedded silty claystone and siltstone.	11	7	
33	6	80	0	Sandstone, soft, occasional pebble bands and coaly streaks.	46	6	Bedding, where seen, almost horizontal.
80	0	105	2	Claystone, occasional ironstone nodules, coal fragments.	25	2	
105	2	106	0	Siltstone, dense		10	
106	0	115	9	Claystone.	9	9	
115	9	116	3	Siltstone, dense.		6	
116	3	126	2	Claystone.	9	11	
126	2	129	0	Claystone, coaly, frequent coal bands.	2	10	Core broken, pseudo-coal bed.
129	0	173	3	Interbedded claystone, siltstone, and very fine sandstone; occasional pebbles and coaly streaks.	44	3	Roof, "Pit" bed.
173	3	175	1	Interbedded bony coal and coaly claystone.	1	10	
175	1	176	7	COAL, dull; bony streaks.	1	6	
176	7	181	9	Claystone; coal streaks and fragments.	5	2	
181	9	182	3	Claystone, coaly.		6	
182	3	183	7	COAL, dull; bony streaks.	1	4	
183	7	184	9	Shale, dark, coal streaks.	1	2	Floor, "Pit" bed.
184	9	186	4	Claystone.	1	7	
186	4	186	11	Claystone, coal streaks.		7	
186	11	204	5	Claystone, siltstone bands, and very fine sandstone bands.	17	6	
204	5	205	2	Shale, dark; coal streaks.		9	
205	2	241	2	Interbedded claystone, siltstone and very fine sandstone.	36	0	
241	2	244	2	Sandstone, soft.	3	0	
244	2	260	9	Claystone, silty; few sandy streaks.	16	7	
260	9	310	3	Sandstone, soft, occasional pebble bands.	49	6	
310	3	313	4	Conglomerate, pebble; soft sandstone matrix.	3	1	Core loss, 2 ft. 3 in.
313	4	320	9	Sandstone, soft to dense.	7	5	

Hole 2 (Con.)

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
320	9	340	6	Sandstone, soft; few pebbles and occasional claystone bands and coaly fragments.	19	9	
340	6	342	11	Sandstone, soft.	2	5	
342	11	372	7	Conglomerate, pebble and cobble, soft sandstone matrix.	29	8	
372	7	376	10	Sandstone, dense; few pebbles and cobbles.	4	3	Bedding where seen nearly horizontal.
376	10	383	7	Conglomerate, pebble, in soft sandstone matrix.	6	9	
383	7	399	0	Claystone, silty bands, occasional ironstone concretions and coaly streaks.	15	5	
399	0	412	4	Sandstone, soft, fine to medium.	13	4	Core loss, 2 ft.
412	4	432	2½	Claystone to silty claystone, occasional ironstone concretions.	19	10½	
432	2½	435	4	Claystone, carbonaceous; coal fragments.	3	1½	Roof of bed corresponding to log, hole 1, 296 ft. 9 in. to 302 ft. 6 in.
435	4	435	9	COAL.		5	
435	9	435	10½	Siltstone.		1½	
435	10½	436	¾	Bone.		2¼	
436	¾	437	1½	COAL.	1	¾	
437	1½	437	6½	Bone.		5	
437	6½	438	0½	COAL.		6	
438	½	438	3	Bone.		2½	
438	3	440	2	Bone, coal streaks.	1	11	
440	2	440	8	Bone.		6	
440	8	441	0	COAL.		4	
441	0	441	3	Bone.		3	
441	3	445	7	Claystone, coal streaks.	4	4	Floor.
445	7	461	3	Interbedded claystone, siltstone, and very fine sandstone.	15	8	
461	3	461	9	Sandstone.		6	
461	9	461	11	Claystone.		2	
461	11	462	1	Sandstone, soft.		2	
462	1	462	11	Claystone.		10	
462	11	463	8	Claystone, coaly.		9	
463	8	477	0	Claystone, occasional sandy streaks.	13	4	Bedding nearly flat.
477	0	484	0	Sandstone, crossbedded, fine to medium, few clay streaks.	7	0	
484	0	508	1	Claystone to silty claystone.	24	1	
508	1	509	10	Sandstone, soft.	1	9	
509	10	511	5	Claystone.	1	7	
511	5	511	8	Claystone, coaly.		3	

Hole 2 (Con.)

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
511	8	533	0	Claystone and fine sandstone, interbedded and crossbedded.	21	4	
533	0	533	8	COAL, bony.		8	
533	8	543	0	Interbedded claystone and fine sandstone.	9	4	
543	0	545	3	Sandstone, claystone inclusions.	2	3	Transition.
545	3	571	11	Sandstone.	26	8	Bedding 15°, brackish water with evident gas pressure.
571	11	605	0	Conglomerate, pebble to cobble, soft sandstone matrix.	33	1	Core loss, 28 ft. 8 in.
605	0	610	4	Sandstone, soft.	5	4	Core loss, 2 ft. 1 in.
610	4	648	4	Conglomerate, pebble to cobble, soft sandstone matrix.	38	0	Core loss, 30 ft. 9 in.
648	4	652	10	Sandstone, dense; calcite-filled fractures.	4	6	Slickensides.
652	10	666	3	Conglomerate, soft matrix.	13	5	Core loss, 12 ft. 11 in.
666	3	675	0	Dense sandstone, coaly fragments.	8	9	Core loss, 7 ft. 1 in.
675	0	692	0	Conglomerate, soft matrix.	17	0	Core loss, 12 ft. 9 in.
692	0	697	0	Claystone, silty.	5	0	Core loss, 7 in. Gas and water increasing down to this stratum. Static pressure up to 45 lb.
697	0	726	3	Claystone, silty; few bands of fine sandstone and occasional ironstone concretions and coaly streaks.	29	3	
726	3	728	2	Claystone, coaly.	1	11	
728	2	729	7	Claystone.	1	5	
729	7	730	11	Claystone, coaly.	1	4	
730	11	733	7	Interbedded claystone and fine sandstone.	2	8	
733	7	735	7	Claystone, coal streaks.	2	0	
735	7	740	7	Claystone, sandy streaks, and lenses.	5	0	
740	7	742	8	Sandstone, fine to medium cross-bedded; coaly streaks and occasional included pebbles.	2	1	
742	8	744	6	Claystone, coaly.	1	10	
744	6	753	3	Interbedded claystone and fine sandstone.	8	9	
753	3	805	11	Sandstone, fine to medium and dense to porous, occasional claystone blebs, and pebble band at 794 ft.	52	8	Another gas channel apparent at 775 ft.; not measurable.
805	11	832	9	Claystone, silty and sandy streaks.	26	10	
832	9	837	0	Sandstone, soft; claystone and coaly streaks.	4	3	

Hole 2 (Con.)

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
837	0	840	9	Claystone, sandy and coaly streaks.	3	9	
840	9	843	3	Claystone, coaly; many bright coal bands.	2	6	
843	3	847	10	Sandstone, soft; occasional claystone streaks.	4	7	
847	10	848	3	Claystone.		5	
848	3	850	8	Claystone, dark; bright coal streaks.	2	5	
850	8	876	0	Interbedded claystone and siltstone.	25	4	
876	0	876	6	Sandstone, crossbedded; streaks of iron carbonate.		6	
876	6	880	8	Claystone, dark; occasional coal streaks.	4	2	
880	8	895	8	Interbedded claystone and silty claystone.	15	0	
895	8	897	10	Sandstone, fine, dense.	2	2	
897	10	903	8	Interbedded claystone and siltstone.	5	10	
903	8	906	1	Claystone, coaly.	2	5	
906	1	913	6	Interbedded claystone, siltstone, and fine sandstone.	7	5	
913	6	917	8	Claystone, coaly; bright streaks.	4	2	
917	8	937	7	Interbedded claystone and siltstone; occasional ironstone concretions.	19	11	
937	7	943	7	Claystone, coaly; many bright coal bands and streaks.	6	0	
943	7	979	0	Interbedded claystone, siltstone, and fine sandstone; occasional ironstone concretions.	35	5	Bedding of all above strata varies from 0° to 15°.
979	0	985	0	Sandstone.	6	0	
985	0	985	9	COAL, bony and bright.		9	
985	9	986	2	Claystone, coaly.		5	
986	2	987	2	COAL, bright.	1	0	
987	2	987	5	COAL, bony and bright.		3	
987	5	988	1	COAL.		8	
988	1	988	6	Claystone, coaly.		5	
988	6	1,013	8	Interbedded claystone and siltstone; 3-ft. zone of ironstone concretions at 994 ft.	25	2	
1,013	8	1,044	6	Sandstone, fine to medium; occasional claystone streaks.	30	10	
1,044	6	1,072	0	Sandstone; frequent conglomerate lenses of indeterminate thickness.	27	6	Core mangled; no loss.

Hole 2 (Con.)

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
1,072	0	1,097	1	Interbedded claystone and silty claystone.	25	1	
1,097	1	1,105	10	Claystone, dark; frequent bright-coal streaks and scattered sandstone concretions.	8	9	
1,105	10	1,106	2	Claystone.		4	
1,106	2	1,112	3	Interbedded claystone, siltstone, and fine sandstone.	6	1	
1,112	3	1,142	0	Sandstone, occasional claystone streaks.	29	9	

Log, Drill Hole 3

Location: 920 feet N. and 265 feet W. of SE. corner, sec. 18, T. 18 N., R. 3 W., Seward Meridian, Houston, Alaska.

Elevation: Collar of hole - 249 feet.

0	0	43	6	Overburden, glacial sand, gravel, and boulders.	43	6	
43	6	48	6	Sandstone, dense, few included pebbles and cobbles.	5	0	Core loss, 3 ft. 4 in.
48	6	50	5	Claystone.	1	11	Core loss, 9 in.
50	5	51	11	Claystone, soft.	1	6	Core loss, 1 ft., 2 in.
51	11	53	2	Shale, dark.	1	3	
53	2	53	5	Claystone, coaly.		3	
53	5	53	7	Claystone, coaly streaks.		2	
53	7	55	0	Claystone, coaly.	1	5	
55	0	58	7	Claystone, dark, silty; occasional coaly streaks.	3	7	
58	7	60	4	COAL, bony.	1	9	
60	4	87	6	Interbedded claystone, silty claystone and siltstone.	27	2	
87	6	87	9	Sandstone.		3	
87	9	90	10	Claystone.	3	1	
90	10	96	11	Sandstone, porous, fine to medium, frequent clay bands.	6	1	
96	11	97	6	Sandstone, dense, fine.		7	
97	6	103	0	Claystone, silty, grading down to siltstone.	5	6	
103	0	103	11	COAL, bony.		11	
103	11	122	4	Interbedded claystone and silty claystone; occasional sandy streaks.	18	5	
122	4	123	0	Shale, carbonaceous.		8	
123	0	125	2	Claystone.	2	2	
125	2	126	0	Claystone, coaly.		10	
126	0	126	1	Claystone.		1	
126	1	126	6	Claystone, coaly.		5	

Hole 3 (Con.)

Depth From- Ft.	Depth From- In.	Depth To- Ft.	Depth To- In.	Material	Thickness Ft.	Thickness In.	Remarks
126	6	127	0	Claystone.	0	6	
127	0	127	11	Claystone, coaly.		11	
127	11	133	5	Claystone, dark; frequent coaly streaks.	5	6	
133	5	142	10	Claystone to silty claystone, occasional coaly fragments.	9	5	
142	10	145	8	Interbedded coaly claystone and carbonaceous shale.	2	10	
145	8	177	3	Interbedded claystone, silty claystone, and very fine sandstone.	31	7	
177	3	181	8	Interbedded claystone and soft, porous sandstone.	4	5	Core loss, 1 ft.
181	8	182	6	Claystone, coaly.		10	
182	6	196	1	Claystone, frequent silty and coaly streaks.	13	7	
196	1	199	4	Claystone, coaly.	3	3	
199	4	217	6	Claystone, occasional silty streaks.	18	2	
217	6	224	0	Sandstone, fine.	6	6	
224	0	233	4	Claystone.	9	4	
233	4	236	9	Claystone, coaly.	3	5	
236	9	243	0	Claystone, occasional thin coaly streaks.	6	3	
243	0	244	0	COAL, bony.	1	0	
244	0	244	3	Shale, carbonaceous.		3	
244	3	256	1	Claystone, occasional coaly fragments and ironstone nodules.	11	10	
256	1	258	8	Claystone, coaly.	2	7	
258	8	260	4	Shale, dark; few thin coaly streaks.	1	8	
260	4	333	1	Interbedded claystone, siltstone, and very fine sandstone.	72	9	
333	1	337	0	Sandstone, soft.	3	11	Core loss, 1 ft. 2 in.
337	0	386	0	Sandstone, soft, few pebbles included.	49	0	Core loss, 42 ft. Bedding throughout is 0° to 15°, with moderate crossbedding. Regular bedding seldom exceeds 5°.

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